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(54) **WATER SUPPLY DEVICE**

WASSERVERSORGUNGSVORRICHTUNG

DISPOSITIF D'ALIMENTATION EN EAU

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(73) Proprietor: **Ebara Corporation**
Ohta-ku, Tokyo 144-8510 (JP)

(72) Inventors:
• **IKEDA, Masayoshi**
Tokyo 144-8510 (JP)
• **TEJIMA, Tomoharu**
Tokyo 144-8510 (JP)

- **NINOMIYA, Hironori**
Tokyo 144-8510 (JP)
- **KINOSHITA, Noboru**
Tokyo 144-8510 (JP)
- **TAMURA, Hiroyuki**
Tokyo 144-8510 (JP)
- **TATEISHI, Kazufumi**
Tokyo 144-8510 (JP)
- **NAKAJIMA, Kaoru**
Tokyo 144-8510 (JP)

(74) Representative: **Wimmer, Hubert**
WAGNER & GEYER
Gewürzmühlstrasse 5
80538 München (DE)

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Description

Technical field

[0001] The present invention relates to a water supply apparatus that pressurizes water from a water main pipe to supply the water to a building, such as an apartment building, a commercial building, or the like.

Background art

[0002] FIG. 7 is a schematic diagram showing a conventional water supply apparatus. As shown in FIG. 7, the water supply apparatus includes a pump 1 for pressurizing water, a motor 2 for rotating the pump 1, an inverter 3 for applying a voltage having a variable frequency to the motor 2, a discharge-side pressure sensor 16 for measuring a discharge-side pressure of the pump 1, and a controller 5 for controlling operation of the pump 1 through the inverter 3 and the motor 2 such that the discharge-side pressure, measured by the pressure sensor 16, is maintained at a preset target pressure.

[0003] A check valve 15 is disposed at a discharge side of the pump 1. A flow switch 19 is disposed at a discharge side of the check valve 15, and the pressure sensor 16 and a pressure tank 18 are disposed at a discharge side of the flow switch 19. The check valve 15 serves as a valve for preventing water from flowing backward when the pump 1 is stopped. The flow switch 19 serves as a flow-rate detector for detecting that the flow rate of the water, discharged from the pump 1, drops to a predetermined value. The pressure tank 18 serves as a pressure retaining device for retaining the discharge-side pressure when the pump 1 is not in operation. The flow switch 19 and the pressure sensor 16 are connected to the controller 5 through signal lines.

[0004] FIG. 8 is a diagram showing performance curves of the conventional water supply apparatus. In FIG. 8, a vertical axis represents the discharge-side pressure [Pa] and a horizontal axis represents the flow rate [L/min] of the water discharged from the pump 1. The rotational speed of the pump 1 is varied (N4 → N0) according to the flow rate of the water so that the discharge-side pressure is kept at a predetermined target pressure PA. An operation state when the flow rate of the water is 0 is referred to as shutoff operation or no-discharge operation. This shutoff operation is in a state of equilibrium in which the target pressure PA and the present discharge-side pressure are equal to each other, and is defined as a normally controlled state. However, because no water flows from the pump 1, this shutoff operation is a wasteful operation. For this reason, the water supply apparatus is designed to perform a low-flow-rate shutdown operation when the flow switch 19 detects a state in which the flow rate of the water has dropped to the predetermined value (this state will hereinafter be referred to as low-flow-rate state). Specifically, the operational speed of the pump 1 is increased temporarily until

the discharge-side pressure rises to a predetermined shutdown pressure, and then the operation of the pump 1 is stopped. The discharge-side pressure is retained by the pressure tank 18 and the check valve 15.

[0005] When the discharge-side pressure is lowered to a predetermined startup pressure, the controller 5 starts the operation of the pump 1. The pump 1 is driven at variable speeds based on output signal from the pressure sensor 16. Typically, the controller 5 performs a constant-discharge-pressure control under which the operational speed of the pump 1 is controlled such that the pressure signal measured by the pressure sensor 16, i.e., the discharge pressure of the pump 1, is kept at a preset constant target pressure regardless of the flow rate of the water discharged from the pump, or performs a constant-estimated-terminal pressure control under which a target pressure is varied in accordance with a pipe resistance so that the pressure of the water supplied to a terminal water tap is kept constant.

