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(54) **HORN DEVICE**

(57) A horn device (A, B), which can prevent the decrease of sound pressure is provided. The horn device (A, B) which resonates, by a resonator (1), sound produced by vibrating a diaphragm (21), and comprises a control part (34, 34B) which vibrates the diaphragm (2), and a temperature measurement part (30); the control part (34, 34B) changes a vibration frequency which vibrates the diaphragm (21) according to a temperature measured by the temperature measurement part (30).

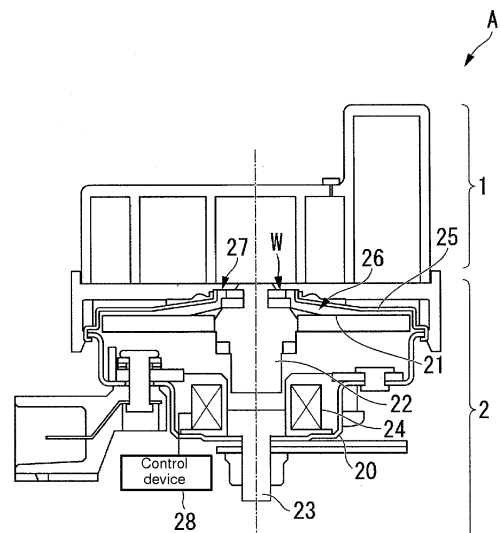


FIG. 1

Description**BACKGROUND OF THE INVENTION**

1. Field of the Invention

[0001] The present invention relates to a horn device.

2. Description of Related Art

[0002] In patent literature 1, a horn device is disclosed which vibrates a diaphragm at a predetermined vibration frequency by magnetic force of an electromagnet, and resonate by a resonator the sound produced by the vibration to produce sound.

[Literature of Prior Art]

[Patent Literature]

[0003] [Patent Literature 1] Japanese Patent Application Laid-Open No. 2017-9624

SUMMARY OF THE INVENTION

[Problems to be Solved by the Invention]

[0004] By the way, in the horn device, due to the change of ambient temperature or the change of voltage value which is used to vibrate the diaphragm, the resonance frequency of the diaphragm which is the frequency with the greatest amplitude changes. Accordingly, the vibration frequency of the diaphragm deviates from the resonance frequency, and sound pressure decreases.

[0005] The present invention is accomplished in view of such situation, and aims at providing a horn device which is capable of preventing the decrease of the sound pressure.

[Means to Solve the Problems]

[0006] One of the embodiments of the present invention is a horn device, which is configured to resonate, by a resonator, sound produced by vibrating a diaphragm, comprising: a control part configured to vibrate the diaphragm; and a temperature measurement part; wherein the control part changes a vibration frequency which vibrates the diaphragm according to a temperature measured by the temperature measurement part.

[0007] One of the embodiments of the present invention is the aforementioned horn device, comprising: a coil; a fixed iron core, which is disposed on a center of the coil, and is fixed to a case; and a movable iron core, which is disposed facing the fixed iron core, and is fixed to the diaphragm; wherein the control part controls energization of the coil according to the vibration frequency corresponding to the temperature measured in the temperature measurement part and vibrates the diaphragm.

[0008] One of the embodiments of the present invention is the aforementioned horn device, comprising a current measurement part which is configured to measure a current value flowing through the coil, wherein the control part changes a duty ratio of energization to the coil according to the current value measured by the current measurement part.

[0009] One of the embodiments of the present invention is the aforementioned horn device, comprising a voltage measurement part which is configured to measure a voltage value used to vibrate the diaphragm, wherein the control part changes a duty ratio of energization to the coil according to the voltage value measured by the voltage measurement part.

[0010] One of the embodiments of the present invention is the aforementioned horn device, wherein the control part reduces the vibration frequency when the temperature measured by the temperature measurement part is lower than a predetermined temperature.

[Effect of the Invention]

[0011] As described above, according to the present invention, decrease of the sound pressure can be prevented.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

Fig. 1 is a drawing showing one example of a schematic structure of a horn device A according to a first embodiment.

Fig. 2 is an external view of a resonator 1 according to the first embodiment.

Fig. 3 is a drawing showing one example of a schematic structure of a control device 28 according to the first embodiment.

Fig. 4 is a drawing illustrating a setting method of a frequency f_{out} according to the first embodiment.

Fig. 5 is a drawing illustrating a setting method of a duty ratio D_{out} according to the first embodiment.

Fig. 6 is a flow chart of an operation of energization control of a coil 24 according to the first embodiment.

Fig. 7 is a flow chart of a variation of the operation of energization control of the coil 24 according to the first embodiment.

Fig. 8 is a drawing showing one example of a schematic structure of a horn device B according to a second embodiment.

Fig. 9 is a drawing showing one example of a schematic structure of a control device 28B according to the second embodiment.

Fig. 10 is a drawing illustrating a setting method of a duty ratio D_{out} according to the second embodiment.

Fig. 11 is a flow chart of an operation of energization control of a coil 24 according to the second embodiment.

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Fig. 12 is a flow chart of a variation of the operation of energization control of the coil 24 according to the second embodiment.

DESCRIPTION OF THE EMBODIMENTS

[0013] In the following part, the present invention is described through embodiments of the invention, but the following embodiments do not limit the invention. Besides, not all the combinations of characteristics described in the embodiments are necessary to the solving method of the invention. In addition, in the drawings, the same or similar parts are marked with the same symbols and repeated description is omitted sometimes. Moreover, shapes, sizes and the like of the elements in the drawings may be exaggeratedly shown for a clearer description.

[0014] In the whole specification, as long as no opposing description exists, the expression that a certain part "include(s)", "has/have" or "comprise(s)" a certain structural element means that other structural elements can be further included instead of being excluded.

[0015] In the following part, a horn device according to one embodiment of the present invention is described with reference to drawings. The horn device according to one embodiment of the present invention is, for example, a horn device which is mounted on a front side of a vehicle such as an automobile and produces a warning sound.

(The first embodiment)

[0016] Fig. 1 is a drawing showing one example of a schematic structure of a horn device A according to a first embodiment. As shown in Fig. 1, the horn device A comprises a resonator 1 and a horn body part 2. The resonator 1 is mounted on the horn body part 2. The resonator 1 resonates the sound produced by the horn body part 2 and produces sound outside.

[0017] Fig. 2 is an external view of the resonator 1 according to the first embodiment. As shown in Fig. 2, the resonator 1 comprises a sound guide 10.

The sound guide 10 is spirally shaped. The sound guide 10 comprises a wall 11 and a sound outlet 12.

[0018] The wall 11 is an enclosure wall with an approximately U-shaped cross section and a predetermined thickness. On an internal side of the wall 11, a path is formed. The path is formed for the sound produced in the horn body part 2 to pass through.

In the central part of the spiral shape in the sound guide 10, a sound inlet (not shown) for the sound produced in the horn body part 2 to get into is arranged.

The sound outlet 12 is a bugle-shaped opening part arranged on an outlet side of the sound guide 10.

[0019] According to the aforementioned structure, the sound produced in the horn body part 2 resonates from the sound inlet of the resonator 1 through the sound guide

10 and is amplified to a predetermined sound pressure. Then, the amplified sound is produced outside from the sound outlet 12 of the resonator 1.

[0020] Back to Fig. 1, the structure of the horn body part 2 according to the first embodiment is described.

The horn body part 2 comprises a case 20, a diaphragm 21, a movable iron core 22, a fixed iron core 23, a coil 24, a cover 25, an air vibration chamber (chamber) 26, an airflow path 27 and a control device 28.

[0021] In the case 20, the diaphragm 21, the movable iron core 22, the fixed iron core 23, the coil 24, the cover 25, the air vibration chamber (chamber) 26, the airflow path 27 and the control device 28 are accommodated.

[0022] The diaphragm 21 is arranged to infill the opening part of the case 20. The diaphragm 21 is, formed to an approximate disk shape by stamping a thin steel plate for example. In the central part of the diaphragm 21, the movable iron core 22 is fixed. For example, the diaphragm 21 is fixed to the resonator 1 by being fastened with a washer W.

