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(54) Method for balancing a washingmachine

(57) The washing machine (1) has a drum (3) rotating about a horizontal axis (3a) and is equipped with at least three water chambers (4a,4b,4c) distributed through the internal periphery of the drum to which chambers a flow of water (13) is provided selectively from the chambers' respective solenoid valves (10a,10b,10c) to compensate for the unbalance, while the drum is accelerated at a gradual rate by means of a T/F speed variator (6) of the motor (5), and the magnitude of the vibration (12) and its position (11) are measured by a vibration sensor (8) and a position sensor (9). The measured values are compared to a preset threshold value which changes with drum rotation speed until the maximum spinning speed is reached.

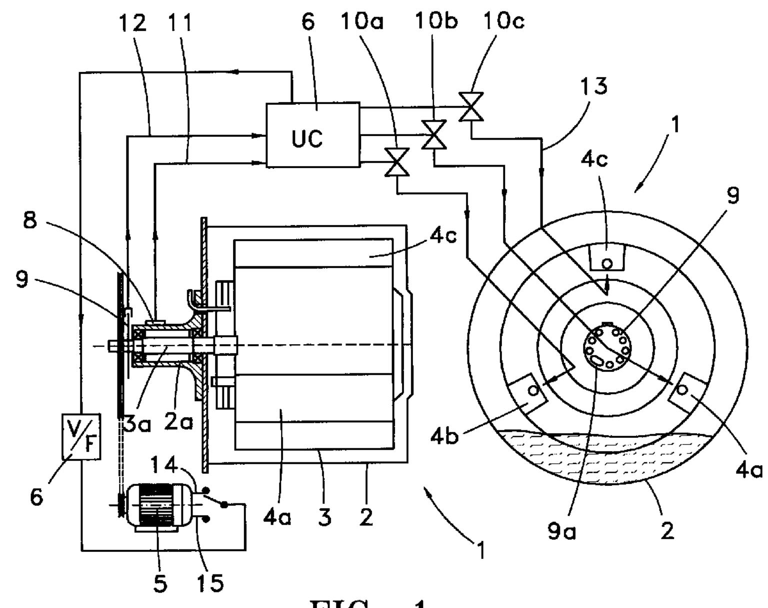

FIG. 1

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Description

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a washing machine whose drum rotates about a horizontal axis, and more particularly to the prevention of vibrations in the clothes-laden drum when it rotates at high speed during the spinning stage.

PRIOR ART

US 5,280,660 describes a method for balancing a washing machine whose drum rotates about a horizontal axis, wherein the washing machine is equipped with at least three water chambers distributed peripherally inside the drum, which chambers selectively receive a preset amount of water from their respective solenoid valves depending upon the result of the vibration measured by a vibration sensor and the drum unbalance position measured by means of a proximity sensor, the signals from both sensors being combined to select the water supply that will compensate for the unbalance, and a motor that accelerates the drum to maximum spinning speed during the compensation process.

US 4,517,695 describes a method for balancing a washing machine whose drum rotates about a horizontal axis, wherein the drive motor is connected to a rotation speed control device that controls drum acceleration from an initial spinning speed to a final speed, depending upon the force exerted by the unbalance of the clothing and the comparison thereof with a preset value calculated for the final spinning speed.

In known methods, drum rotation is accelerated from a low initial value to a high final maximum spinning value, in spurts by means of various abrupt speed increases, and maintaining constant velocity in each spurt, in intervals whose length depends upon the result of the measurement of vibration at each constant speed value. During the course of the interval at constant drum speed, a preset quantity of water is placed in the selected compensation chamber, and this action is repeated until the measured vibration value falls below a certain reference value. With known methods, the acceleration time that transpires until the maximum speed for carrying out the compensation method is reached is excessive, because the water is added to the compensation chambers in ever-equal given doses, and because the drum undergoes successive accelerations after acceleration-free intervals.

DISCLOSURE OF THE INVENTION

The object of the invention is a method for balancing the drum of a washing machine equipped with three or more hollow water chambers distributed through its internal periphery by means of compensating for unbalance while the drum accelerates from a low initial speed to a high final maximum spinning speed, while combining the addition of water to the selected water chamber, which is situated diametrically opposite the unbalanced position. The addition of compensating water is continuous, by means of a given flow; acceleration is likewise continuous in gradual fashion, while vibration is measured continuously, and only the rate of acceleration is dependent upon the result of the vibration measurement.