[0006] The use of the flow switch 19 is advantageous in that the flow switch 19 can easily detect the low-flow-rate state by only its detection signal, while the flow switch 19 is expensive in general and may fail to work properly when its inner detection float wears as a result of its repetitive motions (e.g., the inner detection float does not work due to adhesion). In addition, the flow switch may malfunction due to foreign matters trapped therein. In the event of such operation failures, the water supply apparatus may make an erroneous decision that the low-flow-rate state has occurred despite the fact that the low-flow-rate state does not actually occur, and hence may stop the operation of the pump 1, resulting in a reduction in the discharge pressure. The water supply apparatus may conversely make an erroneous decision that the low-flow-rate state does not occur despite the fact that the low-flow-rate state has actually occurred, and hence may not stop the operation of the pump 1. As a result, the shutoff operation is continued, thus causing overheat of the pump 1, a mechanical stress on the pump 1, and waste of energy.

[0007] As disclosed in JP 2002 130141 A, there has been proposed a water supply apparatus which is capable of detecting a low-flow-rate state without using a flow switch. This conventional flow-switch-less water supply apparatus is designed to detect the low-flow-rate state by switching a pump control mode from a feedback control (such as the constant-discharge-pressure control) to a fixed-rotational-speed control, rotating a pump at a rotational speed lower than a rotational speed that corresponds to a shutoff pressure, and detecting whether the discharge-side pressure drops or not.

[0008] According to the conventional process, however, it is necessary to switch the pump control mode from the feedback control to the fixed-rotational-speed control in order to detect the low-flow-rate state. Switching of the control mode may cause a sudden change in the pressure of the water discharged. In particular, the rotational speed of the pump may increase abruptly when the pump

control mode returns from the fixed-rotational-speed control to the feedback control.

Citation List

Patent Literatures

[0009] JP2002 54577 A discloses a pump controlling method. The pump controlling method is equipped with a control device to make speed change control of pumps using a discharge pressure sensor mounted near the discharge hole, and when pressure feedback control is to be conducted for converging the discharge pressure to a control target pressure, the control target pressure is decreased after the pressure is once raised at certain time intervals or after the pressure is left as it is, followed by returning of the control target pressure after the set period of time, and in the case the control target pressure is to be decreased when the rate of flow has lessened, the pumps are stopped using the phenomenon that the pump frequency is going to decrease through the action of the pressure feedback control.

Summary of Invention

Technical Problem

[0010] The present invention has been made in view of the above conventional drawback. It is therefore an object of the present invention to provide a water supply apparatus which is capable of detecting a low-flow-rate state while performing a discharge-side pressure feedback control, such as a constant-discharge-pressure control.

Solution to Problem

[0011] In accordance with the present invention, a water supply apparatus as set forth in claim 1 is provided. Further embodiments are inter alia disclosed in the dependent claims. For example, in order to achieve the above object, according to an aspect of the present invention, there is provided a water supply apparatus comprising: a pump; a motor configured to rotate the pump; an inverter configured to apply a voltage having a variable frequency to the motor; a discharge-side pressure sensor configured to measure a discharge-side pressure of the pump; and a controller configured to perform a feedback control of controlling a rotational speed of the pump through the motor and the inverter based on a measured value of the discharge-side pressure of the pump in order to keep the discharge-side pressure at a predetermined target pressure. The controller stores therein a first lower limit value of the rotational speed which is higher than a shutoff rotational speed, and a second lower limit value of the rotational speed which is lower than the shutoff rotational speed, the shutoff rotational speed being a rotational speed required for achieving the target pressure

in a shutoff state. The controller is configured to switch a lower limit of the rotational speed of the pump from the first lower limit value to the second lower limit value, and determine that the pump is in a low-flow-rate state if the rotational speed of the pump becomes equal to or lower than the shutoff rotational speed within a predetermined detection time.

[0012] In accordance with the present invention, the controller is configured to switch the lower limit of the rotational speed of the pump from the first lower limit value to the second lower limit value if the rotational speed of the pump has been not more than the first lower limit value continuously for a predetermined confirmation time.

[0013] In a preferred aspect of the present invention, the controller is configured to switch the lower limit of the rotational speed of the pump from the first lower limit value to the second lower limit value if the rotational speed of the pump has been not more than the first lower limit value and the discharge-side pressure has been higher than a predetermined management value continuously for the predetermined confirmation time.