[0023] The movable iron core 22 is formed to a cylinder shape by magnetic material. One end of the movable iron core 22 is fixed to the diaphragm, and the other end is disposed facing the fixed iron core 23. Here, the shaft center of the movable iron core 22 corresponds with the shaft center of the fixed iron core 23. That is, the movable iron core 22 and the fixed iron core 23 are disposed coaxially with each other.

[0024] The fixed iron core 23 is disposed on the center of the coil 24. That is, the fixed iron core 23 and the coil 24 are formed as an electromagnet. Besides, the fixed iron core 23 is fixed to the case 20.

[0025] The coil 24 is formed by conductive material, and is wound with a predetermined number of turns. The coil 24 is electrically connected with the control device 28. The cover 25 is fixed to the case 20. The periphery section of the cover 25 is fastened to both the periphery section of the case 20 and the periphery section of the diaphragm 21.

[0026] An air vibration chamber 26 is formed between the cover 25 and the diaphragm 21.

The airflow path 27 is formed between the cover 25 and the washer W. The airflow path 27 is configured to let the air from the air vibration chamber 26 pass through, accompanied by the vibration of the diaphragm 21.

[0027] By energizing the coil 24, the control device 28 turns the fixed iron core 23 disposed on the center of the coil 24 to an electromagnet and produces magnetic force.

[0028] In the following part, a sound producing method according to the first embodiment is described.

By the magnetic force generated by the energization control performed to the coil 24 at a predetermined frequency f_{out} , the control device 28 moves the movable iron core 22 back and forth to vibrate the diaphragm 21. Accordingly, a volume of the ring-shaped air vibration chamber 26, which is formed between the cover 25 and the diaphragm 21, increases or decreases. Therefore, air flowing is generated in the airflow path 27. In this way, the

diaphragm 21 vibrates at a predetermined frequency f_{out} , and the vibration becomes sound and is produced from the airflow path 27. In addition, when the predetermined frequency f_{out} is approximately the same as the resonance frequency f_c , the sound pressure is the largest. Moreover, the resonance frequency f_c is a value determined by, for example, the shape or material of the diaphragm 21 or the resonator 1, and varies in accordance with the ambient temperature of the horn device A or the heat generation of the coil 24.

[0029] In the following part, the structure of the control device 28 according to the first embodiment is described with reference to Fig. 3.

As shown in Fig. 3, the control device 28 comprises a temperature measurement part 30, a current measurement part 31, a power supply device 32, a driving part 33, a control part 34 and a memory part 35.

The temperature measurement part 30 measures the ambient temperature T of the horn device A. For example, the temperature measurement part 30 is arranged inside the control device 28. Then, the temperature measurement part 30 measures the temperature inside the control device 28 as the temperature T . The temperature measurement part 30 outputs the measured temperature T to the control part 34.

[0030] The current measurement part 31 measures a current value I_c flowing through the coil 24. The current measurement part 31 outputs the measured current value I_c to the control part 34. For example, the current measurement part 31 is a current transformer (CT). Besides, the current measurement part 31 is a current measurement circuit, which comprises a shunt resistor arranged on the path of the current flowing through the coil 24 and is configured to be capable of measuring the current value I_c from the voltages of two ends of the shunt resistor.

[0031] The power supply device 32 supplies power to each part of the control device 28. For example, the power supply device 32 is a battery. For example, secondary batteries such as a nickel-hydrogen battery or a lithium-ion battery can be used as the power supply device 32. Besides, instead of secondary batteries, an electric double layer capacitor (condenser) can also be used.

[0032] Based on a PWM (Pulse Width Modulation) signal output from the control part 34, the driving part 33 converts the direct-current power from the power supply device 32 to an alternating-current power, and outputs the converted alternating-current power to the coil 24. In this way, the coil 24 is energized.

[0033] By outputting the PWM signal to the driving part 33, the control part 34 energizes the coil 24 and vibrates the diaphragm 21 at a predetermined frequency. In this case, the control part 34 changes the frequency which vibrates the diaphragm 21 according to the temperature T measured in the temperature measurement part 30. Here, the frequency at which the diaphragm 21 vibrates (referred to as "vibration frequency" hereinafter) is the frequency f_{out} of the PWM signal.

[0034] For example, by controlling the energization of the coil 24 at the frequency f_{out} corresponding to the temperature T measured by the temperature measurement part 30, the control part 34 moves the movable iron core 22 back and forth to vibrate the diaphragm 21. In addition, the frequency f_{out} is set to correspond with the resonance frequency f_c .

The control part 34 can also set the frequency f_{out} corresponding with the temperature T measured by the temperature measurement part 30 based on, for example, a table stored in the memory part 35 in advance. In the following part, the setting method of the frequency f_{out} according to the first embodiment is described with reference to Fig. 4.

[0035] As shown in Fig. 4, in the memory part 35, different frequencies f_{out} with respect to each predetermined temperature range of the temperature T are stored in the form of a table. For example, when the temperature T is lower than a first temperature threshold T_{th1} , the frequency f_{out} is set to a value $(f_0 + fx)$ obtained by adding a predetermined frequency fx to a frequency f_0 . Here, the frequency f_0 is the initial value of the frequency of PWM signals.

[0036] When the temperature T is higher than the first temperature threshold T_{th1} and lower than a second temperature threshold T_{th2} ($>T_{th1}$), the frequency f_{out} is set to the frequency f_0 . In addition, the frequency f_0 is the resonance frequency f_c in normal temperature range (higher than the first temperature threshold T_{th1} and lower than the second temperature threshold T_{th2}).

When the temperature T is higher than the second temperature threshold T_{th2} and lower than a third temperature threshold T_{th3} ($>T_{th2}$), the frequency f_{out} is set to a value $(f_0 - fx)$ obtained by subtracting a predetermined fx from the frequency f_0 . When the temperature T is higher than the third temperature threshold T_{th3} , the frequency f_{out} is set to a value $(f_0 - 2fx)$ obtained by subtracting a predetermined $2 \times fx$ from the frequency f_0 . Moreover, the temperature range and the frequency f_{out} shown in Fig. 4 are just examples, and the number of temperature ranges or the frequency f_{out} can be properly set. However, the frequency f_{out} is set to increase as the temperature T decreases.

[0037] Besides, the control part 34 changes a duty ratio D_{out} of the energization to the coil 24 according to the current value I_c measured by the current measurement part 31. For example, the control part 34 sets the duty ratio corresponding to the current value I_c measured by the current measurement part 31 as the duty ratio D_{out} of the PWM signal. The control part 34 can also set the duty ratio D_{out} corresponding to the current value I_c measured by the current measurement part 31 based on, for example, a table stored in the memory part 35 in advance. In the following part, the setting method of the duty ratio D_{out} according to one embodiment of the present invention is described with reference to Fig. 5.

[0038] As shown in Fig. 5, in the memory part 35, different duty ratios D_{out} with respect to each predetermined

current range of the current value I_c are stored in the form of a table. For example, when the current value I_c is lower than a first current threshold I_{th1} , the duty ratio D_{out} is set to a value (D_o+D_x) obtained by adding a predetermined duty ratio D_x to a duty ratio D_o . Here, the duty ratio D_o is the initial value of the duty ratio of PWM signal. When the current value I_c is higher than the first current threshold I_{th1} and lower than a second current threshold I_{th2} ($>I_{th1}$), the duty ratio D_{out} is set to the duty ratio D_o .

[0039] When the current value I_c is higher than the second current threshold I_{th2} , the duty ratio D_{out} is set to a value (D_o-D_x) obtained by subtracting the duty ratio D_x from the duty ratio D_o . In addition, the current range and the duty ratio D_{out} shown in Fig. 5 are just examples, and the number of the current ranges or the duty ratio D_{out} can be properly set. However, the duty ratio D_{out} is set in the range between the upper limit and the lower limit. And the duty ratio D_{out} is set to decrease as the current value I_c increases.

[0040] In the following part, the operation of the energization control of the coil 24 according to this embodiment is described with reference to Fig. 6.

First, the control part 34 sets the frequency f_{out} to the frequency f_o which is the initial value. Besides, the control part 34 sets the duty ratio D_{out} to the duty ratio D_o which is the initial value (step S101). Here, when a warning signal is obtained from outside, the control part 34 generates PWM signals of the set frequency f_{out} and duty ratio D_{out} , and outputs the generated PWM signals to the driving part 33. In this way, the control part 34 energizes the coil 24 and vibrates the diaphragm 21 at the frequency f_o , by which sound is produced from the sound outlet 12 of the resonator 1 to outside.