With the method according to the invention, smooth rotation is achieved without exceeding an admissible washing machine vibration value by means of drum acceleration at a gradual rate until reaching a maximum speed, while the unbalance of the clothes is compensated for in a shorter total process time.

In order to carry out drum acceleration at a gradual rate, the drum drive motor is controlled through a voltage/frequency speed variator governed by the washing machine's electronic controller to regulate the rate of drum acceleration as a function of the result of the vibration measurement and its comparison with a preset reference value.

One characteristic of the invention is that the vibration reference value for comparison with the real value is changing throughout the range of spinning speeds and is reduced as the drum accelerates to maintain the unbalanced mass of the drum always below a constant value, inasmuch as vibration increases at a square rate with the drum speed. The speed variator also allows the torque of the drum drive motor to be raised at a speed as low as 10 r/min, to effect full water chamber emptying before beginning a new balancing process.

The vibration sensor used to execute the method has the advantages of lower economic cost and easier installation than the accelerometers of known methods, as well as the fact that the result of measurement is not affected by the mass of the washing machine's structure, as occurs with an accelerometer, but only by the unbalance of the clothing, thus also gaining time in the execution of the compensation process until final compensation is achieved.

DESCRIPTION OF THE DRAWINGS

FIG. 1 shows two views of the washing machine with the system for carrying out the method for balancing the washing machine drum according to the invention.

FIG. 2 is a wiring diagram of the sensor used to measure vibration.

FIG. 3 is a diagram of the measurement of the vibration generated by the drum unbalance combined with the measurement of the unbalance position.

FIG. 4 is a diagram of the different drum accelerations depending upon the unbalance, in a first embodiment of the invention.

FIG. 5 is the diagram of the steps included in the first preferred embodiment of the balancing method.

FIG. 6 is a diagram of the different drum accelerations depending upon the unbalance, in a second embodiment of the balancing method.

FIG. 7 is a diagram of the magnitude of vibration during the course of drum acceleration according to the diagram in figure 6.

FIG. 8 is the diagram of the steps included in a second preferred embodiment of the balancing method.

PREFERRED EMBODIMENTS OF THE INVENTION

With reference to figures 1 to 3, the washing machine 1 for executing the method according to the invention is comprised of a tub 2 fixed to the washing machine structure, the drum 3 rotating about a horizontal drive axis 3a through whose internal periphery are distributed three water chambers 4a,4b,4c, a housing 2a holding the bearings of the axis 3a which is fixed to the rear of the tub 2, the induction motor 5 for driving the drum 3, the washing machine's electronic controller 6, the voltage-frequency converter speed variator 7, the device 8,9 for detecting vibration and position, and the solenoid valves 10a,10b,10c activated individually by the controller 6 to compensate for the unbalance by means of selectively filling the chambers 4a,4b,4c by means of water streams according to the arrows 13 in figure 1.

The drum drive motor 5 shown in figure 1 has two windings 14,15 powered separately to achieve two ranges of drum rotation speed N, the low 35-to-55 r/min speed for clothes washing and the high spinning speed between 200 and 900 r/min, these latter two speeds being referenced respectively as Nini and Nmax. Both windings of the motor 5 are powered through the speed variator 7, the low-speed winding 14 to reduce the speed N to a very low value such as 10 r/min when the chambers 4a,4b,4c are to be emptied, and the winding 15 to bring the speed N up gradually to spinning speed during the unbalance compensation process.

The unbalance detection device 8,9 includes a vibration magnitude sensor 8, shown in figure 2, and an unbalance position sensor 9 shown in figure 3, which rotates of a piece with the drum axis 3a.

The vibration sensor 8 used for the execution of the compensation method, shown in fig. 2, is preferably constructed using a strain gauge 8a and an associated circuit 8b for filtering, amplifying and processing the output signal. The gauge 8a is fixed through a substrate to the bearing-holding housing 2a where it is easily accessible and in a place to which all radial drum vibration is transmitted. The circuit 8b faithfully reproduces the oscillation of the vibration through its signal 11 of electrical voltage V oscillating between two alternating peak values Vc which is almost a sine function, shown in figure 3, and the numerical result of the measurement is the value lying between the negative and positive peak values Vc.

