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(54) **Method for balancing a washing machine**

Verfahren zum Auswuchten einer Waschmaschine

Procédé d'équilibrage d'une machine à laver

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Description

TECHNICAL FIELD OF THE INVENTION

[0001] 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

[0002] 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.

[0003] 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.

[0004] 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

[0005] 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 in-

itial 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.

[0006] 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.

[0007] 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.

[0008] 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.

[0009] 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

[0010] 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.

[0011] FIG. 2 is a wiring diagram of the sensor used to measure vibration.

[0012] FIG. 3 is a diagram of the measurement of the vibration generated by the drum unbalance combined with the measurement of the unbalance position.

[0013] FIG. 4 is a diagram of the different drum accelerations depending upon the unbalance, in an embodiment of the invention.

[0014] FIG. 5 is the diagram of the steps included in

the embodiment of the balancing method, according to fig. 4.

PREFERRED EMBODIMENT OF THE INVENTION

[0015] 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.

[0016] 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.

[0017] The unbalance detection device 8, 9 includes a vibration magnitude sensor 8, shown in figure 2, and a position sensor 9 to measure the position of the unbalance, shown in figure 3, which rotates of a piece with the drum axis 3a.

[0018] 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 $+V_c$ and $-V_c$ which is almost a sine function, shown in figure 3, and the numerical result of the measurement is the V_c peak to peak amplitude.

[0019] 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 ϕ , as shown in figure 3, between the said groove 9a and the peak value $+V_c$ 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.

[0020] Figure 4 depicts the acceleration of the drum 3 by means of the variator 7 in an embodiment of the method 40 for balancing the drum 3 according to the flow diagram in figure 5. The acceleration of the drum 3 takes place smoothly, from the initial spinning speed Nini and gradually up to the maximum speed Nmax, 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 Na as a function of the initial unbalanced mass.

[0021] Vibration magnitude is measured between the two opposing peak values V_c of the signal from sensor 8 shown in figure 3. The vibration value V_{um} is a threshold value admissible for each actual speed value N according to an exponential function found by experiment, examples being $V_{um} = 600$ mV at 200 r/min and $V_{um} = 150$ mV at 900 r/min, and the safety limit value V_{lim} is for example 2000 mV.

[0022] The preferred embodiment 40 of the balancing method, according to the step diagram in figure 5, includes prior steps 41 to 44, the balance compensating sequence of steps 45 to 50, and final steps 51 to 53, which include:

- step 41, 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 checking of the water chamber that causes the vibration V_c to vary;
- step 42, emptying of the water chambers 10 at a very slow speed N such as 10 r/min;
- step 43 checking of the records present in the controller 6 for the safety limit vibration V_{lim} , the balancing threshold vibration V_{um} at each actual speed N, the maximum rotation speed Nmax, and the maximum spinning time t_{max} ;
- step 44, acceleration of the drum to an initial spinning speed Nini, for example 200 r/min, and choosing the actual acceleration rate N8 among said plu-

rality of gradual rates, after measuring of the vibration V_c at the initial spinning speed N_{ini} ;

- the sequence of steps 45 to 50 comprising, measuring, step 45, of the vibration V_c and the unbalance position ϕ ; the choice of chamber 4, step 46, to which the water stream 13 must be supplied and the activation of the corresponding valve 10; the increase "delta N", step 47, of the speed N , the comparison, step 48, of the actual speed N with the maximum speed N_{max} ; the comparison, step 49, of the measurement V_c with the balancing threshold value V_{um} (figure 3), which is changing with the real speed N of the rotation of the drum 3; and step 50, activation of solenoid valves 10 when V_c is greater than V_{um} ;
- step 51, the comparison of the vibration measurement V_c with the safety limit value V_{lim} ;

[0023] The water flow 13 in this embodiment is supplied, step 50, to the selected chamber 4a-4c, or interrupted, step 52, according to the result of the comparison in step 49, and the result thus found conditions the activation and deactivation of the selected solenoid valves 10, since inasmuch the acceleration N_8 is uninterrupted, when the measurement V_c is less than the value V_{um} , the valve is deactivated, step 52, 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 V_c oscillates with the course of time around the threshold value V_{um} , while the acceleration N_8 is continuous.