[0041] Next, the control part 34 obtains the temperature T from the temperature measurement part 30. The control part 34 determines whether the obtained temperature T is lower than the first temperature threshold T_{th1} (step S103). In the case when the obtained temperature T is determined to be lower than the first temperature threshold T_{th1} , the control part 34 sets the frequency f_{out} to a value (f_o+fx) obtained by adding the predetermined frequency fx to the frequency f_o (step S104). Here, the expression that the temperature T is lower than the first temperature threshold T_{th1} means that the temperature T is in a range of low temperature. Here, the resonance frequency f_c becomes higher and higher as the ambient temperature decreases. Therefore, in the treatment of step S104, when the ambient temperature is a low temperature, the control part 34 adds the frequency fx to the frequency f_o which is the present frequency f_{out} in order to match the frequency f_{out} with the resonance frequency f_c . That is, the control part 34 corrects the frequency f_{out} to the resonance frequency f_c which becomes a higher value as the temperature decreases. Accordingly, the frequency f_{out} is set to the resonance frequency f_c ($=f_o+fx$).

[0042] When the obtained temperature T is higher than

the first temperature threshold T_{th1} , the control part 34 determines whether the temperature T is lower than the second temperature threshold T_{th2} (step S105). When the obtained temperature T is determined to be higher than the first temperature threshold T_{th1} and lower than the second temperature threshold T_{th2} , the control part 34 sets the frequency f_{out} to the frequency f_o (step S106). In this way, in the treatment of step S105, when the temperature T is determined to be within a range of normal temperature, the control part 34 sets the present frequency f_{out} to the frequency f_o in order to match the frequency f_{out} with the resonance frequency f_c .

[0043] On the other hand, when the obtained temperature T is determined to be higher than the second temperature threshold T_{th2} , the control part 34 determines whether the temperature T is lower than the third temperature threshold T_{th3} (step S107). When the obtained temperature T is determined to be higher than the second temperature threshold T_{th2} and lower than the third temperature threshold T_{th3} , the control part 34 sets the frequency f_{out} to the value (f_o-fx) obtained by subtracting the predetermined fx from the frequency f_o (step S108). Here, the temperature T is higher than the second temperature threshold T_{th2} means that the temperature T is in the range of high temperature. Here, the resonance frequency f_c becomes lower and lower as the ambient temperature increases. Therefore, in the treatment of step S108, when the ambient temperature is a high temperature, the control part 34 subtracts the frequency fx from the frequency f_o which is the present frequency f_{out} in order to match the frequency f_{out} with the resonance frequency f_c . That is, the control part 34 corrects the frequency f_{out} to the resonance frequency f_c which becomes a low value as the temperature becomes high. Accordingly, the frequency f_{out} is set to the resonance frequency f_c ($=f_o-fx$).

[0044] When the obtained temperature T is determined to be higher than the third temperature threshold T_{th3} , the control part 34 sets the frequency f_{out} to the value (f_o-2fx) obtained by subtracting $2 \times fx$ from the frequency f_o (step S109). That is, when the temperature T is higher than the third temperature threshold T_{th3} , the resonance frequency f_c becomes a value even lower than the value (f_o+fx) set in the treatment of step S108. Therefore, in the treatment of step S109, the control part 34 subtracts a value two times of the frequency fx from the frequency f_o which is the present frequency f_{out} in order to match the frequency f_{out} with the resonance frequency f_c . Accordingly, the frequency f_{out} is set to the resonance frequency f_c ($=f_o-2fx$).

[0045] Next, the control part 34 obtains the current value I_c from the current measurement part 31 (step S110). The control part 34 determines whether the obtained current value I_c is higher than the first current threshold I_{th1} (step S111). When the obtained current value I_c is determined to be lower than the first current threshold I_{th1} , the control part 34 determines whether the present duty ratio D_{out} is the upper limit (step S112). When it is deter-

mined that the present duty ratio D_{out} is not the upper limit, the control part 34 sets a value obtained by adding a predetermined duty ratio D_x (for example, 10%) to the present duty ratio D_{out} as a new duty ratio D_{out} . Accordingly, when the current value I_c flowing through the coil 24 is lower than the first current threshold I_{th1} , the duty ratio D_{out} is raised (step S113). However, when the present duty ratio D_{out} is determined to be the upper limit, the control part 34 sets the present duty ratio D_{out} to the duty ratio D_o (step S115).

[0046] When the obtained current value I_c is determined to be higher than the first current threshold I_{th1} , the control part 34 determines whether the current value I_c is lower than the second current threshold I_{th2} (step S114). When the obtained current value I_c is determined to be higher than the first current threshold I_{th1} and lower than the second current threshold I_{th2} , the control part 34 sets the present duty ratio D_{out} to the duty ratio D_o (step S115).

[0047] When the obtained current value I_c is determined to be higher than the second current threshold I_{th2} , the control part 34 determines whether the present duty ratio D_{out} is the lower limit (step S116). When it is determined that the present duty ratio D_{out} is not the lower limit, the control part 34 sets a value obtained by subtracting a predetermined duty ratio D_x (for example, 10%) from the present duty ratio D_{out} as a new duty ratio D_{out} (step S117). On the other hand, when the present duty ratio D_{out} is determined to be the lower limit, the control part 34 sets the present duty ratio D_{out} to the duty ratio D_o (step S115).

[0048] Here, the control part 34 usually controls the current value I_c flowing through the coil 24 to a scope ranging from the first current threshold I_{th1} to the second current threshold I_{th2} . However, due to the change of the ambient temperature, the resistance value of the coil 24 changes, so that the current value I_c flowing through the coil 24 may fall outside the scope ranging from the first current threshold I_{th1} to the second current threshold I_{th2} . For example, when the ambient temperature becomes a low temperature and the resistance value of the coil 24 decrease, the current value flowing through the coil 24 may increase above the second current threshold I_{th2} . In this situation, because the current value flowing through the coil 24 increases, the magnetic force of the electromagnet increases. Accordingly, the movable iron core 22 and the fixed iron core 23 may collide with each other, resulting in an abnormal noise. Therefore, when the current value I_c flowing through the coil 24 increases above the second current threshold I_{th2} , the control part 34 of this embodiment prevents the increase of the magnetic force of the electromagnet by reducing the duty ratio D_{out} . Accordingly, the control part 34 can prevent the abnormal noise generated due to the collision of the movable iron core 22 and the fixed iron core 23.

[0049] As mentioned above, the horn device A according to the first embodiment changes the frequency which vibrates the diaphragm 21 according to the temperature

T measured by the temperature measurement part 30. In this way, the horn device A can correct the vibration frequency of the diaphragm 21 to the resonance frequency f_c even when the resonance frequency f_c changes because of the change of the ambient temperature. Therefore, the horn device A can ensure the predetermined sound pressure even when the resonance frequency f_c of the diaphragm 21 changes because of the increasing or decreasing of the ambient temperature.

[0050] Besides, the aforementioned horn device A changes the duty ratio D_{out} according to the current value I_c flowing through the coil 24. Accordingly, the control part 34 prevented the increase of the current value I_c flowing through the coil 24 due to the decreasing of the ambient temperature. Therefore, the horn device A can prevent the abnormal noise which is generated because the movable iron core 22 and the fixed iron core 23 collide with each other due to the increasing of the current value I_c .

[0051] In addition, when the ambient temperature is low, the control part 34 may deviate the frequency f_{out} from the resonance frequency f_c by changing the corrected frequency f_{out} . Accordingly, the vibration of the diaphragm 21 can be prevented and the abnormal noise can be prevented. For example, as shown in Fig. 7, after the treatment of step S104, the control part 34 may deviate the frequency f_{out} from the resonance frequency f_c by performing the treatment (step S201) in which a value obtained by subtracting $2 \times f_x$ from the present frequency f_{out} is set as the new frequency f_{out} . That is, when the temperature T is lower than the predetermined temperature, the control part 34 reduces the vibration frequency. Moreover, in order to avoid the complication of the description, in steps S104 and S201 shown in Fig. 7, the present frequency is referred to as the value f'_{out} .