The sensor 9 sensing the unbalance position in relation to the water chambers 4 used preferably for the execution of the method is an optic sensor where the photoelectric transmitter not shown in the figures is associated with a rotating disk fixed to the axis 3a and perforated with a number of orifices 9b distributed uniformly over its periphery indicating the angle rotated by the drum. The position sensor 9 could also be a magnetic proximity or Hall effect sensor. One of the perforations in the disk in sensor 9 is a long groove 9a whose position relative to one of the chambers 4 is recorded in the controller 6, serving as a "zero" reference of the angle rotated by the drum 3. The photoelectric transmitter provides an electrical signal 12 associated with the position of the groove 9a, and the controller 6 combines the two electrical signals 11 and 12 to measure the phase angle phi, as shown in figure 3, between the said groove 9a and the peak value Vc of the vibration signal 11, to select one or two of the three chambers 4a,4b,4c, diametrically opposite the location of the mass causing the unbalance.

Figure 4 depicts the acceleration of the drum 3 by means of the variator 7 in a first preferred embodiment of the method 20 for balancing the drum 3 according to the stage diagram in figure 5. The acceleration of the drum 3 takes place smoothly, from the initial spinning speed Nini to the maximum speed Nmax, and gradually by means of tiny successive "delta N" increments, for example increments of 50 r/min or less at a time, yielding different rates of acceleration N1 to N4 as a function of the initial unbalanced mass. The different drum accelerations N1 to N4 are the effect of the different times t transpired for the flow 13 to supply the necessary amount of water to the selected chamber 10.

Vibration magnitude is measured between the two opposing values Vc of the signal from sensor 8 shown in figure 3. The vibration value Vum is a threshold value admissible for each actual speed value N according to an exponential function found by experiment, examples being Vum = 600 mV at 200 r/min and Vum = 150 mV at 900 r/min, and the safety limit value Vlim is for example 2000 mV.

The first preferred embodiment 20 of the balancing method, according to the step diagram in figure 5, includes prior steps 21 to 24, the balance compensating sequence of steps 25 to 31, and final steps 32 and 33, which include:

- step 21, identification of one of the chambers 4a,4b,4c with the "zero" position of groove 9a of position sensor 9, and identification of each of the solenoid valves 10a,10b,10c with its respective chamber 4, which stage is performed only once, when the washing machine is installed on its site. The respective solenoid valve 10a,10b,10c is associated with the water chambers 4a,4b,4c by means of successive activation and check of the water chamber that causes the vibration Vc to vary,
- step 22, emptying of the water chambers 10 at a

very slow speed N such as 10 r/min,

- step 23, checking of the records present in the controller 6 for the safety limit vibration Vlim, the balancing threshold vibration Vum at each speed N, the maximum spinning time tmax, and the maximum rotation speed Nmax,
- step 24, acceleration of the drum to an initial spinning speed Nini, for example 200 r/min,
- the sequence of steps 25 to 31, comprising the measurement, step 25, of the vibration Vc and the unbalance position phi, the choice of the chamber 4, stage 26, to which the water stream 13 must be supplied and the activation of the corresponding valve 10, the comparison, step 27, of the measurement Vc with the threshold value Vum (figure 3), the comparison of the transpired time t with the recorded spinning speed tmax, step 28, the comparison of the vibration measurement Vc with the safety limit value Vlim, step 29, the comparison of the actual speed N with the maximum speed Nmax, step 30, and the increase of the speed N by an increment ▒delta N,▒ step 31,
- step 32, deactivation of the solenoid valve 10 once the maximum speed Nmax has been reached,
- step 33, spinning at maximum speed until the maximum spinning time tmax has expired, and finalization of the balancing method.

The sequence of steps 25 to 29 is performed for each speed increase ▒delta n,▒ step 31, which increases occur continuously one after another, since the stream of water 13 flows uninterruptedly until the maximum spinning speed Nmax is reached.