[0024] Finally, step 53, the elapsed time t is compared with the recorded maximum spinning time t_{max} , and the drum 3 rotates at the maximum spinning speed N_{max} until the maximum spinning time t_{max} has expired.

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 (V_c) magnitude sensor (8), a position sensor (9) to measure 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 compensation 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 (47) between an initial and a

final spinning rotation speed (N_{ini} , N_{max}), and the controller (6) repeats a sequence of operations (45-50) including measurement (45) of the vibration (V_c) and the unbalance position (ϕ), comparison (49) of the resulting measurement of the vibration (V_c) with a preset value (V_{um}), and comparison (48) of the actual drum speed (N) with the maximum spinning speed (N_{max}), **characterized by** the steps

- an initial prior step (41) to identify one of the compensation 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);
- an actual acceleration rate (N_a) is chosen among a plurality of different rates (N_5 - N_9) depending upon the resulting measurement of the vibration (V_c) at said initial spinning speed (N_{ini});
- while said sequence (45-50) of operation is executed repeatedly to compensate for the unbalance, the drum (3) is accelerated continuously at said rate (N_5 - N_9), and simultaneously a flow (13) of water is supplied to the selected compensation chamber (4a,4b,4c);
- the continuous comparison (49) of the measured vibration value (V_c) with a preset vibration value (V_{um}), the latter changing with the actual drum speed (N).

2. The method for balancing a washing machine of claim 1, wherein said actual acceleration rate (N_a) is chosen among different constant rates (N_5 - N_9) and the water flow (13) is supplied to the selected chamber (4) or interrupted depending upon the result of said comparison (49) of the measured vibration value (V_c) with said preset vibration value (V_{um}).

3. The method for balancing a washing machine of claim 1, wherein the result of vibration measurement (45) is the measurement (V_c) of the peak to peak amplitude ($+V_c$, $-V_c$) of the alternating signal (12), produced by the vibration sensor (8) which is fixed to the casing (2a) of the drum bearing-holding, and that of the unbalance position is the measurement of the phase (ϕ) between one of said peaks ($+V_c$) and an electrical signal (11) from the position sensor (9).

Patentansprüche

1. Verfahren zum Auswuchten einer Waschmaschine, deren Trommel (3) sich um eine horizontale Achse (3a) dreht, wobei die Waschmaschine ausgestattet

ist mit mindestens drei am Innenumfang verteilten Wasserkammern (4a, 4b, 4c) für den Ausgleich der Unwichtigkeit der Trommel, einem Motor (5) mit Mitteln (7) für die gesteuerte Beschleunigung der Trommel (3), einem Sensor (8) für die Grösse der Schwingung (Vc), einem Stellungssensor (9) zur Messung der Stellung der Unwichtigkeit am Umfang der Trommel (3), einer Steuerelektronik (6) der Waschmaschine zur Kombination der von den beiden Sensoren (8, 9) abgegebenen elektrischen Signale (11, 12), um zumindest eine der Ausgleichskammern (4a, 4b, 4c) zu wählen und dieser über ein Elektroventil (10a, 10b, 10c) eine entsprechende Wassermenge (13) zum Ausgleich der Unwichtigkeit zuzuführen, während die Trommel zwischen einer anfänglichen und einer abschliessenden Drehgeschwindigkeit (Nanf \leftrightarrow Nmax) beschleunigt wird und die Steuerelektronik (6) eine Sequenz von Arbeitsgängen (45 - 50) wiederholt, zu denen die Messung (45) der Schwingung (Vc) und der Unwichtigkeitsstellung (ϕ), der Vergleich (49) des sich ergebenden Schwingungsmasses (Vc) mit einem zuvor registrierten Wert (Vum) und der Vergleich (48) der tatsächlichen Geschwindigkeit (Na) der Trommel mit der höchsten Schleudergeschwindigkeit (Nmax) gehören, **dadurch gekennzeichnet dass** das die folgende Schritte umfasst:

- einem ersten Schritt zur vorherigen Identifikation (41) einer der Ausgleichskammern (4a, 4b, 4c) mit einer Referenzstellung (9a) des Stellungssensors (9) und zur Verbindung einer der Ausgleichskammern (4a, 4b, 4c) mit ihrem jeweiligen Elektroventil (10a, 10b, 10c);
- ein tatsächliche Beschleunigungsrhythmus (Na) wird unter einer Vielzahl von Rhythmen (N5 - N9) gewählt und ist von dem sich ergebenden Schwingungsmass (Vc) bei der genannten Schleudergeschwindigkeit (Nini) abhängig;
- während der wiederholten Durchführung dieser Sequenz (45 - 50) von Arbeitsgängen zum Ausgleich der Unwichtigkeit wird die Trommel (3) kontinuierlich in diesem Rhythmus (N5 - N9) beschleunigt, und die Wassermenge (13) gleichzeitig der ausgewählten Ausgleichskammer (4a, 4b, 4c) zugeführt;
- der fortwährend Vergleich (27, 49) des gemessenen Schwingungswertes (Vc) mit dem zuvor registrierten Schwingungswert (Vum), wobei sich dieser in Abhängigkeit von der tatsächlichen Geschwindigkeit (N) der Trommel ändert.

2. Verfahren zum Auswuchten einer Waschmaschine nach Anspruch 1 **dadurch gekennzeichnet, dass** der tatsächlichen Beschleunigungsrhythmus (Na) der Trommel unter den verschiedenen konstanten Rhythmen (N5 - N9) ausgewählt und der Wasser-

strom (13) der ausgewählten Kammer (4) zugeführt bzw. unterbrochen wird, jeweils in Abhängigkeit vom Ergebnis des Vergleichs (49) des gemessenen Schwingungswertes (Vc) mit dem zuvor registrierten Schwingungswert (Vum).

3. Verfahren zum Auswuchten einer Waschmaschine nach Anspruch 1, **dadurch gekennzeichnet, dass** das Ergebnis der Schwingungsmessung (45) dem Mass (Vc) der Weite von Spitze zu Spitze (+Vc, -Vc) des wechselnden Signals (12) des Schwingungssensors (8) ist, welcher an dem die Kugellager der Trommel aufnehmenden Gehäuse (2a) montiert wird, während die ausgewuchtete Stellung dem Phasenmass (ϕ) zwischen einer der Spitzen (+Vc) und eine elektrischen Signal (11) des Stellungssensors (9) entspricht.

20 Revendications

1. Procédé d'équilibrage d'une machine à laver dont le tambour (3) tourne autour d'un axe (3a) horizontal, la machine à laver équipée d'au moins trois chambres (4a, 4b, 4c) d'eau réparties sur sa périphérie interne pour la compensation du déséquilibre du tambour, un moteur (5) équipé de moyens (7) pour l'accélération contrôlée du tambour (3), un capteur (8) de la grandeur de vibration (Vc), un capteur (9) de position pour mesurer la position du déséquilibre à la périphérie du tambour (3), un contrôleur (6) électronique de la machine à laver qui combine les signaux électriques (11, 12) émis par les deux capteurs (8,9) pour sélectionner au moins l'une des chambres (4a, 4b, 4c) de compensation, et lui fournir au moyen de l'électrovanne respective (10a, 10b, 10c) une quantité d'eau (13) pour la compensation du déséquilibre, tandis que le tambour est accéléré (47) entre deux vitesses de rotation (Nini, Nmax) initiale et finale d'essorage, le contrôleur (6) répétant une séquence d'opérations (45-50) qui comprend la mesure (45) de la vibration (Vc) et de la position du déséquilibre (ϕ), la comparaison (49) de la mesure résultant de la vibration (Vc) avec une valeur préenregistrée (Vum), et la comparaison (48) de la vitesse actuelle (Na) du tambour avec la vitesse maximale (Vmax) d'essorage, **caractérisé par** les étapes,
 - une étape initiale d'identification préalable (41) de l'une quelconque des chambres (4a, 4b, 4c) de compensation avec une position de référence (9a) du capteur (9) de position et l'association de chacune des chambres (4a, 4b, 4c) avec son électrovanne (10a, 10b, 10c) respective ;
 - un rythme d'accélération (Na) réel est choisi parmi plusieurs rythmes (N5-N9) en fonction de

la mesure résultant de la vibration (V_c) à cette vitesse initiale (N_{ini}) d'essorage ;

- pendant que cette séquence (45-50) d'opérations est exécutée d'une façon répétée pour la compensation du déséquilibre, le tambour (3) est accéléré d'une façon continue à ledit rythme (N5-N9) et simultanément un débit (13) d'eau est fourni à la chambre (4a, 4b, 4c) de compensation sélectionnée ;
- la comparaison (27, 49) continue de la valeur mesurée (V_c) de la vibration avec une valeur préenregistrée (V_{um}) de la vibration, celle-ci variant avec la vitesse réelle (N) du tambour.

