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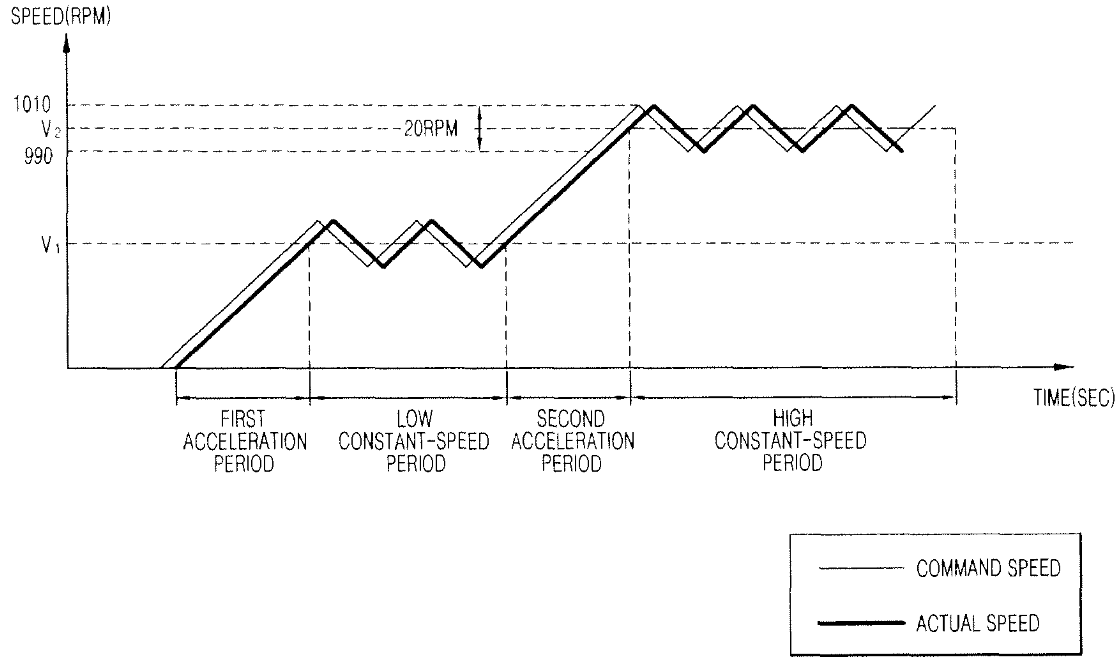
(54) Washing machine and control method thereof

(57) A washing machine (10) and a control method thereof to alleviate high-frequency noise generated during rotation of a motor (29). The washing machine includes a speed sensing unit to sense a speed of the motor, and a control unit to output a speed control signal to adjust the speed of the motor. The control unit confirms whether to enter a constant-speed period upon progress of a dehydration operation, and repeatedly raises or lowers the speed of the universal motor within a predetermined magnitude range if it is confirmed to enter the constant-speed period, thereby alleviating high-frequency noise.

FIG. 4A



EP 2 295 623 A1

Description

BACKGROUND

1. Field

[0001] Embodiments relate to a washing machine and a control method thereof to alleviate high-frequency noise generated during rotation of a motor.

2. Description of the Related Art

[0002] Generally, washing machines may be classified into a drum washing machine, a pulsator washing machine, and an agitator washing machine. The drum washing machine washes clothes using collision force between wash water and the clothes as the clothes drop by rotation of a drum. The pulsator washing machine washes clothes by friction between the clothes and wash water as a pulsator is rotated at a bottom surface of a drum. The agitator washing machine washes clothes by friction between the clothes and wash water as an agitator mounted in a washtub forcibly generates water streams.

[0003] The above-described various kinds of washing machines performs a washing operation in such a manner that the drum, the pulsator, or the agitator is rotated forward or reverse at a low speed to rotate the wash water or to agitate the clothes. Also, a dehydration operation is performed in such a manner that the drum, in which all of the clothes are received, is rotated at a high speed to apply centrifugal force to the clothes, causing water remaining on the clothes to be removed by the centrifugal force.

[0004] Meanwhile, a motor of these washing machines is generally rotated by a Pulse Width Modulation (PWM) control method. In the PWM control method, a specific form of PWM signal is output by inputting a sinusoidal reference signal and a triangular wave carrier signal into a comparator and comparing them with each other. The PWM signal controls switching of an inductor. A motor drive signal output from the inductor is input to each coil of the motor, inducing rotational force of the motor. The PWM control method serves to change a rotational speed of the motor by, e.g., changing frequencies of triangular and sinusoidal waves.

SUMMARY

[0005] Therefore, it is an aspect to provide a washing machine and a control method thereof to alleviate high-frequency noise generated during a constant-speed period of a dehydration operation.

[0006] Additional aspects of the invention will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the invention.

[0007] In accordance with one aspect, a control method of a washing machine includes confirming whether to enter a constant-speed period upon progress of a dehydration operation, and repeatedly raising or lowering a speed of a universal motor within a predetermined magnitude range if it is confirmed to enter the constant-speed period, so as to alleviate high-frequency noise.

[0008] The repeated raising or lowering of the speed of the universal motor within the predetermined magnitude range may include adjusting a command speed of the universal motor to repeatedly raise or lower the speed of the universal motor within the predetermined magnitude range.

[0009] The adjustment of the command speed of the universal motor may include repeatedly raising or lowering the command speed of the universal motor within a predetermined magnitude range.

[0010] The repeated raising or lowering of the speed of the universal motor within the predetermined magnitude range may include adjusting a voltage applied to the universal motor to repeatedly raise or lower the speed of the universal motor within the predetermined magnitude range.

[0011] The adjustment of the voltage applied to the universal motor may include repeatedly raising or lowering the voltage applied to the universal motor within a predetermined magnitude range.

[0012] The repeated raising or lowering of the voltage applied to the universal motor within the predetermined magnitude range may include adjusting a duty ratio of the voltage to repeatedly raise or lower the voltage applied to the universal motor within the predetermined magnitude range.

[0013] The repeated raising or lowering of the voltage applied to the universal motor within the predetermined magnitude range may include adjusting a phase of the voltage to repeatedly raise or lower the voltage applied to the universal motor within the predetermined magnitude range.

[0014] The repeated raising or lowering of the speed of the universal motor within the predetermined magnitude range may include periodically repeatedly raising or lowering the speed of the universal motor within the predetermined magnitude range.

[0015] The repeated raising or lowering of the speed of the universal motor within the predetermined magnitude range may include aperiodically repeatedly raising or lowering the speed of the universal motor within the predetermined magnitude range.

[0016] In accordance with another aspect, a washing machine includes a universal motor, and a control unit to repeatedly raise or lower a speed of the universal motor within a predetermined magnitude range if it is confirmed to enter a constant-speed period upon progress of a dehydration operation, so as to alleviate high-frequency noise.

[0017] The control unit may repeatedly raise or lower the speed of the universal motor within the predetermined magnitude range by adjusting a command speed of the universal motor.

[0018] The control unit may repeatedly raise or lower the speed of the universal motor within the predetermined magnitude range by adjusting a voltage applied to the universal motor.

[0019] The control unit may repeatedly raise or lower the speed of the universal motor within the predetermined magnitude range by repeatedly raising or lowering the voltage applied to the universal motor within a predetermined magnitude range.

[0020] The control unit may repeatedly raise or lower the voltage applied to the universal motor within the predetermined magnitude range by adjusting a duty ratio of the voltage.

[0021] The control unit may repeatedly raise or lower the voltage applied to the universal motor within the predetermined magnitude range by adjusting a phase of the voltage.

[0022] The control unit may periodically repeatedly raise or lower the speed of the universal motor within the predetermined magnitude range.