The second embodiment 40 of the balancing method according to the diagram in figure 8 includes the same prior steps 41 to 44 as the first embodiment, plus the previous record of different acceleration rates N5 to N9, shown in figure 6, in the controller 6, since the speed increase is continued at one of the said rates N1 to N9, an acceleration rate N8 being chosen after the measurement of the vibration Vc at the initial speed Nini. Steps 45 to 50 included in the repeated sequence of operations are the same as in the first embodiment 20, except that the speed increase ▒delta N,▒ step 47, is inserted between measurement 45 and comparison 49 of the measured value Vc with the threshold value Vum, the water supply 13 in this second embodiment being interrupted, step 51, according to the result of the comparison in step 49. The vibration measurement Vc is compared to the threshold value Vum, step 49, and the result thus found conditions the activation and deactivation of the selected solenoid valve 10, since inasmuch as the acceleration N8 is uninterrupted, when the measurement Vc is less than the value Vum, the valve is deactivated, step 51, and the selected chamber 4 is prevented from overloading, which could cause an unbalance in the position of the selected chamber 4 greater than the unbalance of the initial mass of clothes in the drum 3 in the opposite position. Thus the measurement Vc oscillates with the course of time around the threshold value Vum, the solenoid valve 10 being connected when Vc is greater than Vum, step 50, while the acceleration N8 is continuous.

Claims

1. Method for balancing a washing machine whose drum (3) rotates about a horizontal axis (3a), which washing machine is equipped with at least three water chambers (4a,4b,4c) distributed through its internal periphery for compensating for drum unbalance, a motor (5) equipped with means (7) for the controlled acceleration of the drum (3), a vibration (Vc) magnitude sensor (8), a sensor (9) of the position of the unbalance on the periphery of the drum (3), an electronic washing machine controller (6) that combines the electrical signals (11,12) transmitted by the two sensors (8,9) to select at least one of the chambers (4a,4b,4c) and supply it by means of a respective solenoid valve (10a,10b,10c) with a quantity of water (13) to compensate for the unbalance, while the drum is accelerated (31,47) between an initial and a final spinning rotation speed (Nini,Nmax), and the controller (6) repeats a sequence of operations (25-31, 45-50) including measurement (25,45) of the vibration (Vc) and the unbalance position (phi), comparison (27,49) of the resulting measurement of the vibration (Vc) with a preset value (Vum), and comparison (30,48) of the actual drum speed (Na) with the maximum spinning speed (Vmax), characterized by the steps

   - an initial prior step (21,41) to identify one of the water chambers (4a,4b,4c) with a reference position (9a) for the position sensor (9), and the association of each of the compensation chambers (4a,4b,4c) with its respective solenoid valve (10a,10b,10c);
   - while the said sequence (25-31, 45-50) of operation is executed repeatedly to compensate for the unbalance, the drum (3) is accelerated continuously at a gradual rate (N1-N9), and simultaneously a flow (13) of water is supplied to the selected compensation chamber (4a,4b,4c);
   - the continuous comparison (27,49) of the measured vibration value (Vc) with a preset vibration value (Vum) which is changing with the real speed (Na) of rotation of the drum.

2. Method for balancing method according to the claim 1, wherein the water flow (13) supplied to the selected water chamber to compensate for the unbalance is uninterrupted and the drum acceleration rate (Na) depends upon the result of the same comparison (27,49) of the measured vibration value (Vc).

3. Method for balancing method according to the claim 1, wherein the drum acceleration rate (Na) is constant and the water flow is supplied to the selected chamber or interrupted depending upon the result of the said comparison (27,49) of the measured vibration value (Vc).

4. Method for balancing method according to the claim 1, wherein the result of vibration measurement (25) is the measurement (Vc) between the alternating peak values (+Vc, -Vc) of the signal (12) produced by the vibration sensor (8), and that of the unbalance position is the measurement (phi) of the phase between the said peak value (+Vc) and the electrical reference signal (11) from the position sensor (9).