[0052] Besides, in this embodiment, the setting method of the frequency f_{out} in steps S104, 106, 108 and 109 is just an example, and the present invention is not limited to this situation. That is, when the temperature T falls into the range of low temperature, the control part 34 just has to set the frequency f_{out} to a value lower than the frequency f_o , and when the temperature T falls into the range of high temperature, the control part 34 just has to set the frequency f_{out} to a value higher than the frequency f_o .

(Second embodiment)

[0053] Fig. 8 is a drawing showing one example of a schematic structure of a horn device B according to a second embodiment. As shown in Fig. 8, the horn device B comprises a resonator 1 and a horn body part 2B.

[0054] The resonator 1 is mounted to the horn body part 2B. The resonator 1 resonates the sound produced by the horn body part 2B and produces sound outside.

[0055] The horn body part 2B comprises a case 20, a diaphragm 21, a movable iron core 22, a fixed iron core 23, a coil 24, a cover 25, an air vibration chamber 26, an

airflow path 27 and a control device 28B.

[0056] As shown in Fig. 9, the control device 28B comprises a temperature measurement part 30, a voltage measurement part 40, a power supply device 32, a driving part 33, a control part 34B and a memory part 35.

[0057] The voltage measurement part 40 measures a voltage value V_b used to vibrate the diaphragm 21. For example, the voltage measurement part 40 measures the voltage value V_b output from the power supply device 32. Here, the voltage value V_b may be a voltage applied to the coil 24. The voltage measurement part 40 outputs the measured voltage V_b to the control part 34B.

[0058] The control part 34B energizes the coil 24 and vibrates the diaphragm 21 at a predetermined frequency by outputting PWM signals to the driving part 33. In this situation, the control part 34 changes the frequency which vibrates the diaphragm 21 according to the temperature T measured by the temperature measurement part 30. Besides, the control part 34B changes the duty ratio D_{out} of the energization to the coil 24 according to the voltage value V_b measured by the voltage measurement part 40.

[0059] For example, the control part 34B sets the duty ratio of the PWM signals to the duty ratio D_{out} corresponding to the voltage value V_b measured by the voltage measurement part 40. The control part 34B may also set the duty ratio D_{out} corresponding to the voltage value V_b measured by the voltage measurement part 40 based on, for example, a table stored in the memory part 35 in advance. In the following part, the setting method of the duty ratio D_{out} according to one embodiment of the present invention is described with reference to Fig. 10.

[0060] As shown in Fig. 10, in the memory part 35, different duty ratios D_{out} with respect to each predetermined voltage range of the voltage value V_b are stored in the form of a table. For example, when the voltage value V_b is lower than a first voltage threshold V_{th1} , the duty ratio D_{out} is set to a value, for example, ($D_0+70\%$) obtained by adding a predetermined value such as 70% to the duty ratio D_0 .

Besides, when the voltage value V_b is higher than the first voltage threshold V_{th1} and lower than a second voltage threshold $V_{th2}(>V_{th1})$, the duty ratio D_{out} is set to a value, for example, ($D_0+65\%$) obtained by adding a predetermined value 65% to the duty ratio D_0 . Besides, when the voltage value V_b is higher than the second voltage threshold V_{th2} and lower than a third voltage threshold $V_{th3}(>V_{th2})$, the duty ratio D_{out} is set to a value, for example, ($D_0+55\%$) obtained by adding a predetermined value 55% to the duty ratio D_0 .

[0061] Besides, when the voltage value V_b is higher than the third voltage threshold V_{th3} and lower than the fourth voltage threshold $V_{th4}(>V_{th3})$, the duty ratio D_{out} is set to a value, for example, ($D_0+45\%$) obtained by adding a predetermined value 45% to the duty ratio D_0 .

Besides, when the voltage value V_b is higher than the fourth voltage threshold V_{th4} , the duty ratio D_{out} is set to a value, for example, ($D_0+40\%$) obtained by adding a

predetermined value 40% to the duty ratio D_0 .

In this way, the duty ratio D_{out} is set to decrease as the voltage value V_b increases.

[0062] In the following part, the operation of the energization control of the coil 24 according to the second embodiment is described with reference to Fig. 11. In addition, because the treatments from step S301 to step S309 are the same as the treatments from step S101 to step S109 of the first embodiment, the description is omitted.

[0063] Next, the control part 34B obtains the voltage value V_b from the voltage measurement part 40 (step S310). The control part 34B determines whether the obtained voltage value V_b is higher than the first voltage threshold V_{th1} (step S311). When the obtained voltage value V_b is determined to be lower than the first voltage threshold V_{th1} , the control part 34B sets a value obtained by adding 70% to the present duty ratio D_{out} as a new duty ratio D_{out} (step S312).

[0064] One the other hand, when the obtained voltage value V_b is determined to be higher than the first voltage threshold V_{th1} , the control part 34B determines whether the voltage value V_b is lower than the second voltage threshold V_{th2} (step S313). When the obtained voltage value V_b is determined to be higher than the first voltage threshold V_{th1} and lower than the second voltage threshold V_{th2} , the control part 34B sets a value obtained by adding 65% to the present duty ratio D_{out} as a new duty ratio D_{out} (step S314).

[0065] When the obtained voltage value V_b is determined to be higher than the second voltage threshold V_{th2} , the control part 34B determines whether the obtained voltage value V_b is lower than the third voltage threshold V_{th3} (step S315). When the obtained voltage value V_b is determined to be higher than the second voltage threshold V_{th2} and lower than the third voltage threshold V_{th3} , the control part 34B sets a value obtained by adding 55% to the present duty ratio D_{out} as a new duty ratio D_{out} (step S316).

[0066] When the obtained voltage value V_b is determined to be higher than the third voltage threshold V_{th3} , the control part 34B determines whether the obtained voltage value V_b is lower than the fourth voltage threshold V_{th4} (step S317). When the obtained voltage value V_b is determined to be higher than the third voltage threshold V_{th3} and lower than the fourth voltage threshold V_{th4} , the control part 34B sets a value obtained by adding 45% to the present duty ratio D_{out} as a new duty ratio D_{out} (step S318).

[0067] When the obtained voltage value V_b is determined to be higher than the fourth voltage threshold V_{th4} , the control part 34B sets a value obtained by adding 40% to the present duty ratio D_{out} as a new duty ratio D_{out} (step S319).

[0068] In this way, the control part 34B changes the duty ratio of the energization to the coil 24 according to the voltage value V_b measured by the voltage measurement part 40. Accordingly, the control part 34 can prevent

the abnormal noise which is generated because the movable iron core 22 and the fixed iron core 23 collide with each other due to the increasing of the voltage value Vb.

[0069] In addition, when the ambient temperature is low, the control part 34B may deviate the frequency f_{out} from the resonance frequency f_c by changing the corrected frequency f_{out} . Accordingly, the vibration of the diaphragm 21 can be prevented and the abnormal noise can be prevented. For example, as shown in Fig. 12, after the treatment of step S304, the control part 34B may deviate the frequency f_{out} from the resonance frequency f_c by performing the treatment (step S201) in which a value obtained by subtracting $2 \times f_x$ from the present frequency f_{out} is set as the new frequency f_{out} . That is, when the temperature T is lower than the predetermined temperature, the control part 34B reduces the vibration frequency. Moreover, in order to avoid the complication of the description, in steps S304 and S201 shown in Fig. 7, the present frequency is referred to as the value f_{out} .

[0070] The control part 34 and 34B of the aforementioned embodiment may also be realized by a computer. In this situation, a program used to realize the function may be recorded in a computer-readable recording medium, and the function may be realized by making a computer system read in the program recorded in the recording medium and implementing the program. In addition, the "computer system" mentioned here includes a hardware such as OS or peripheral device. Besides, the "computer-readable recording medium" is a memory device such as a movable medium like a flexible disk, a magnetic optical disk, a ROM and a CD-ROM, and a built-in hard disk in the computer system. Further, the expression of "computer-readable recording medium" means a recording medium which dynamically keeps programs for a short time like a communication wire that transmits programs via a network such as the Internet or via a communication line such as a telephone line, including a recording medium which keeps programs for a specific time like a volatile memory within the computer system which becomes a server or client in this situation. Moreover, the programs may be programs which are used to realized a part of the functions, may be programs realized by a further combination with programs which already record the functions in the computer system, or may be programs which are realized by using programmable logic arrays such as a FPGA (Field Programmable Gate Array).