[0023] The control unit may aperiodically repeatedly raise or lower the speed of the universal motor within the predetermined magnitude range.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] These and/or other aspects will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

FIG. 1 is a view schematically illustrating an overall configuration of a washing machine according to an exemplary embodiment;

FIG. 2A is a schematic view illustrating a universal motor according to the embodiment;

FIG. 2B is a perspective view illustrating a configuration of a rotor of the universal motor according to the embodiment;

FIG. 2C is a front view of the rotor of the universal motor according to the embodiment;

FIG. 3 is a schematic circuit diagram illustrating a drive unit in the washing machine according to the embodiment;

FIGS. 4A and 4B are speed control graphs of a motor in the washing machine according to the embodiment;

FIGS. 5A and 5B are speed control graphs of the motor in the washing machine according to the embodiment;

FIGS. 6A and 6B are graphs illustrating a noise waveform depending on an operation frequency of the washing machine according to the embodiment;

FIG. 7 is a control flow chart of the washing machine according to the embodiment; and

FIG. 8 is a control flow chart of the washing machine according to the embodiment.

DETAILED DESCRIPTION

[0025] Reference will now be made in detail to the embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout.

[0026] FIG. 1 is a view schematically illustrating an overall configuration of a washing machine according to an exemplary embodiment.

[0027] As shown in FIG. 1, the washing machine 10 includes a housing 20 defining an outer appearance of the washing machine 10, a control panel 30 provided at an upper end of a front surface of the housing 20, a drum 40 mounted in the housing 20, a tub 50 surrounding the drum 40, and a universal motor 29 to rotate the drum 40 so as to perform a washing operation, a rinsing operation, and a dehydration operation.

[0028] The housing 20 defines the outer appearance of the washing machine 10. The housing 20 receives a variety of devices required to operate the washing machine 10. The front surface of the housing 20 has an opening 22, to which a door 25 is hinged to open or close the opening 22. The door 25 is centrally provided with an observation window 27, to allow a user to observe the progress of washing from the outside without opening the door 25.

[0029] The control panel 30 includes a variety of operating buttons (not shown) required by the user to operate the washing machine 10 and a display window (not shown) to show the progress of washing. The control panel 30 is coupled to the upper end of the front surface of the housing 20 via hook fastening or screwing. A controller (not shown) is installed at a rear end of the control panel 30 and generates control signals required, e.g., to determine the supply amount of water, to adjust the amounts of wash water and rinse water, to control the progress of washing and rinsing, and to change a rotational speed of the universal motor 29.

[0030] The drum 40 mounted in the housing 20 has a cylindrical shape and receives laundry therein to provide a space in which washing of the laundry is actually performed. In consideration of the fact that the drum 40 comes into direct contact with wash water, the drum 40 is made of, e.g., rustproof stainless steel. The drum 40 is rotated clockwise or counterclockwise upon receiving rotational force from the universal motor 29, causing washing of the laundry.

[0031] The tub 50 is configured to surround the drum 40 and provides a space to receive wash water therein. An inlet channel 52 is connected at one end thereof to an upper end of the tub 50 to introduce the wash water into the tub 50. The other end of the inlet channel 52 is connected to a water source at the outside of the housing 20. A detergent box 53 is located on a portion of the inlet channel 52. Detergent received in the detergent box 53 is dissolved in the wash water as the wash water passes through the detergent box 53. The resulting detergent dissolved wash water is introduced into the tub 50 through the inlet channel 52. An outlet channel 54 to discharge the wash water is connected to a lower end of the tub 50 out of the tub 50. Specifically, the outlet channel 54 serves to discharge contaminated wash water generated during washing out of the washing machine 10 based on a control signal of the controller. If the drum 40 undergoes eccentricity due to the laundry or the wash water, the tub 50 linked to the drum 40 is vibrated. To alleviate vibration of the tub 50, the tub 50 is connected to the housing 20 by use of a supporting device (not shown). A door packing 58 is fitted between the tub 50 and the opening 22 of the housing 20. The door packing 58 is made of a flexible material and thus, acts to prevent vibration of the tub 50 from being directly transmitted to the housing 20. The universal motor 29 rotates the drum 40, to perform a washing operation, a rinsing operation, and a dehydration operation. Specifically, if commercial alternating current (AC) power output from a power source unit 60 whose duty ratio or phase is controlled is transmitted to the universal motor 29, rotational force of the universal motor 29 is changed, causing the drum 40, in which the laundry is received, to be rotated at a predetermined speed.

[0032] FIG. 2A is a schematic view illustrating a universal motor according to the embodiment. FIG. 2B is a perspective view illustrating a configuration of a rotor of the universal motor according to the embodiment, and FIG. 2C is a front view of the rotor of the universal motor according to the embodiment.

[0033] As shown in FIGS. 2A to 2C, the universal motor 29 includes a stator 2 kept stationary inside a motor housing (not shown), and a rotor 200 rotatably installed inside the stator 2 while maintaining a predetermined air gap with an inner peripheral surface of the stator 2. The universal motor 29 further includes a rectifier 5, and brushes 7 installed at opposite sides of the rectifier 5 to come into elastic contact with an outer surface of the rectifier 5 so as to supply power to the rectifier 5. The rotor 200 includes an armature core 110 and slot edge pieces 130. The armature core 110 includes a base 111, through the center of which a rotating shaft 4 is press-fitted, and a plurality of teeth 113 formed at an outer circumference of the base 111 for coil winding. The slot edge pieces 130 are installed between the respective neighboring teeth 113 to insulate the respective teeth 113 from one another.

[0034] In the above-described universal motor 29, if AC power is applied to a coil of the stator 2, electricity moving through the coil of the stator 2 is supplied to the rectifier 5 through one of the brushes 7. The electricity supplied to the rectifier 5 is rectified into direct current (DC) and is supplied to a coil of the rotor 200. The electricity moving through the coil of the rotor 200 is supplied to the coil of the stator 2 through an opposite one of the brushes 7, escaping out of the motor 29. A magnetic field created in the motor 29 upon the above-described movement of the power causes rotation of the rotor 200.

[0035] With the above-described configuration of the universal motor 29, the brushes 7 and the rectifier 5 may cause high-frequency noise due to mechanical friction when the universal motor 29 is rotated at a high speed. In addition, as shown in FIG. 2C, air is introduced into and collides with stepped regions 9 between the respective teeth 113 and the slot edge pieces 130 during rotation of the rotor 200 of the universal motor 29. This may further increase the strength of high-frequency noise, causing a user discomfort.

[0036] FIG. 3 is a schematic circuit diagram illustrating a drive unit in the washing machine according to the embodiment.

[0037] As shown in FIG. 3, the drive unit of the washing machine 10 includes an operation manipulating unit 80 to allow the user to manipulate operation of the washing machine 10, a speed sensing unit 90 to sense a speed of the motor 29, a control unit 100 to control general operations of the washing machine 10, a triac 72 having an On/Off operation by a speed control signal of the control unit 100, first and second relays 74 and 76 to be switched so as to rotate the motor 29 forward or reverse, the power source unit 60 to supply power, a rectifying unit 78 to rectify and output commercial AC power, and the motor 29 to rotate the drum 40.

[0038] The operation manipulating unit 80 outputs an electric signal corresponding to a user input command when the user selects a washing course (e.g., a washing operation and a rinsing operation).

[0039] The speed sensing unit 90 senses the speed of the universal motor 29 to output and transmit a corresponding sensed signal to the control unit 100. For example, the speed sensing unit 90 may be a hall sensor.

[0040] The control unit 100 outputs a speed control signal to adjust the speed of the universal motor 29 (or a speed of the drum 40) and a switching control signal to rotate the universal motor 29 forward or reverse. Specifically, the control unit 100 receives key signals transmitted from the operation manipulating unit 80 and outputs the speed control signal for adjustment of the speed of the universal motor 29 to the triac 72 and the switching control signal for forward or reverse rotation of the universal motor 29 to the first and second relays 74 and 76.

[0041] The control unit 100 repeatedly raises or lowers the speed of the universal motor 29 within a predetermined magnitude range by changing a command speed of the universal motor 29 during a high or low constant-speed period of a dehydration operation, to alleviate high-frequency noise.

[0042] In addition, the control unit 100 repeatedly raises or lowers the speed of the universal motor 29 within the predetermined magnitude range by changing a voltage applied to the universal motor 29 during the high or low constant-speed period of the dehydration operation, to alleviate high-frequency noise.

[0043] The control unit 100 repeatedly raises or lowers the voltage applied to the universal motor 29 within a predetermined magnitude range by adjusting a duty ratio of commercial AC power applied from the power source unit 60.