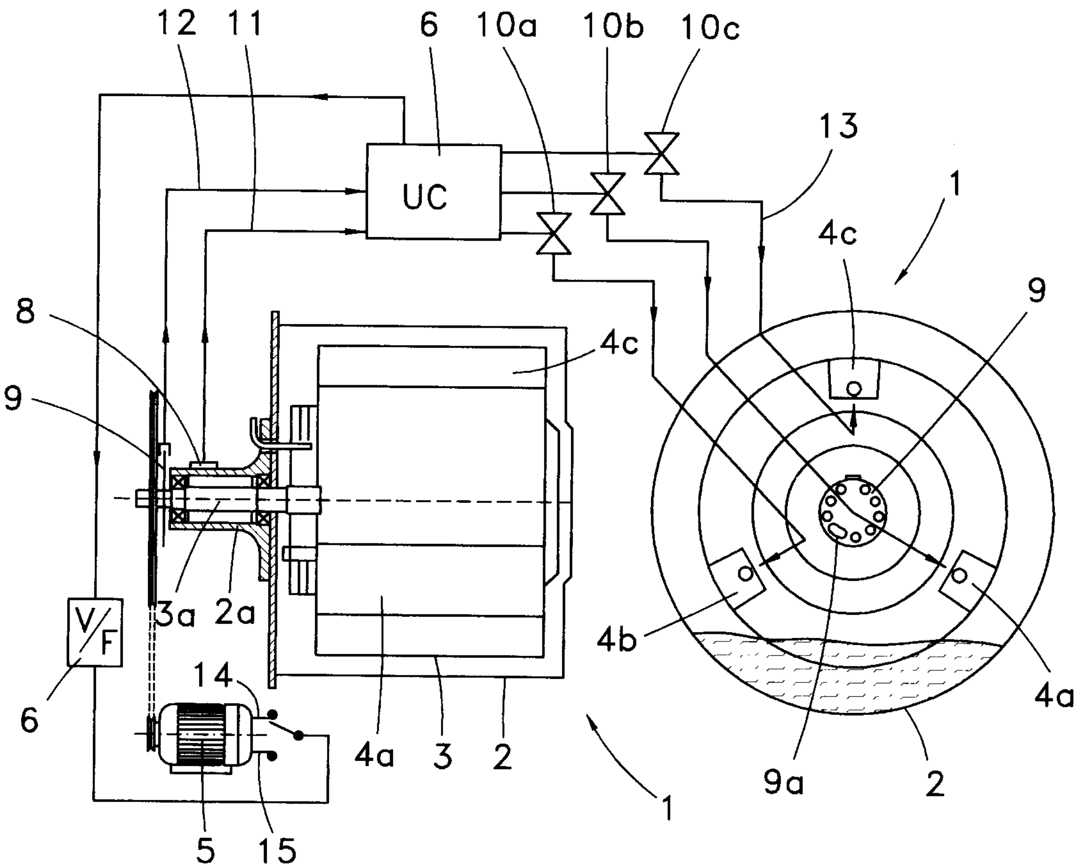

FIG. 1

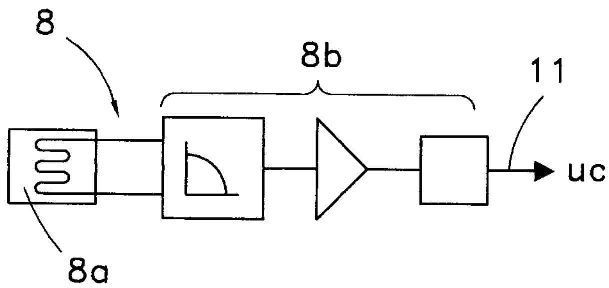

FIG. 2

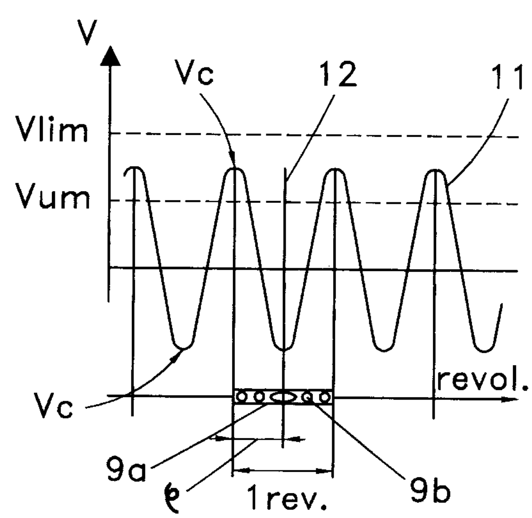