2. Procédé d'équilibrage selon la revendication 1 dans lequel ce rythme (N_a) réel d'accélération du tambour est choisi parmi différents rythmes constants (N5-N9) et le débit d'eau (13) est fourni à la chambre (4) sélectionnée ou interrompu, en fonction du résultat de cette comparaison (49) de la valeur mesurée (V_c) de la vibration avec cette valeur de vibration (V_{um}) préenregistrée.

3. Procédé d'équilibrage selon la revendication 1 dans lequel le résultat de la mesure (45) de la vibration est la mesure (V_c) de la grandeur crête à crête ($+V_c, -V_c$) du signal alterné (12), produit par le capteur de vibration (8) qui est fixé à la carcasse (2a) portant les roulements du tambour, et celui de la position d'équilibre est la mesure de la phase (ϕ) entre l'une de ces crêtes ($+V_c$) et un signal électrique (11) depuis le capteur (9) de position.

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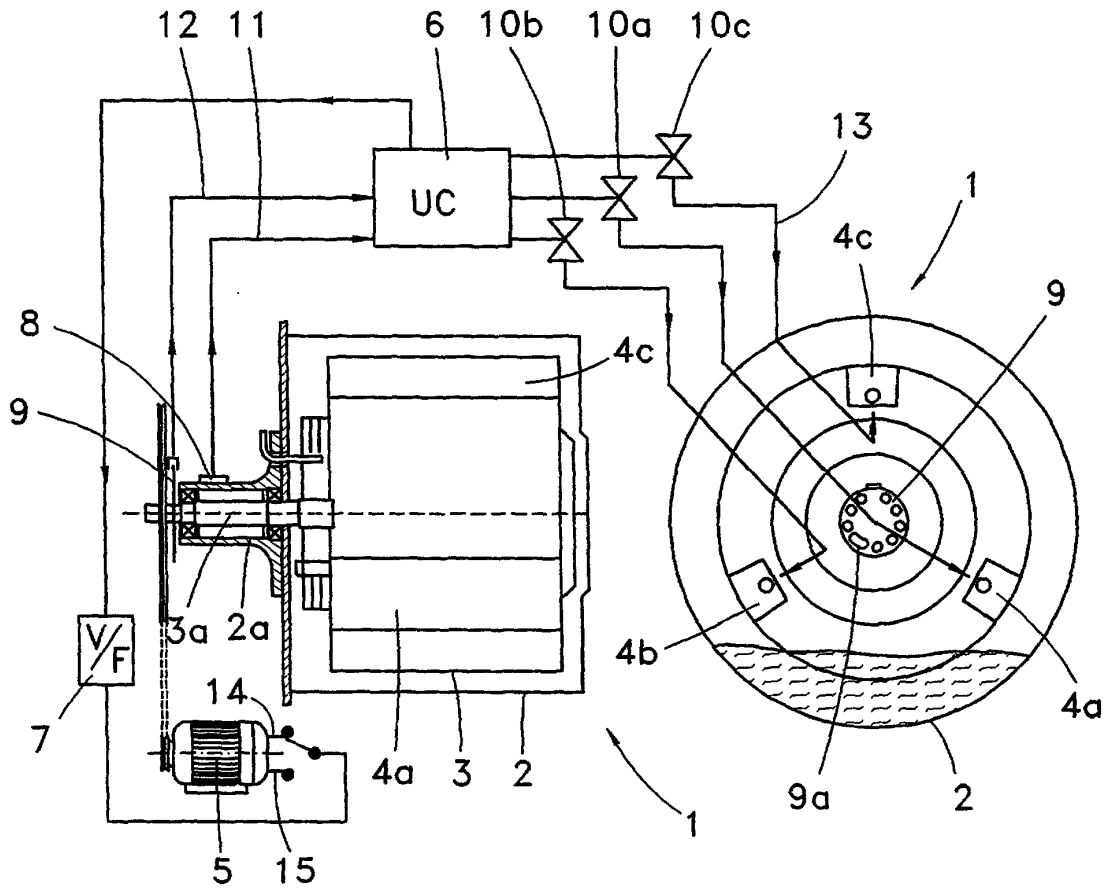