[0044] The control unit 100 controls a phase of commercial AC power applied from the power source unit 60 to a Pulse Width Modulation (PWM) signal as the speed control signal, thereby repeatedly raising or lowering the voltage applied to the universal motor 29 within the predetermined magnitude range. The control unit 100 adjusts an input voltage applied to the universal motor 29 via the phase control, thereby changing the rotational force of the universal motor 29.

[0045] The triac 72 performs an On/Off operation by the speed control signal transmitted from the control unit 100. With the On/Off operation of the triac 72, the commercial AC power of the power source unit 60 is supplied to the rectifier 78 or is intercepted. The triac 72 controls the applied commercial AC power to a firing angle based on the PWM signal as the speed control signal, so as to change a magnitude of output voltage and consequently, to change the rotational speed of the universal motor 29. That is, the triac 72 controls phase or duty ratio of commercial AC power so as to supply the controlled power to the universal motor 29.

[0046] The first relay 74 and the second relay 76 are switched by the switching control signal of the control unit 100, causing forward or reverse rotation of the universal motor 29. For example, if the switching control signal switches the first relay 74 to an A terminal and the second relay 76 to a D terminal, the voltage is supplied to a rotor 29a and a stator 29b of the universal motor 29 via the A terminal of the first relay 74 and the D terminal of the second relay 76, causing forward rotation of the universal motor 29. With the forward rotation of the universal motor 29, the drum 40 is rotated forward, performing the dehydration operation. On the other hand, if the switching control signal switches the first relay 74 to a B terminal and the second relay 76 to a C terminal, the universal motor 29 is rotated in reverse.

[0047] The power source unit 60 supplies the commercial AC power required to drive the washing machine 10, and the rectifying unit 78 rectifies and outputs the commercial AC power supplied from the power source unit 60.

[0048] The universal motor 29 is driven upon receiving a predetermined voltage output from the rectifying unit 78 and includes the rotor 29a and the stator 29b.

[0049] FIGS. 4A and 4B are speed control graphs of the motor in the washing machine according to the embodiment.

[0050] In FIG. 4A, considering change in the RPM of the universal motor during the dehydration operation of the washing machine, the dehydration operation is divided into a first acceleration period in which the speed is accelerated at a fixed rate to a first speed V1, a low constant-speed period in which the first speed V1 is kept for a predetermined time, a second acceleration period in which the speed is accelerated at a fixed rate to a second speed V2, and a high constant-speed period in which the second speed V2 is kept for a predetermined time. The universal motor 29 generates high-frequency noise due to mechanical friction between the brushes and the rectifier during rotation thereof. The mechanical frictional noise of the universal motor 29 is mainly generated during the high or low constant-speed period. Accordingly, controlling the speed of the universal motor 29 to be changed within a high or low speed range during the high or low constant-speed period may alleviate the high-frequency noise.

[0051] To alleviate the high-frequency noise, the control unit 100 repeatedly raises or lowers the command speed of the universal motor 29 within a predetermined magnitude range (for example, 20 rpm). When the command speed of the universal motor 29 is repeatedly raised or lowered within the predetermined magnitude range, an actual speed of the universal motor 29 is repeatedly raised or lowered within a predetermined magnitude range. It may be seen from FIG. 4A that the actual speed of the universal motor 29 is repeatedly raised or lowered within the predetermined magnitude range with a slight time difference when the command speed of the universal motor 29 is periodically repeatedly raised or lowered within the predetermined magnitude range (for example, 20 rpm) during the high or low constant-speed period.

[0052] FIG. 4B illustrates that the actual speed of the universal motor 29 is aperiodically repeatedly raised or lowered within the predetermined magnitude range when the command speed of the universal motor 29 is aperiodically repeatedly raised or lowered within the predetermined magnitude range (for example, 20 rpm).

[0053] FIGS. 5A and 5B are speed control graphs of the motor in the washing machine according to the embodiment.

[0054] FIG. 5A is a graph illustrating that the actual speed of the universal motor 29 is repeatedly raised or lowered with a certain period within the predetermined magnitude range according to the magnitude of voltage applied to the universal motor 29. The control unit 100 keeps the command speed of the universal motor 29 at a predetermined speed (for example, 1000 rpm) and periodically repeatedly raises or lowers the voltage applied to the universal motor 29 within a predetermined magnitude range (for example, 2V). When the voltage applied to the universal motor 29 is periodically repeatedly raised or lowered within the predetermined magnitude range, the actual speed of the universal motor 29 is periodically repeatedly raised or lowered within the predetermined magnitude range (for example, 20 rpm). The control unit 100 may adjust the voltage applied to the universal motor 29 by controlling the phase of commercial AC power to the PWM signal as the speed control signal. The control unit 100 may also adjust the voltage applied to the universal motor 29 by controlling the duty ratio of commercial AC power.

[0055] FIG. 5B is a graph illustrating that the actual speed of the universal motor 29 is aperiodically repeatedly raised or lowered within the predetermined magnitude range according to the magnitude of voltage applied to the universal motor 29. The control unit 100 keeps the command speed of the universal motor 29 at the predetermined speed (for example, 1000 rpm) and aperiodically repeatedly raises or lowers the voltage applied to the universal motor 29 within the predetermined magnitude range (for example, 2V). When the voltage applied to the universal motor 29 is aperiodically repeatedly raised or lowered within the predetermined magnitude range, the actual speed of the universal motor 29 is aperiodically repeatedly raised or lowered within the predetermined magnitude range (for example, 20 rpm).

[0056] FIGS. 6A and 6B are graphs illustrating a noise waveform depending on an operation frequency of the washing machine according to the embodiment.

[0057] FIG. 6A illustrates a noise waveform depending on an operation frequency band of 2 kHz to 4 kHz when the universal motor 29 is rotated at 970 rpm. It may be appreciated that this causes a pointed noise waveform and the maximum noise strength is 56 dB.

[0058] FIG. 6B illustrates a noise waveform depending on an operation frequency band of 2 kHz to 4 kHz when the universal motor 29 is rotated at 970 rpm under the assumption that a noise removal algorithm according to the embodiment (for example, phase control, duty ratio control, and command speed control) is used. It may be appreciated as compared to FIG. 6A that the noise waveform becomes relatively gentle and the maximum noise strength is lowered to 50 dB.

[0059] FIG. 7 is a control flow chart of the washing machine according to the embodiment.

[0060] As shown in FIG. 7, once a dehydration operation is initiated, the control unit 100 confirms whether the universal motor 29 enters the high or low constant-speed period in which the universal motor 29 is rotated at a high or low speed for a predetermined time. The dehydration operation is divided into the first acceleration period in which the speed is accelerated at a fixed rate to the first speed V1, the low constant-speed period in which the first speed V1 is kept for a predetermined time, the second acceleration period in which the speed is accelerated at a fixed rate to the second speed V2, and the high constant-speed period in which the second speed V2 (V2 > V1) is kept for a predetermined time (S10 and S20).

[0061] Next, if it is confirmed to enter the high or low constant-speed period, the control unit 100 repeatedly raises or lowers the speed of the universal motor 29 within the predetermined magnitude range by adjusting the command speed of the universal motor 29. To alleviate the high-frequency noise, the control unit 100 repeatedly raises or lowers the command speed of the universal motor 29 within the predetermined magnitude range (for example, 20 rpm). When the command speed of the universal motor 29 is repeatedly raised or lowered within the predetermined magnitude range (for example, 20 rpm), the actual speed of the universal motor 29 is repeatedly raised or lowered within the predetermined magnitude range (S30).

[0062] Next, the control unit 100 confirms whether the dehydration operation is terminated, e.g., by the lapse of a dehydration operation time. If the termination of the dehydration operation is confirmed, the control unit 100 changes the command speed of the universal motor 29 to a command speed depending on a following operation (S40 and S50).

[0063] FIG. 8 is a control flow chart of the washing machine according to the embodiment.

[0064] As shown in FIG. 8, once the dehydration operation is initiated, the control unit 100 confirms whether the universal motor 29 enters the high or low constant-speed period in which the universal motor 29 is rotated at a high or low speed for a predetermined time (S100 and S110).