FIG. 3

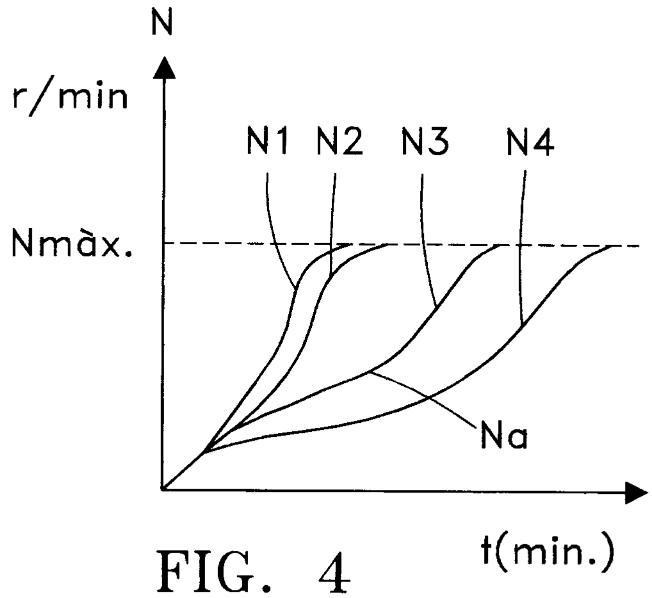

FIG. 4

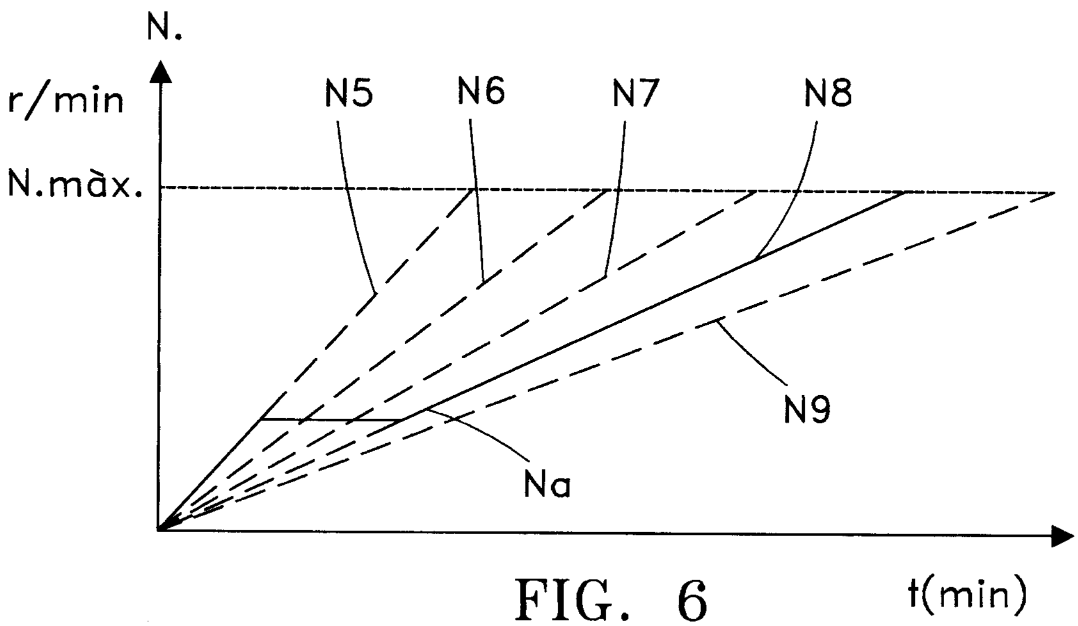

FIG. 6