[0071] In the aforementioned part, the embodiment of the present invention is described in detail with reference to the drawings, but the specific structure is not limited to the embodiment, and the designs in a scope not departing from the spirit of the present invention are also included.

[0072] The fact should be noticed that the devices, systems and programs shown in the specification and the drawings, as well as the implementation sequence of each treatment of the operations, procedures, steps and stages in the method can be performed in any sequence

as long as there is no particular description such as "before ...", "in advance of ..." and so on, and the result of the former treatment is not used in the latter treatment. As for the operation flow in the specification and the drawings, even if the expressions of "first", "next" and so on are used in the description for convenience, it is not necessary to follow this sequence.

[Description of the Symbols]

[0073]

A, B	Horn device
1	Resonator
2, 2B	Horn body part
20	Case
21	Diaphragm
22	Movable iron core
23	Fixed iron core
24	Coil
25	Cover
26	Air vibration chamber (chamber)
27	Airflow path
28, 28B	Control device
30	Temperature measurement part
31	Current measurement part
32	Power supply device
33	Driving part
34, 34B	Control part
35	Memory part
40	Voltage measurement part

Claims

1. A horn device (A, B), which is configured to resonate, by a resonator (1), sound produced by vibrating a diaphragm (21), comprising:
 - a control part (34, 34B) configured to vibrate the diaphragm (21); and
 - a temperature measurement part (30); wherein the control part (34, 34B) changes a vibration frequency which vibrates the diaphragm (21) according to a temperature measured by the temperature measurement part (30).
2. The horn device (A, B) according to claim 1, comprising:
 - a coil (24);
 - a fixed iron core (23), which is disposed on a center of the coil (24), and is fixed to a case (20); and
 - a movable iron core (22), which is disposed facing the fixed iron core (23), and is fixed to the diaphragm (21); wherein the control part (34, 34B) controls energization

of the coil (24) according to the vibration frequency corresponding to the temperature measured in the temperature measurement part (30) and vibrates the diaphragm (21).

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3. The horn device (A) according to claim 2, comprising a current measurement part (31) which is configured to measure a current value flowing through the coil (24), wherein
the control part (34) changes a duty ratio of energization to the coil (24) according to the current value measured by the current measurement part (31). 10
4. The horn device (B) according to claim 2, comprising a voltage measurement part (40) which is configured to measure a voltage value used to vibrate the diaphragm (21), wherein
the control part (34B) changes a duty ratio of energization to the coil (24) according to the voltage value measured by the voltage measurement part (40). 15 20
5. The horn device (A, B) according to any one of claims 1 to 4, wherein the control part (34, 34B) reduces the vibration frequency when the temperature measured by the temperature measurement part (30) is lower than a predetermined temperature. 25

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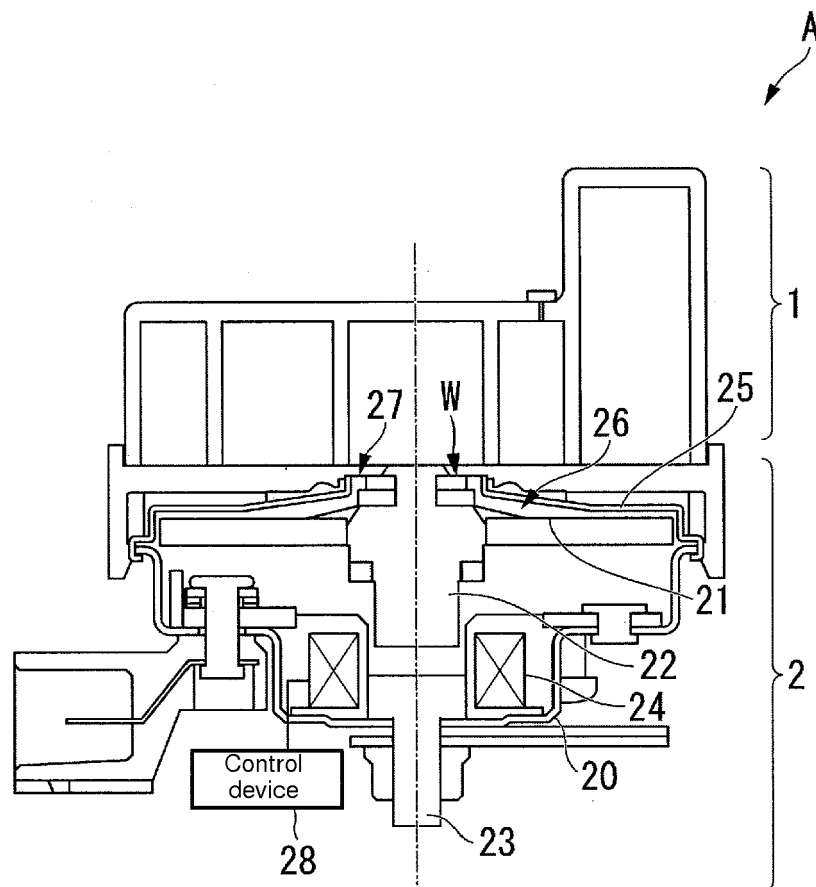