[0065] Next, if it is confirmed to enter the high or low constant-speed period, the control unit 100 repeatedly raises or lowers the speed of the universal motor 29 within the predetermined magnitude range by adjusting the voltage applied to the universal motor 29. To alleviate the high-frequency noise, the control unit 100 repeatedly raises or lowers the voltage applied to the universal motor 29 within the predetermined magnitude range (for example, 2V). When the voltage applied to the universal motor 29 is repeatedly raised or lowered within the predetermined magnitude range (for example, 2V), the actual speed of the universal motor 29 is repeatedly raised or lowered within the predetermined magnitude range (for example, 20 rpm). The control unit 100 adjusts the voltage applied to the universal motor 29 by controlling the phase of commercial AC power to the PWM signal as the speed control signal. The control unit 100 also adjusts the voltage applied to the universal motor 29 by controlling the duty ratio of commercial AC power (S120).

[0066] Next, the control unit 100 confirms whether the dehydration operation is terminated, e.g., by the lapse of the dehydration operation time. If the termination of the dehydration operation is confirmed, the control unit 100 changes the voltage applied to the universal motor 29 to a voltage depending on a following operation (S130 and S140).

[0067] As is apparent from the above description, according to the embodiment, a speed of a universal motor is repeatedly raised or lowered within a predetermined magnitude range if the motor enters a high or low constant-speed period of a dehydration operation, resulting in alleviated high-frequency noise.

[0068] Although a few embodiments have been shown and described, it would be appreciated by those skilled in the art that varies may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

Claims

1. A control method of a washing machine comprising:

confirming whether to enter a constant-speed period upon progress of a dehydration operation; and
repeatedly raising or lowering a speed of a universal motor within a predetermined magnitude range if it is confirmed to enter the constant-speed period, so as to alleviate high-frequency noise.

2. The control method according to claim 1, wherein the repeated raising or lowering of the speed of the universal motor within the predetermined magnitude range includes adjusting a command speed of the universal motor to repeatedly raise or lower the speed of the universal motor within the predetermined magnitude range.

3. The control method according to claim 2, wherein the adjustment of the command speed of the universal motor includes repeatedly raising or lowering the command speed of the universal motor within a predetermined magnitude range.

4. The control method according to claim 1, wherein the repeated raising or lowering of the speed of the universal motor within the predetermined magnitude range includes adjusting a voltage applied to the universal motor to repeatedly raise or lower the speed of the universal motor within the predetermined magnitude range.

5. The control method according to claim 4, wherein the adjustment of the voltage applied to the universal motor includes repeatedly raising or lowering the voltage applied to the universal motor within a predetermined magnitude range.

6. The control method according to claim 5, wherein the repeated raising or lowering of the voltage applied to the universal motor within the predetermined magnitude range includes adjusting a duty ratio of the voltage to repeatedly raise or lower the voltage applied to the universal motor within the predetermined magnitude range.

7. The control method according to claim 5, wherein the repeated raising or lowering of the voltage applied to the universal motor within the predetermined magnitude range includes adjusting a phase of the voltage to repeatedly raise or lower the voltage applied to the universal motor within the predetermined magnitude range.

8. The control method according to claim 1, wherein the repeated raising or lowering of the speed of the universal motor within the predetermined magnitude range includes periodically or aperiodically repeatedly raising or lowering the speed of the universal motor within the predetermined magnitude range.

9. A washing machine comprising:

a universal motor; and
a control unit to repeatedly raise or lower a speed of the universal motor within a predetermined magnitude range if it is confirmed to enter a constant-speed period upon progress of a dehydration operation, so as to alleviate high-frequency noise.

10. The washing machine according to claim 9, wherein the control unit repeatedly raises or lowers the speed of the universal motor within the predetermined magnitude range by adjusting a command speed of the universal motor.

11. The washing machine according to claim 9, wherein the control unit repeatedly raises or lowers the speed of the universal motor within the predetermined magnitude range by adjusting a voltage applied to the universal motor.

12. The washing machine according to claim 11, wherein the control unit repeatedly raises or lowers the speed of the universal motor within the predetermined magnitude range by repeatedly raising or lowering the voltage applied to the universal motor within a predetermined magnitude range.

13. The washing machine according to claim 11, wherein the control unit repeatedly raises or lowers the voltage applied to the universal motor within the predetermined magnitude range by adjusting a duty ratio of the voltage.

14. The washing machine according to claim 11, wherein the control unit repeatedly raises or lowers the voltage applied to the universal motor within the predetermined magnitude range by adjusting a phase of the voltage.

15. The washing machine according to claim 10, wherein the control unit periodically or aperiodically repeatedly raises or lowers the speed of the universal motor within the predetermined magnitude range.