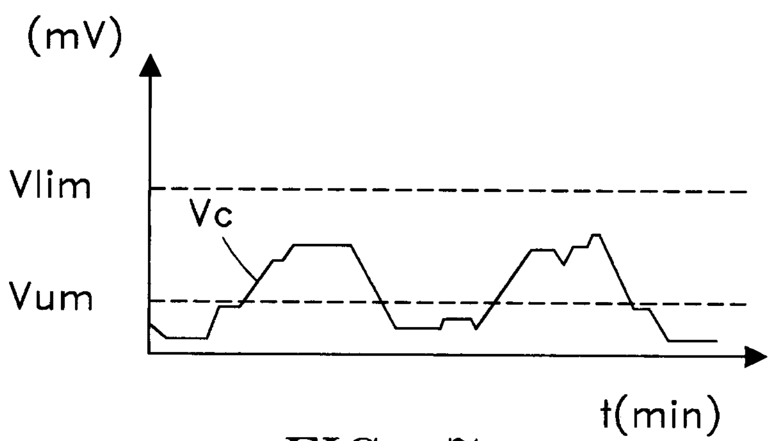

FIG. 7

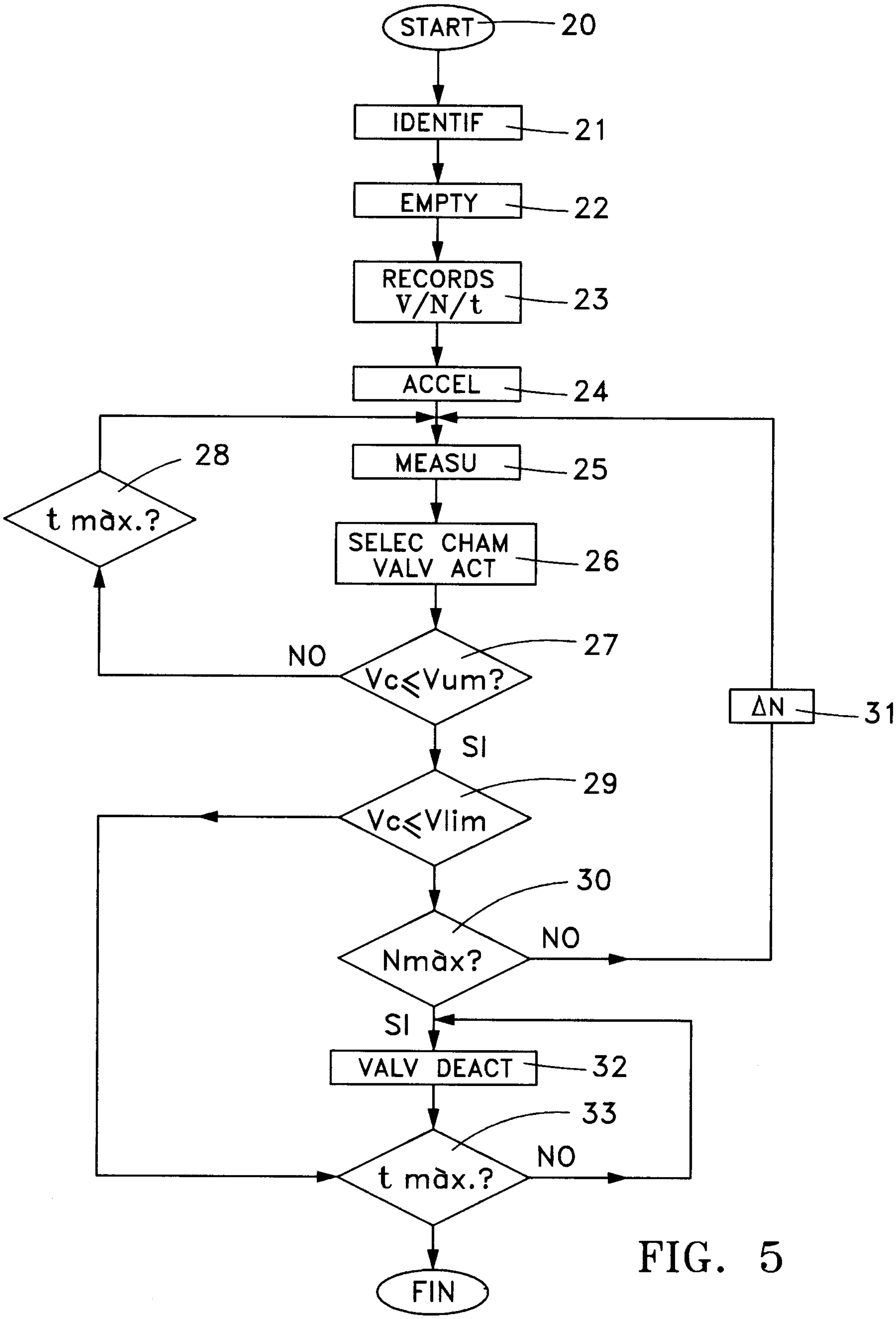
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FIG. 5