FIG. 1

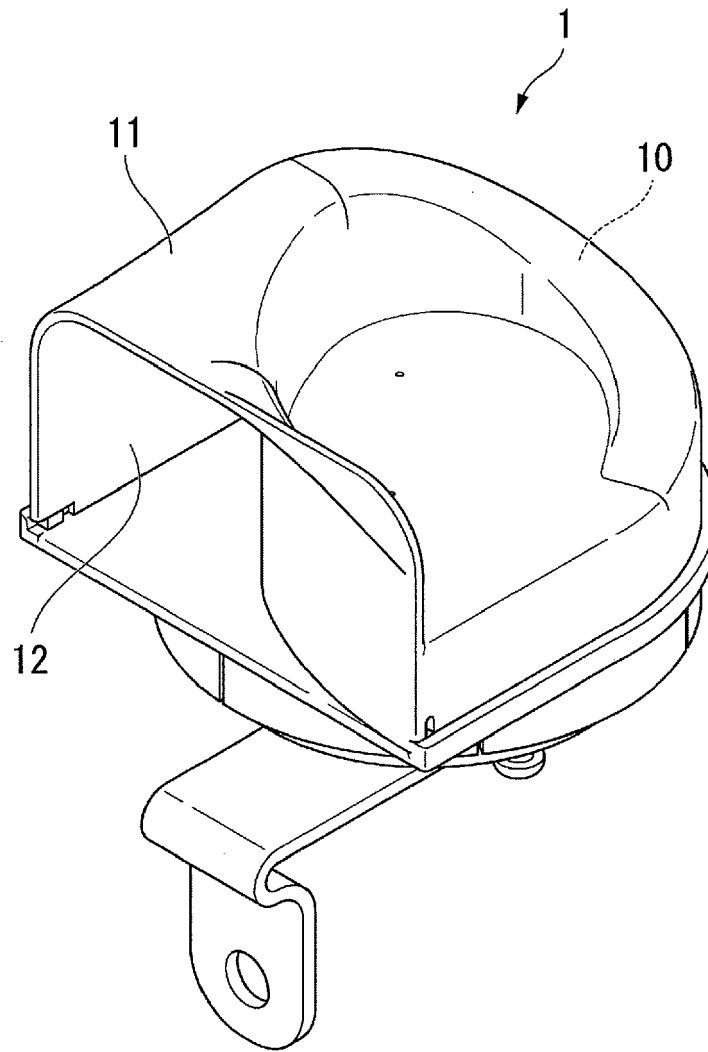


FIG. 2

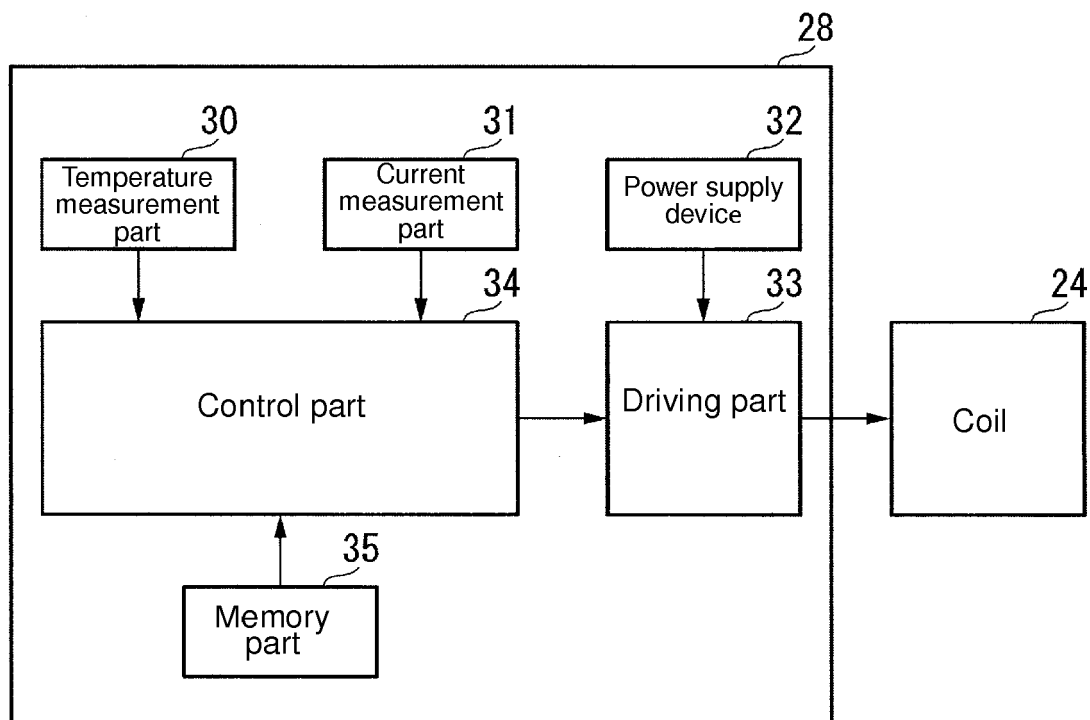


FIG. 3

Temperature range of temperature T	Frequency f_{out}
Temperature $T < \text{first temperature threshold } T_{th1}$	$f_{out} = f_0 + f_x$
First temperature threshold $T_{th1} \leq \text{temperature } T < \text{second temperature threshold } T_{th2}$	$f_{out} = f_0$
Second temperature threshold $T_{th2} \leq \text{temperature } T < \text{third temperature threshold } T_{th3}$	$f_{out} = f_0 - f_x$
Temperature $T \geq \text{third temperature threshold } T_{th3}$	$f_{out} = f_0 - 2f_x$

FIG. 4

Current range of current value I_C	Duty D_{out}
Current value $I_C < \text{first current threshold } I_{th1}$	$D_{out} = D_0 + Dx$
First current threshold $I_{th1} \leq \text{current value } I_C < \text{second current threshold } I_{th2}$	$D_{out} = D_0$
Current value $I_C \geq \text{second current threshold } I_{th2}$	$D_{out} = D_0 - Dx$