FIG. 1

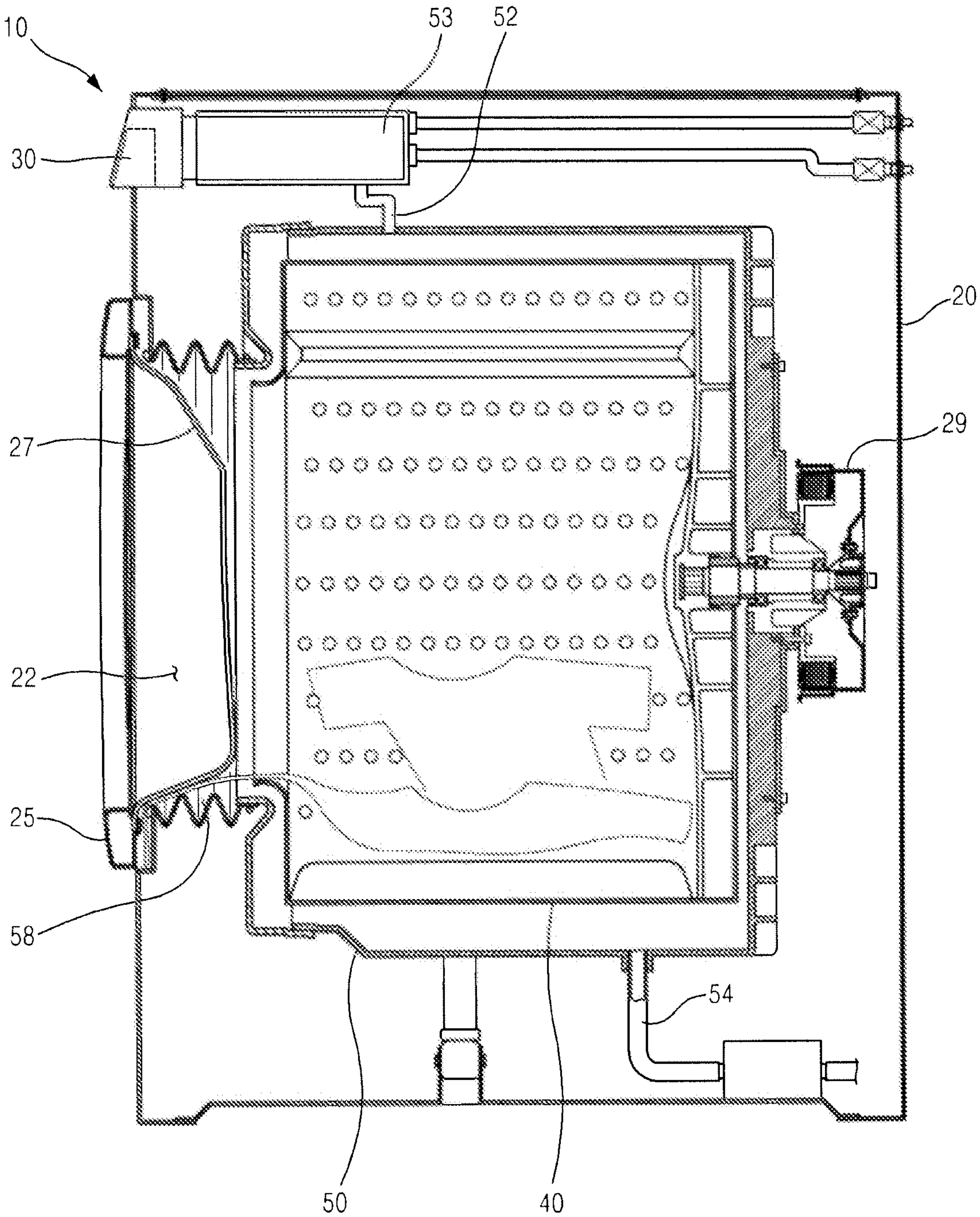


FIG. 2A

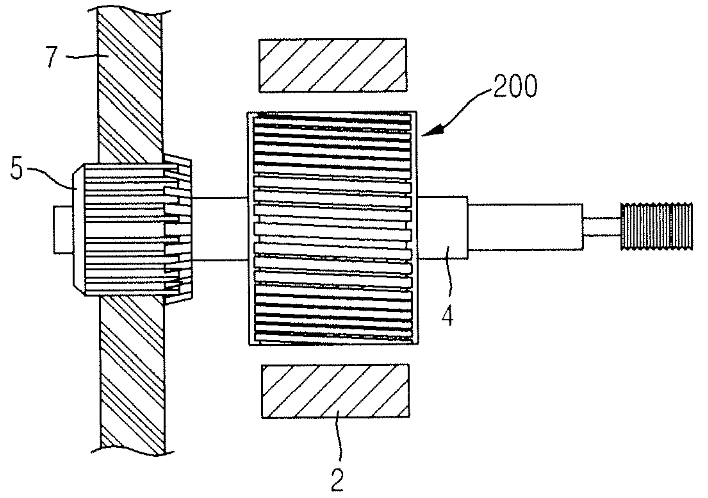


FIG. 2B

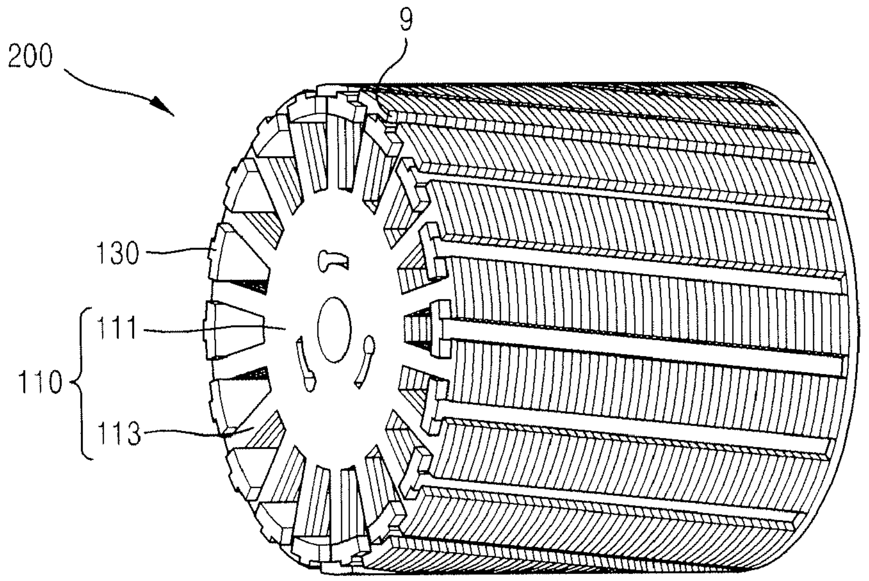


FIG. 2C

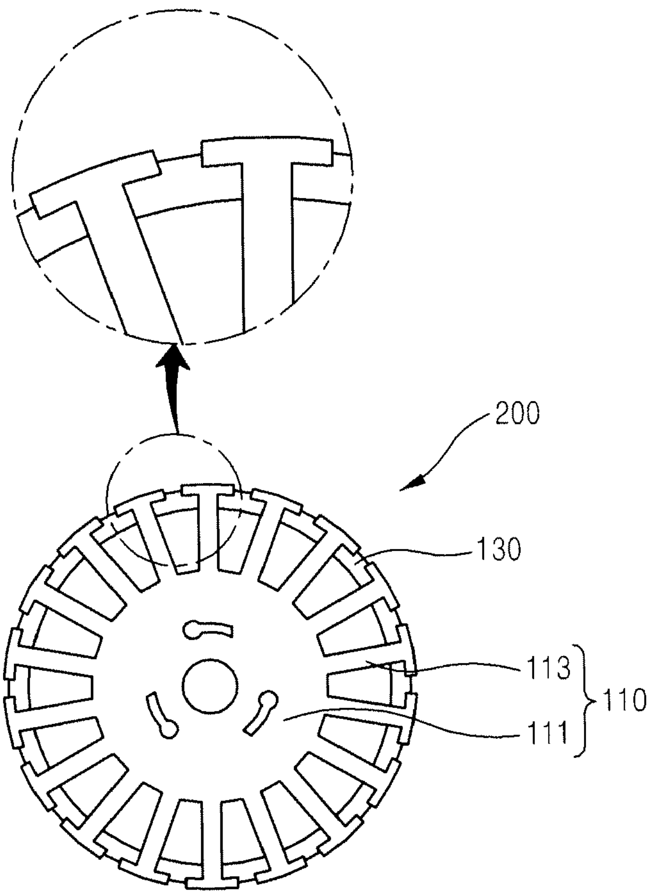


FIG. 3

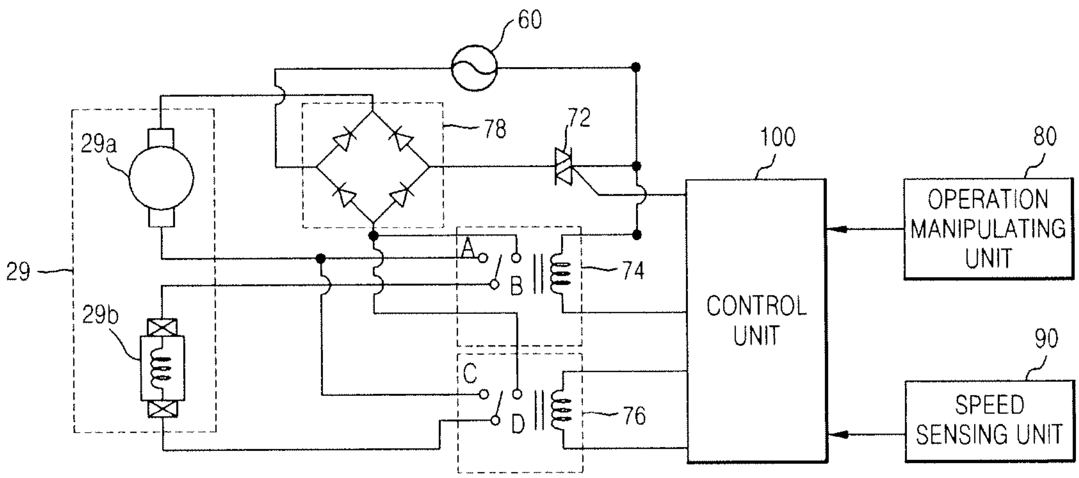

60
78
72
100
80
29a
29
29b
A
B
74
C
D
76
CONTROL UNIT
OPERATION MANIPULATING UNIT
90
SPEED SENSING UNIT

FIG. 4A

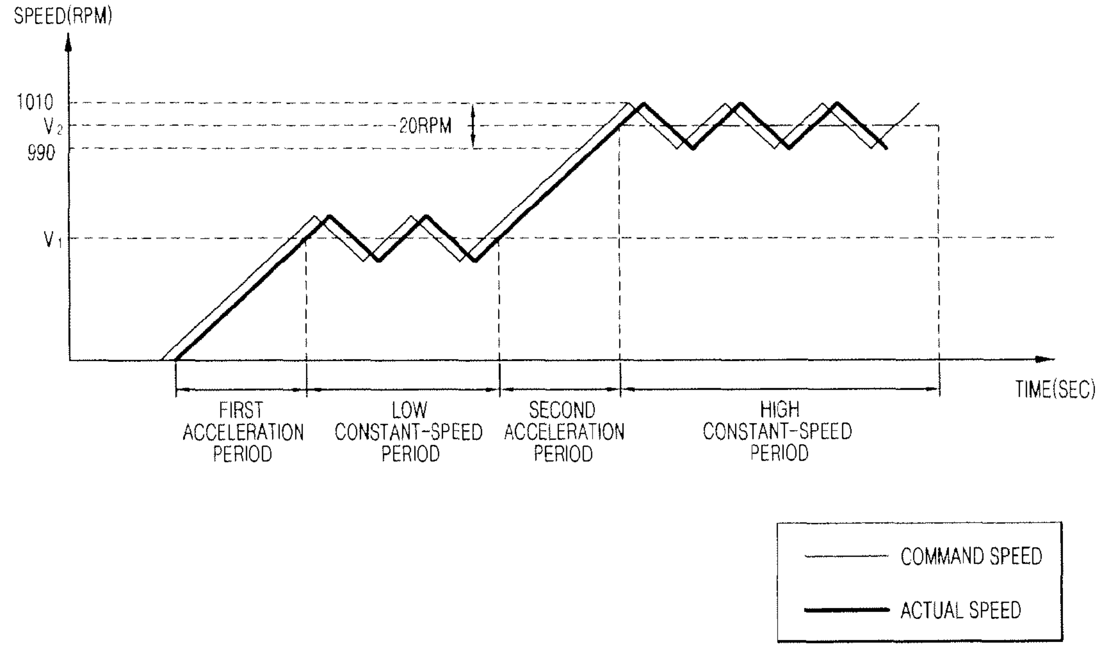

SPEED(RPM)
1010
V_2
990
V_1
20RPM
TIME(SEC)
FIRST ACCELERATION PERIOD
LOW CONSTANT-SPEED PERIOD
SECOND ACCELERATION PERIOD