FIG. 1

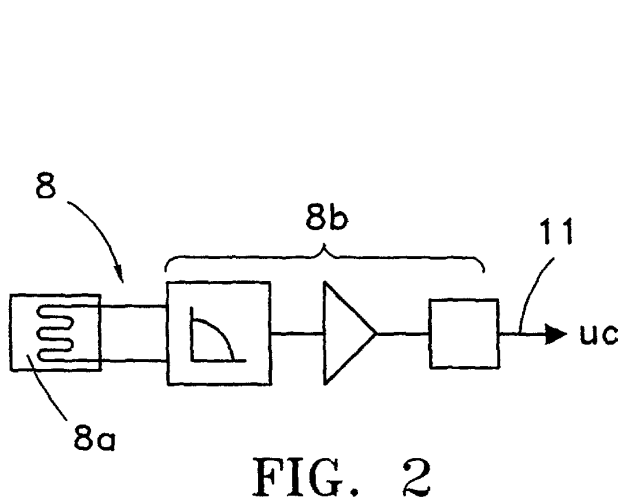


FIG. 2

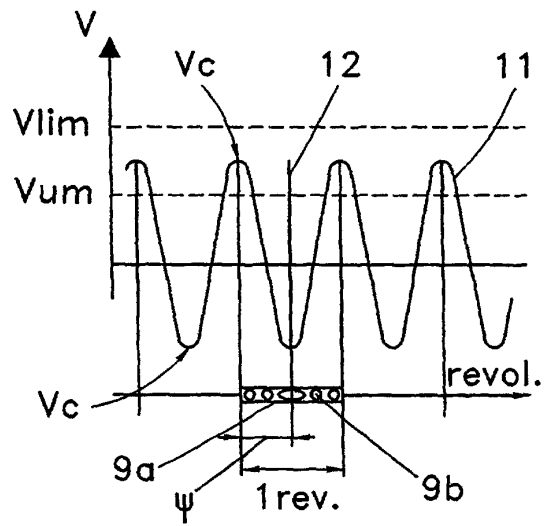