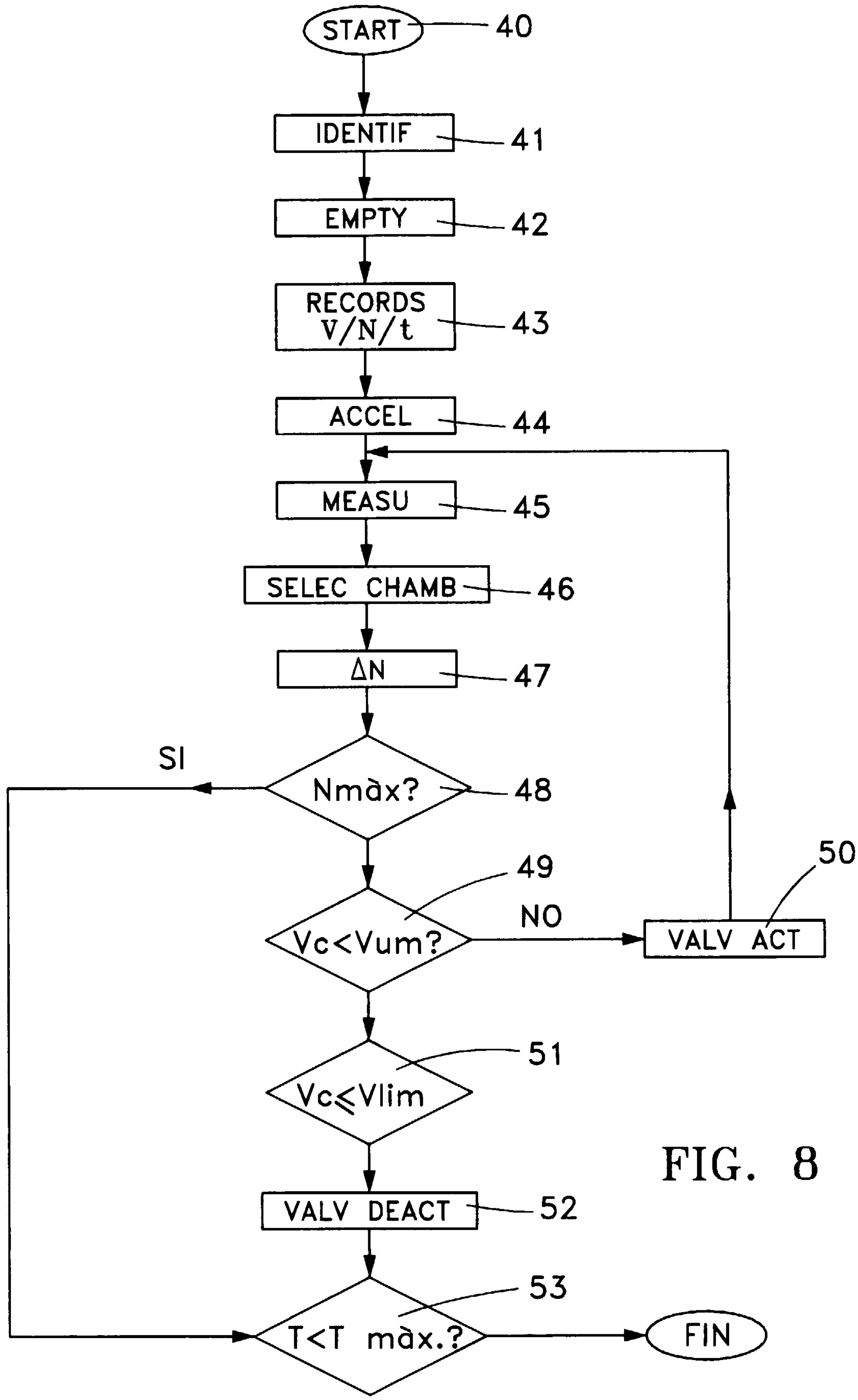
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FIG. 8