HIGH CONSTANT-SPEED PERIOD
COMMAND SPEED
ACTUAL SPEED

FIG. 4B

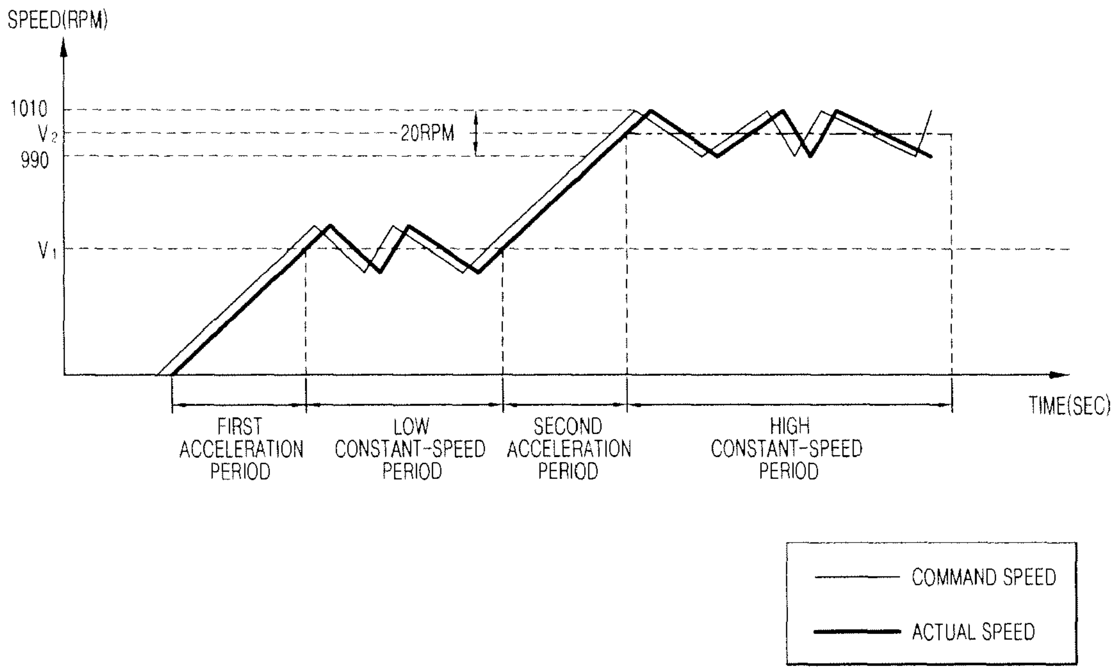

SPEED(RPM)
1010
V_2
990
20RPM
V_1
TIME(SEC)
FIRST ACCELERATION PERIOD
LOW CONSTANT-SPEED PERIOD
SECOND ACCELERATION PERIOD
HIGH CONSTANT-SPEED PERIOD
COMMAND SPEED
ACTUAL SPEED

FIG. 5A

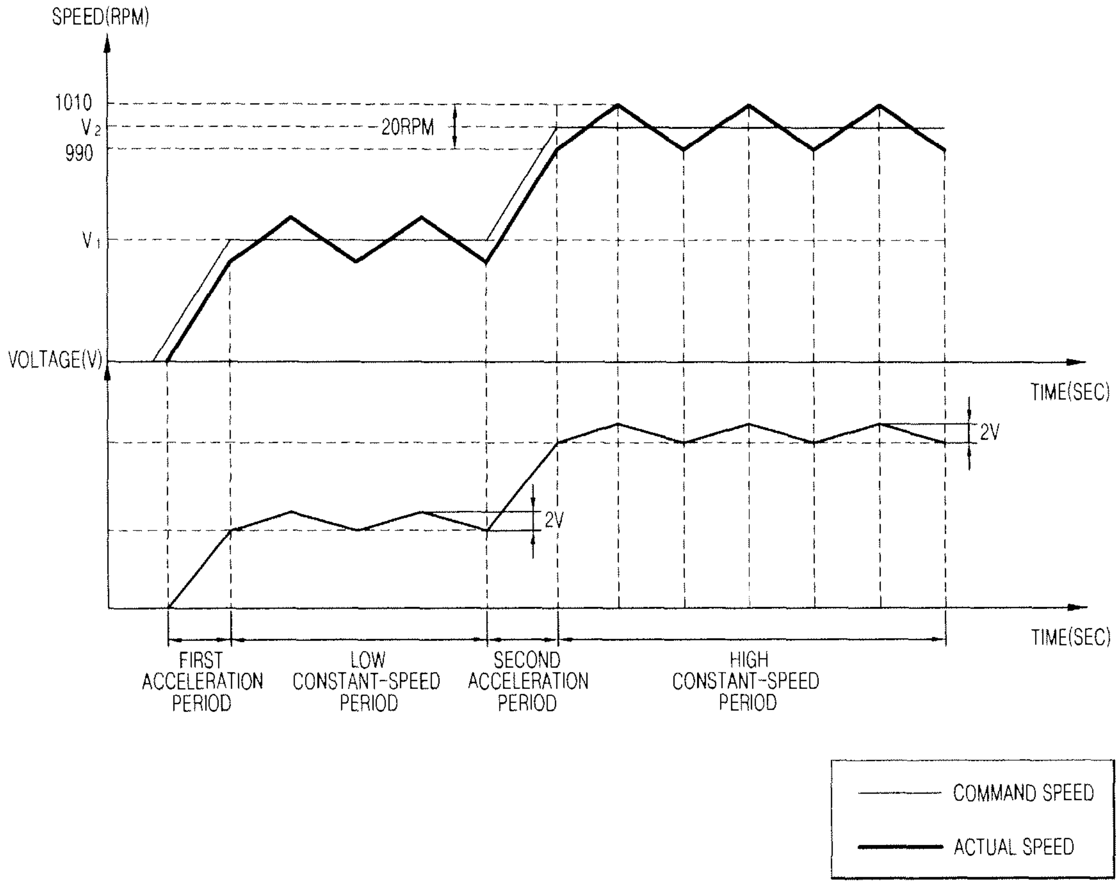

SPEED(RPM)
1010
V2
990
20RPM
V1
VOLTAGE(V)
TIME(SEC)
2V
2V
TIME(SEC)
FIRST ACCELERATION PERIOD
LOW CONSTANT-SPEED PERIOD
SECOND ACCELERATION PERIOD
HIGH CONSTANT-SPEED PERIOD
COMMAND SPEED
ACTUAL SPEED