FIG. 3

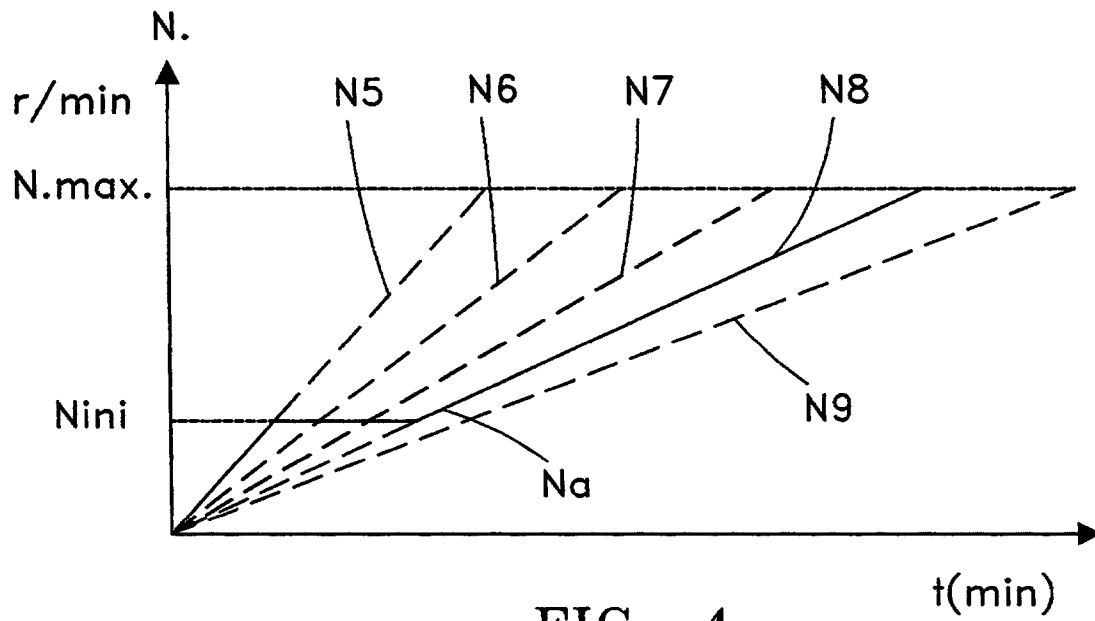


FIG. 4

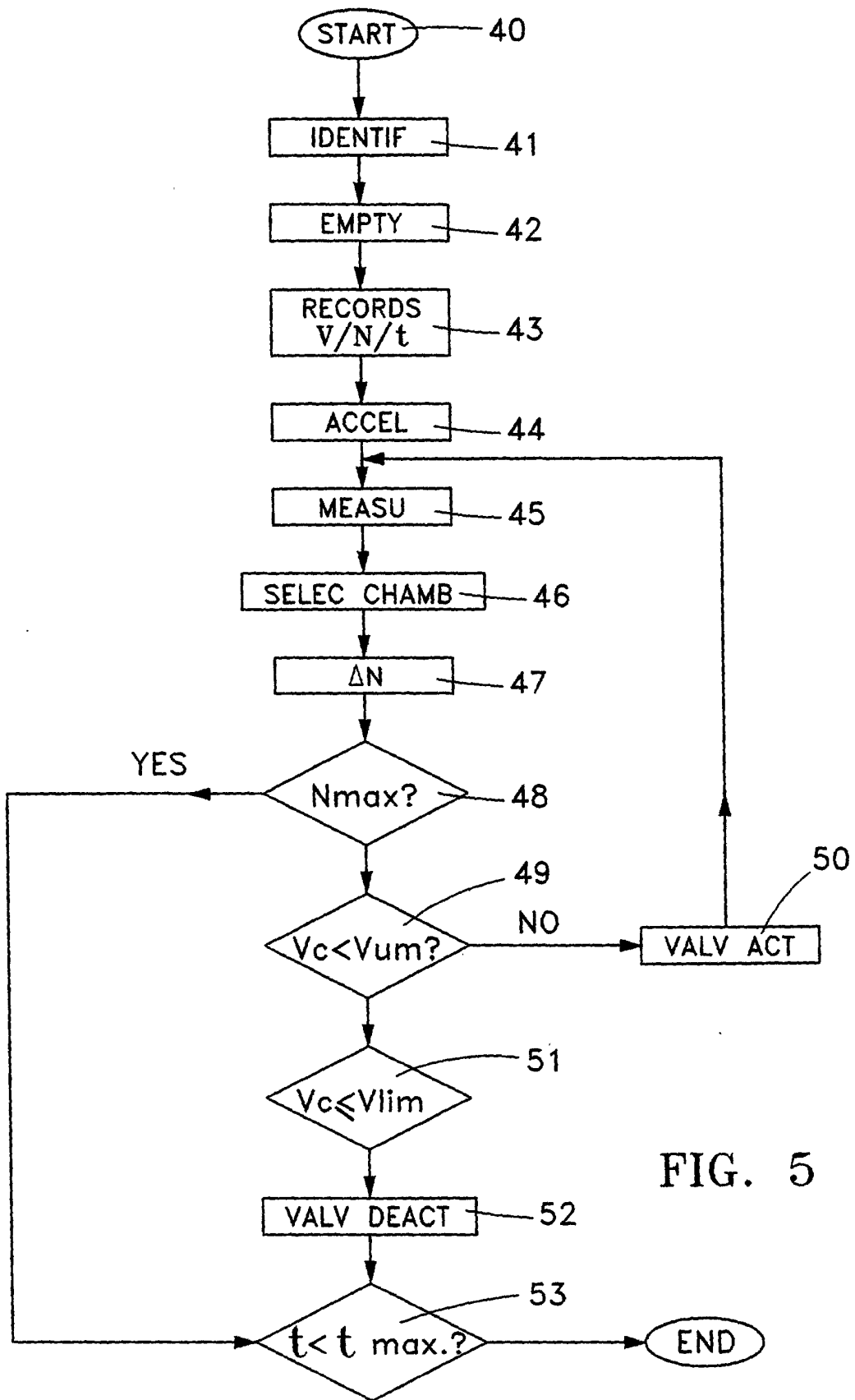


FIG. 5