FIG. 5

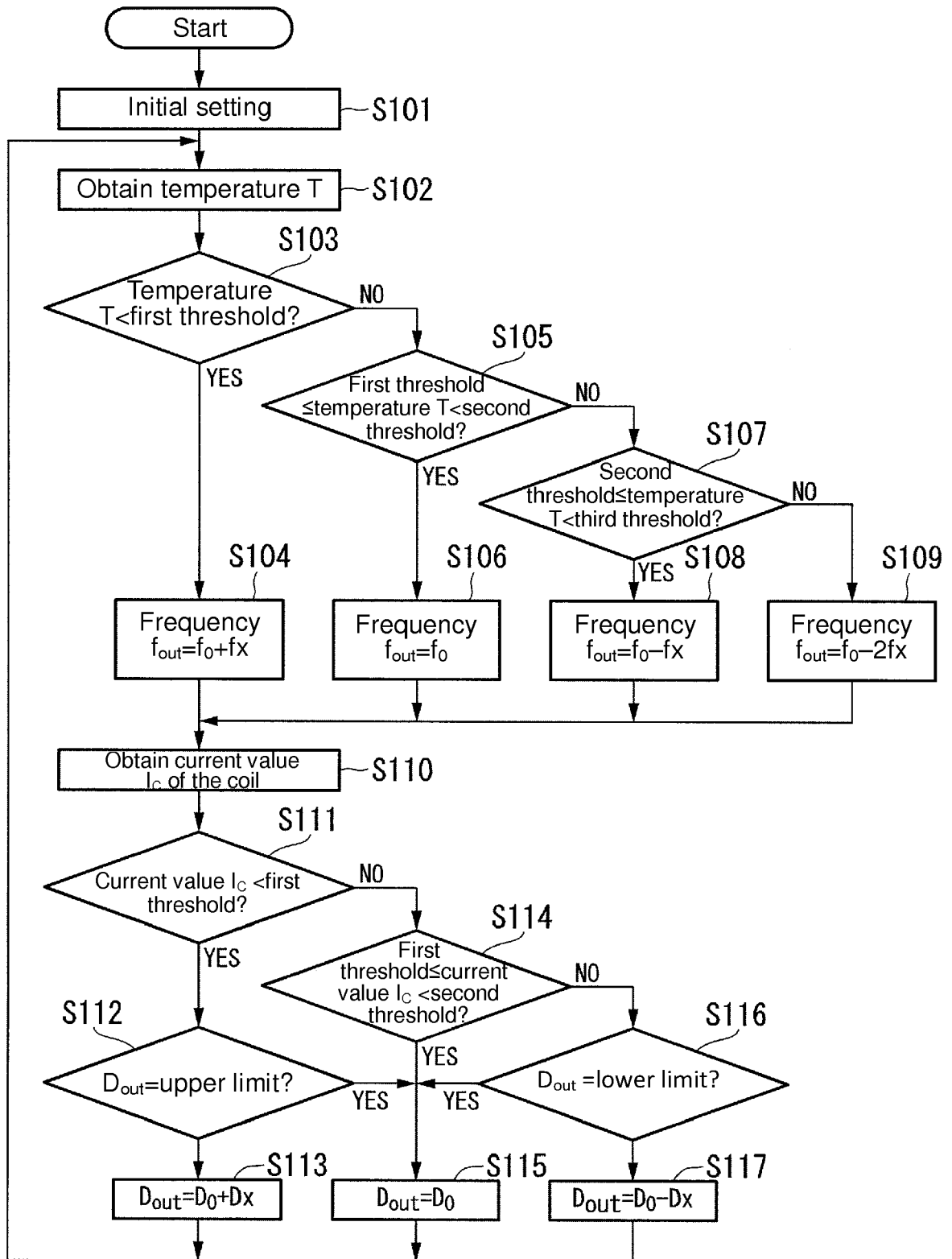


FIG. 6

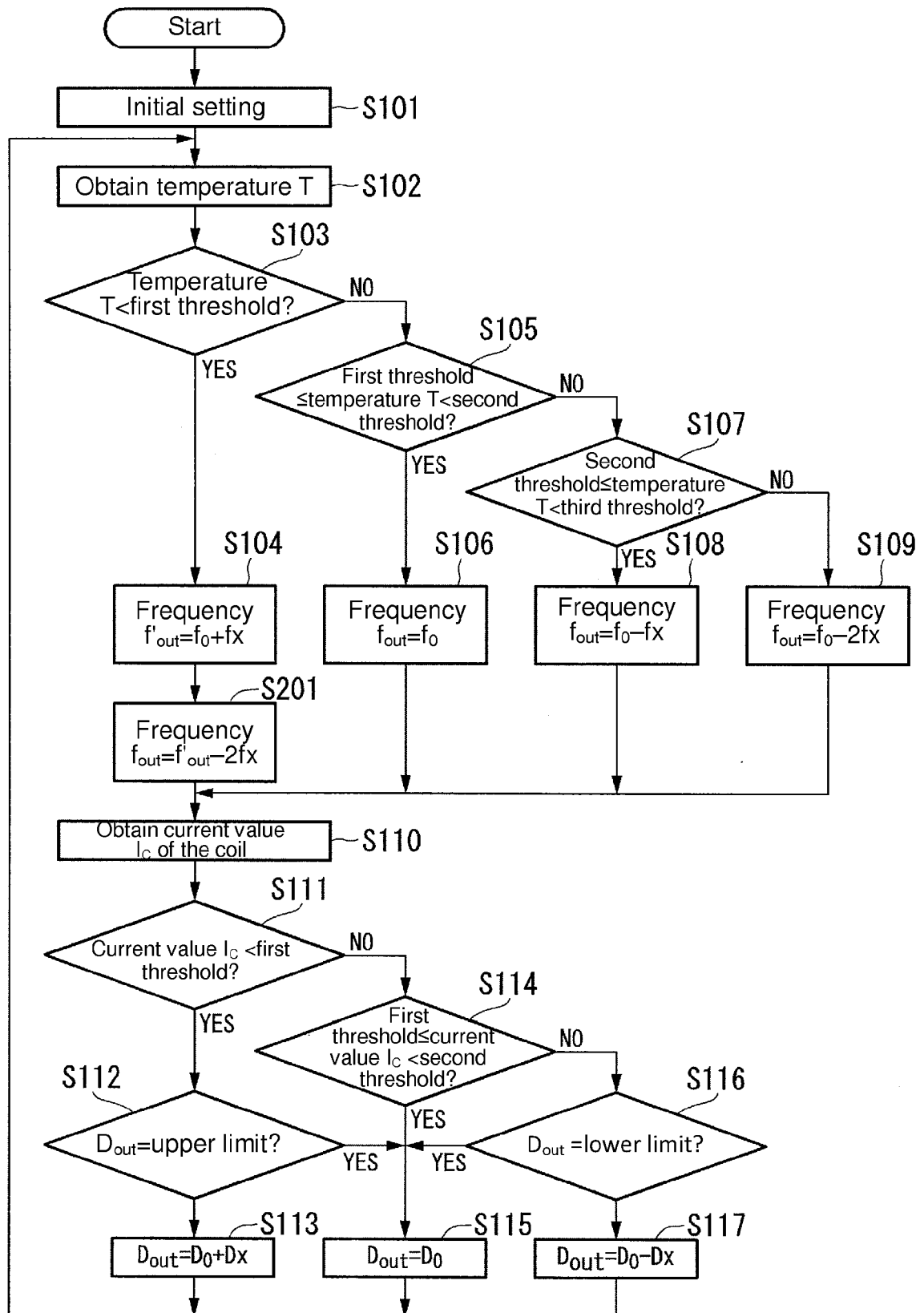


FIG. 7

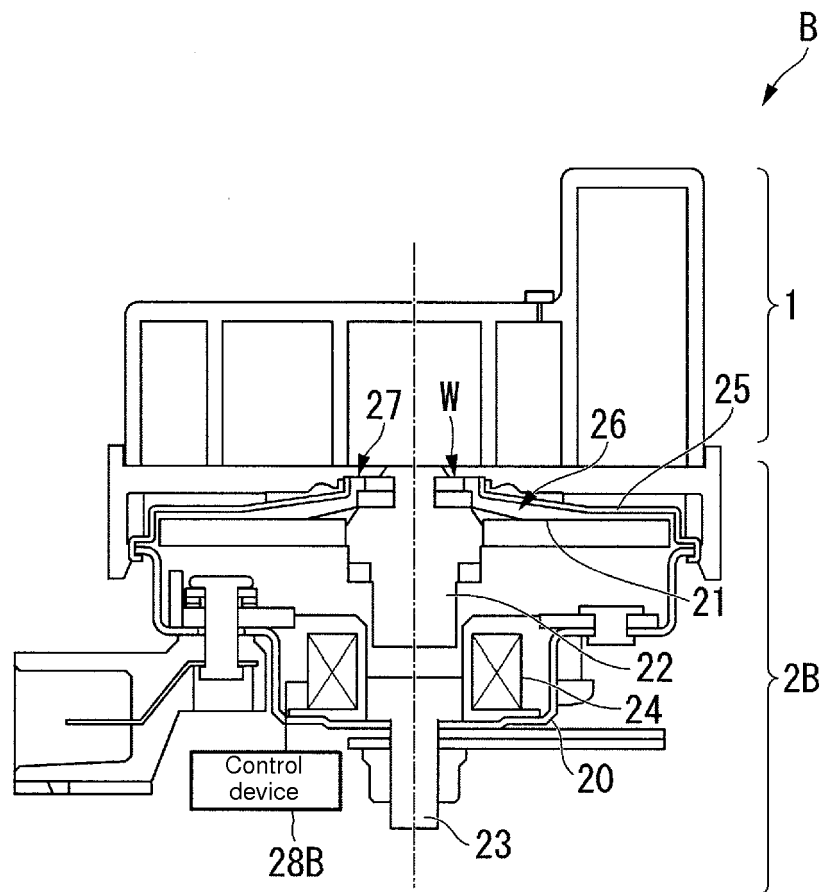


FIG. 8

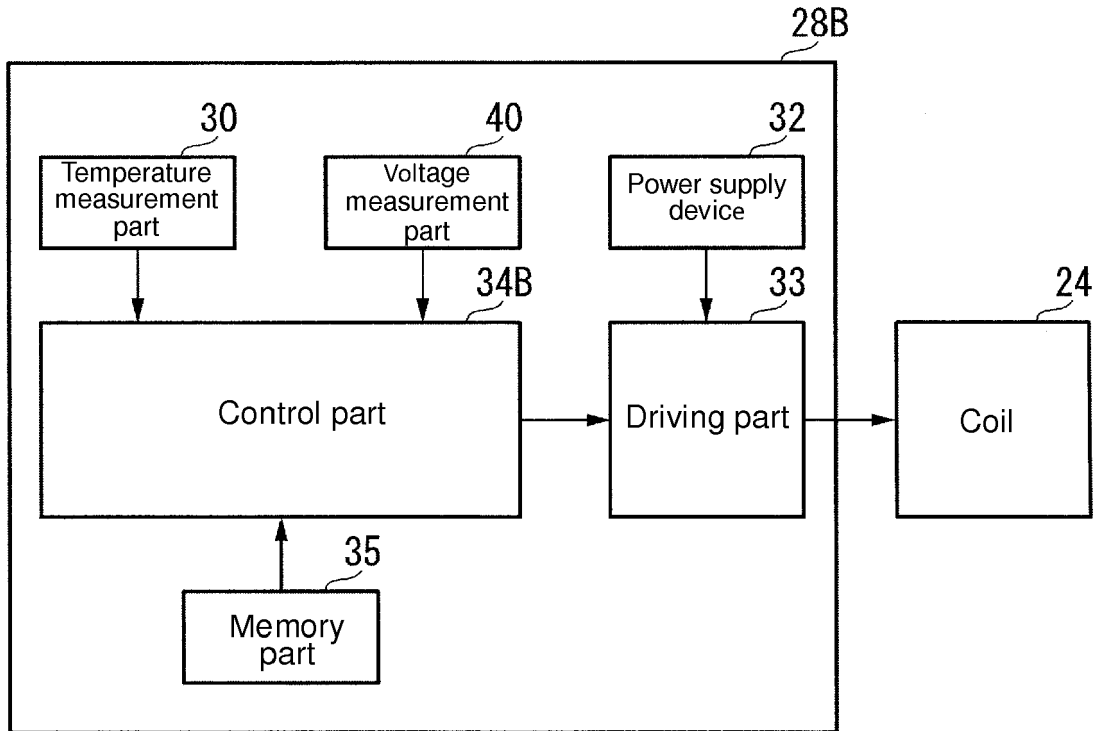


FIG. 9

Voltage range of voltage value Vb	Duty D_{out}
Voltage value $V_b < \text{first voltage threshold } V_{th1}$	$D_{out} = D_0 + 70\%$
First voltage threshold $V_{th1} \leq \text{voltage value } V_b < \text{second voltage threshold } V_{th2}$	$D_{out} = D_0 + 65\%$
Second voltage threshold $V_{th2} \leq \text{voltage value } V_b < \text{third voltage threshold } V_{th3}$	$D_{out} = D_0 + 55\%$
Third voltage threshold $V_{th3} \leq \text{voltage value } V_b < \text{fourth voltage threshold } V_{th4}$	$D_{out} = D_0 + 45\%$
Fourth voltage threshold $V_{th4} \leq \text{Voltage value } V_b$	$D_{out} = D_0 + 40\%$