FIG. 5B

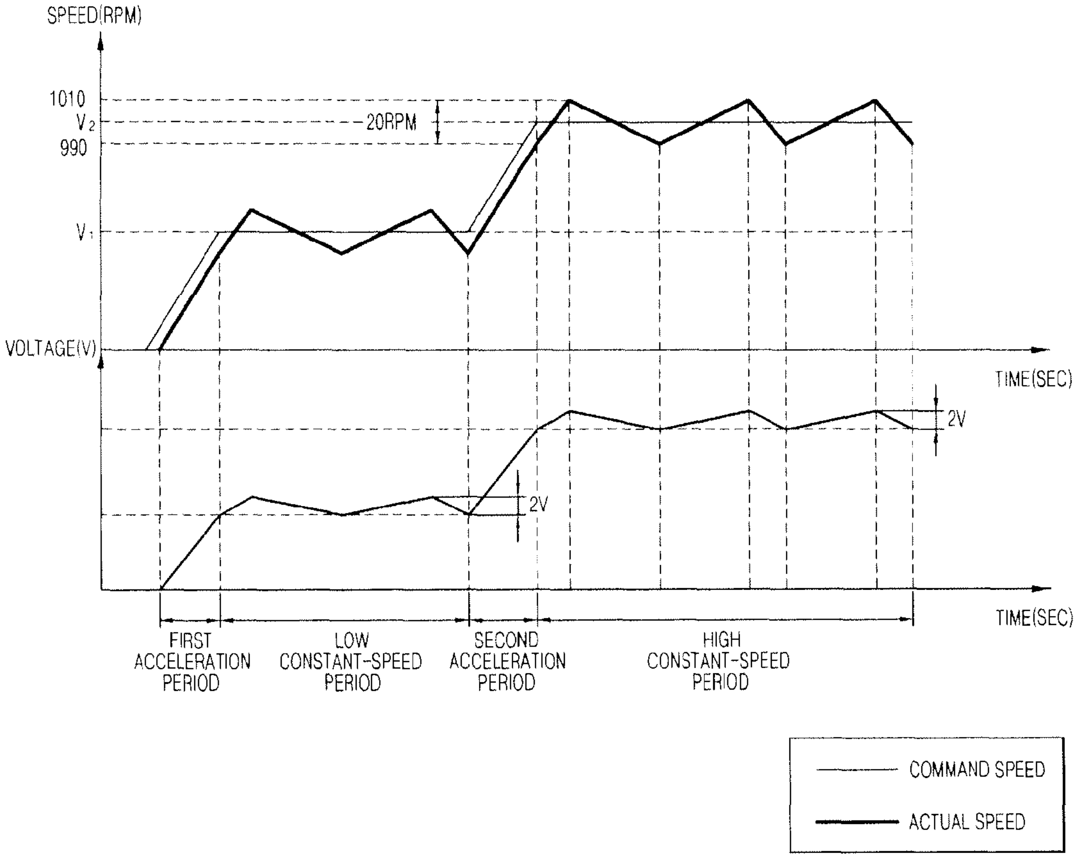

SPEED(RPM)
1010
V_2
990
20RPM
V_1
VOLTAGE(V)
TIME(SEC)
2V
2V
TIME(SEC)
FIRST ACCELERATION PERIOD
LOW CONSTANT-SPEED PERIOD
SECOND ACCELERATION PERIOD
HIGH CONSTANT-SPEED PERIOD
COMMAND SPEED
ACTUAL SPEED

FIG. 6A

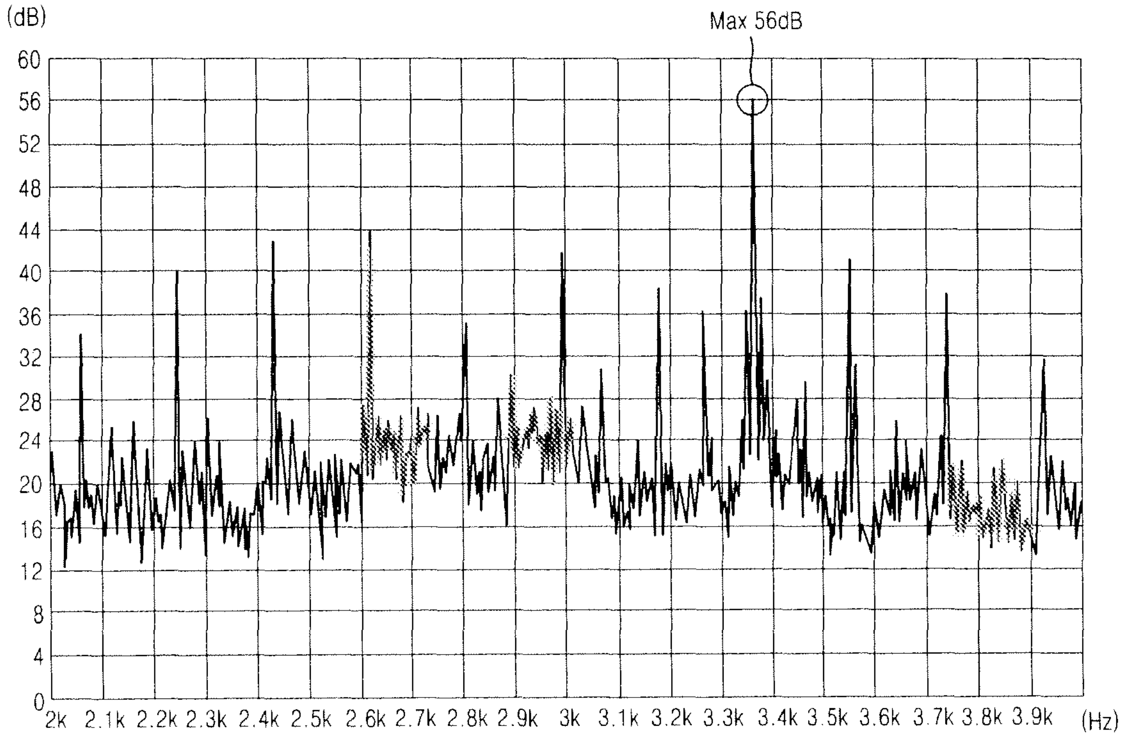

(dB)
Max 56dB
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
0
2k 2.1k 2.2k 2.3k 2.4k 2.5k 2.6k 2.7k 2.8k 2.9k 3k 3.1k 3.2k 3.3k 3.4k 3.5k 3.6k 3.7k 3.8k 3.9k
(Hz)

FIG. 6B

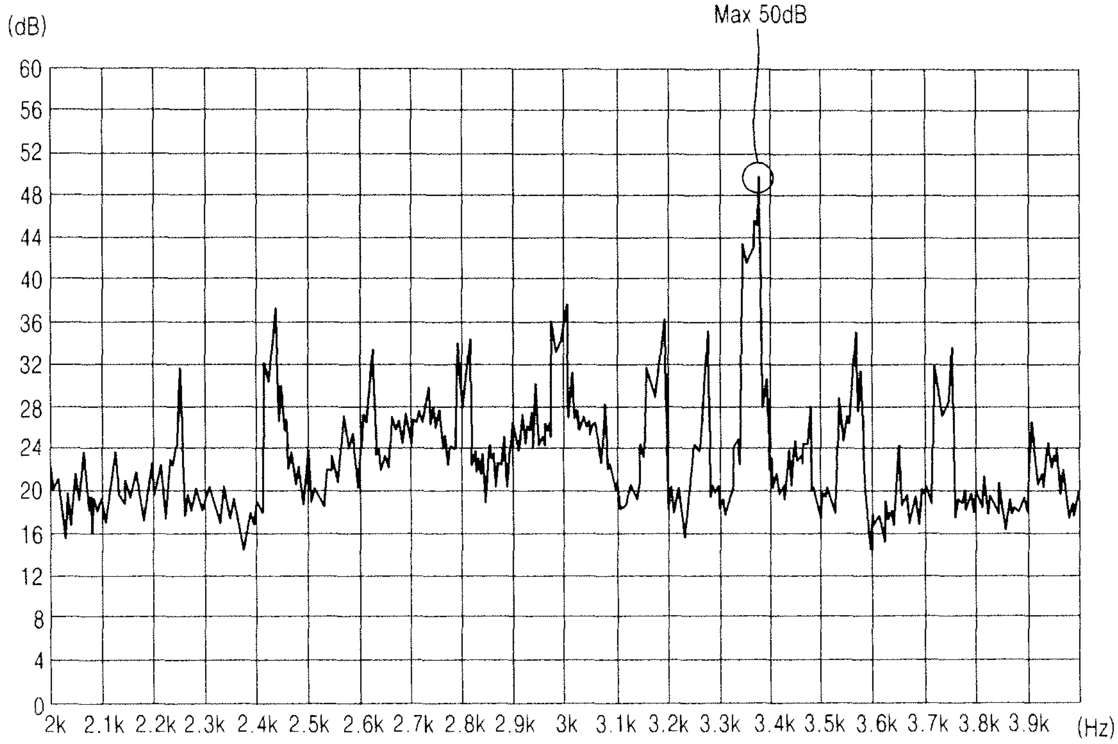

(dB)
Max 50dB
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
0
2k
2.1k
2.2k
2.3k
2.4k
2.5k
2.6k
2.7k
2.8k
2.9k
3k
3.1k
3.2k
3.3k
3.4k
3.5k
3.6k
3.7k
3.8k
3.9k
(Hz)

FIG. 7

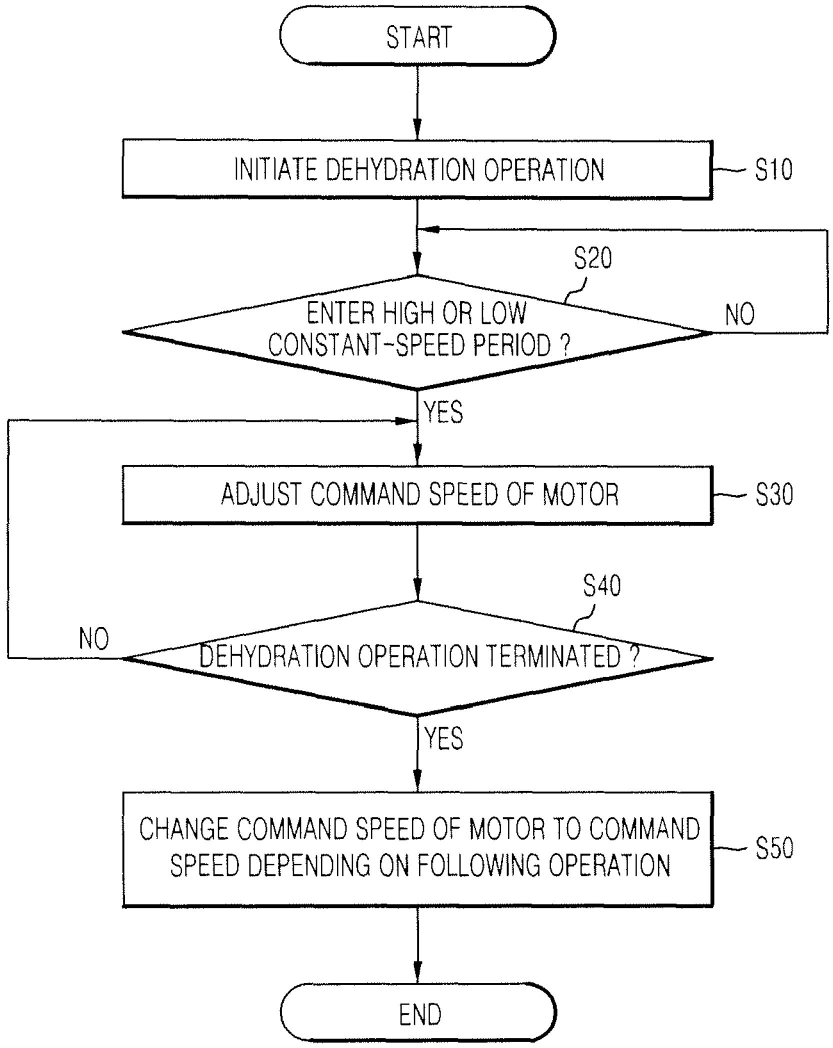
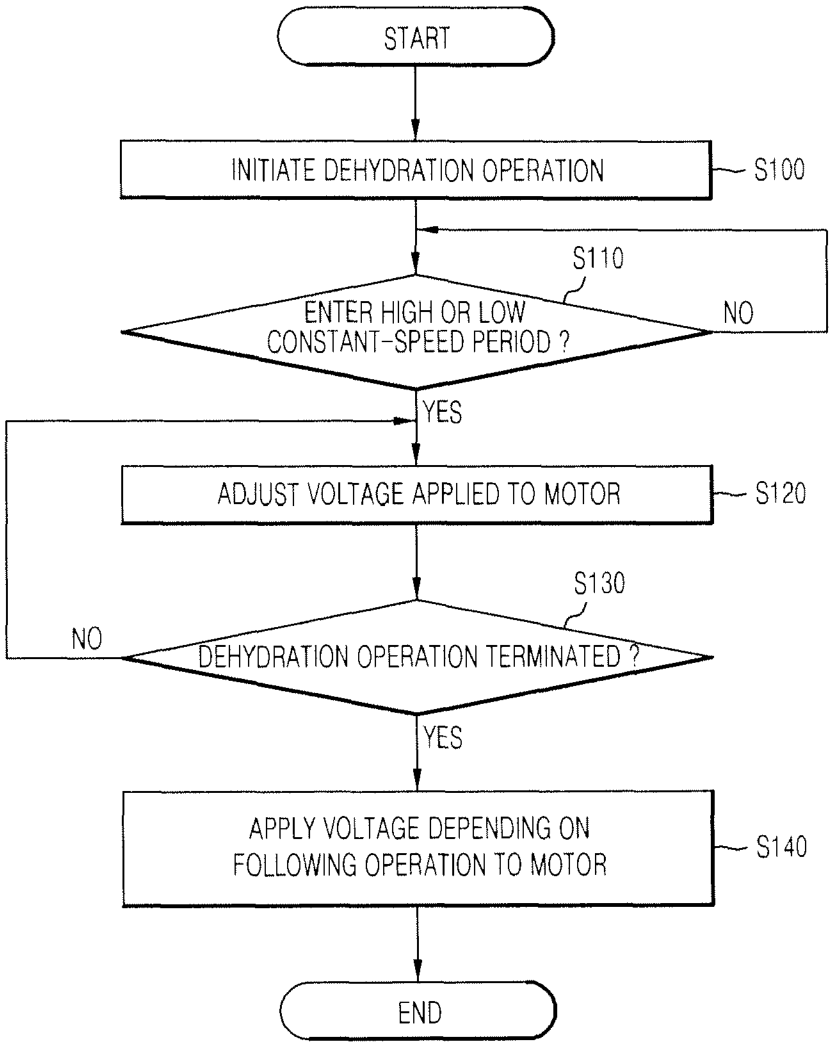

START
INITIATE DEHYDRATION OPERATION
S10
S20
ENTER HIGH OR LOW CONSTANT-SPEED PERIOD ?
NO
YES
ADJUST COMMAND SPEED OF MOTOR
S30
S40
NO
DEHYDRATION OPERATION TERMINATED ?
YES
CHANGE COMMAND SPEED OF MOTOR TO COMMAND SPEED DEPENDING ON FOLLOWING OPERATION
S50
END

FIG. 8


START
INITIATE DEHYDRATION OPERATION
S100
S110
ENTER HIGH OR LOW CONSTANT-SPEED PERIOD ?
NO
YES
ADJUST VOLTAGE APPLIED TO MOTOR
S120
S130
NO
DEHYDRATION OPERATION TERMINATED ?
YES
APPLY VOLTAGE DEPENDING ON FOLLOWING OPERATION TO MOTOR
S140
END

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EUROPEAN SEARCH REPORT

Application Number
EP 10 16 5821

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 4 782 544 A (NYSTUEN ARNE M [US] ET AL) 8 November 1988 (1988-11-08) * column 4, line 12 - column 6, line 7; figures 3,4 * -----	1-15	INV. D06F35/00
X	EP 1 803 846 A1 (IAR SILTAL S P A [IT]) 4 July 2007 (2007-07-04) * paragraph [0014] - paragraph [0023]; figures 1-2 * -----	1-3, 8-12,15	

TECHNICAL FIELDS SEARCHED (IPC)
D06F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	23 November 2010	Hannam, Martin

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

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23-11-2010

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US 4782544	A	08-11-1988	CA	1306367 C	18-08-1992
EP 1803846	A1	04-07-2007	NONE		

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82