FIG. 10

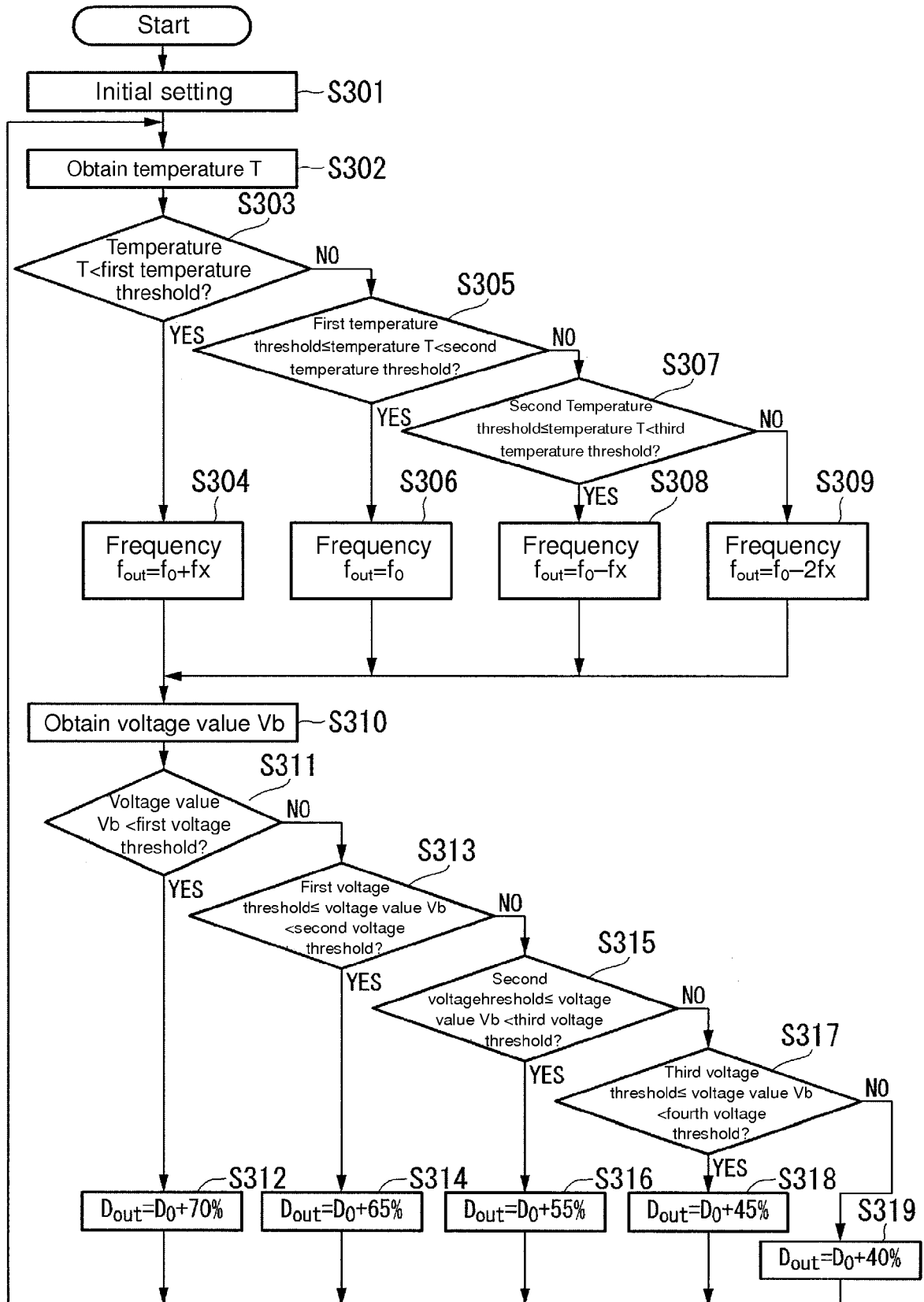


FIG. 11

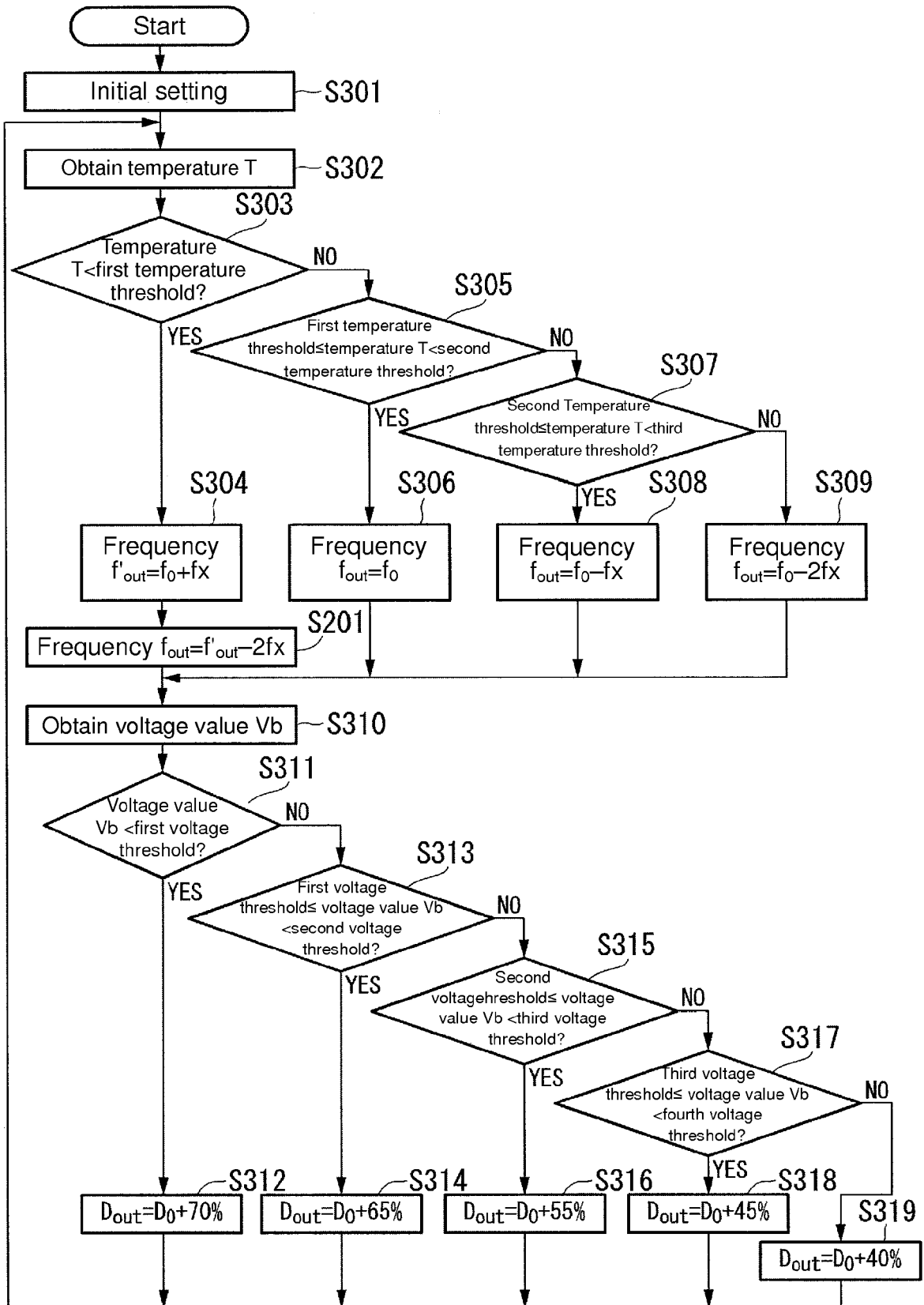


FIG. 12



EUROPEAN SEARCH REPORT

 Application Number
 EP 18 16 2949

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Y	US 5 293 149 A (WILSON CARL R [US] ET AL) 8 March 1994 (1994-03-08) * column 5, lines 45-53,56-62 * * column 7, lines 21-30 *	3,4	
Y	US 2008/309466 A1 (ZHAO HONGWEI [CN]) 18 December 2008 (2008-12-18) * abstract * * paragraphs [0011], [0013], [0021], [0024], [0025], [0026], [0030], [0032] *	3,4	
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 8 August 2018	Examiner Mirkovic, Olinka
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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