[0014] In a preferred aspect of the present invention, the management value is equal to the target pressure for a shutoff operation.

[0015] In a preferred aspect of the present invention, the controller determines that the pump is in the low-flow-rate state if the rotational speed of the pump becomes equal to or lower than the shutoff rotational speed within the predetermined detection time and the rotational speed of the pump has been not more than the shutoff rotational speed continuously for a predetermined monitoring time.

[0016] In a preferred aspect of the present invention, the target pressure is constant regardless of a flow rate of water discharged from the pump.

[0017] In a preferred aspect of the present invention, the target pressure is varied according to a flow rate of water discharged from the pump.

Advantageous Effect of Invention

[0018] When the pump is in the low-flow-rate state or in the shutoff state, an operating point of the pump is on a pump performance curve that represents the first lower limit value. When the first lower limit value is switched to the second lower limit value in this state, the rotational speed of the pump quickly decreases based on the feedback control. Therefore, the controller can detect the low-flow-rate state from such a decrease in the rotational speed of the pump.

Brief Description of Drawings

[0019]

FIG. 1 is a diagram showing a water supply apparatus according to an embodiment of the present in-

vention;

FIG. 2 is a diagram showing pump performance curves of the water supply apparatus according to the present invention;

FIG. 3 is a flowchart showing an operation of a low-flow-rate detection;

FIG. 4 is a diagram showing pump performance curves illustrating a constant-estimated-terminal pressure control;

FIG. 5 is a diagram showing a direct-coupling-type water supply apparatus;

FIG. 6 is a diagram showing an embodiment of a water supply apparatus which has two sets of pumps, motors, and inverters;

FIG. 7 is a schematic diagram showing a conventional water supply apparatus; and

FIG. 8 is a diagram showing pump performance curves of the conventional water supply apparatus.

Description of Embodiments

[0020] Embodiments of the present invention will be described with reference to the drawings.

[0021] FIG. 1 is a diagram showing a water supply apparatus according to an embodiment of the present invention. Structural elements of this embodiment which are identical to those shown in FIG. 7 are denoted by the same reference numerals, and repetitive descriptions thereof will be omitted.

[0022] The water supply apparatus according to the present embodiment has the same basic structures as those of the water supply apparatus shown in FIG. 7, but is different from the water supply apparatus shown in FIG. 7 in that the water supply apparatus according to the present embodiment has no flow switch. The water supply apparatus of this embodiment includes a controller 10 for controlling a rotational speed of a pump 1 through a motor 2 and an inverter 3 based on a discharge-side pressure that is measured by a pressure sensor 16. More specifically, the controller 10 is configured to perform a feedback control for controlling the rotational speed of the pump 1 based on the discharge-side pressure measured by the pressure sensor 16 such that the discharge-side pressure of the pump 1 is maintained at a preset target pressure.

[0023] Examples of the feedback control include a constant-discharge-pressure control under which the operational speed of the pump 1 is controlled such that the discharge-side pressure is maintained at a constant target pressure regardless of the flow rate of the water discharged from the pump 1, and a constant-estimated-terminal pressure control under which a target pressure is varied in accordance with a pipe resistance so that the pressure of the water supplied to a terminal water tap is kept constant.

[0024] The controller 10 is configured to send to the inverter 3 a command value for the rotational speed of the pump 1 for eliminating a difference between the

present discharge-side pressure, measured by the pressure sensor 16, and the preset target pressure. In accordance with the command value for the rotational speed, the inverter 3 drives the motor 2 to rotate the pump 1 at a rotational speed indicated by the command value. The controller 10 further has a function to detect a state in which the flow rate of the water, discharged from the pump 1, has reached a predetermined lower limit, i.e., a low-flow-rate state, based on the aforementioned feedback control.

[0025] FIG. 2 is a diagram showing pump performance curves of the water supply apparatus according to the present invention. FIG. 2 illustrates an example of the constant-discharge-pressure control in which the target pressure is constant regardless of the flow rate of the water. The controller 10 stores in advance a first lower limit value L1 and a second lower limit value L2, both of which are lower limits of the rotational speed of the pump 1. The first lower limit value L1 is set to be higher than a rotational speed N0 of the pump 1 which corresponds to a target pressure PA at a shutoff operation (which will be hereinafter referred to as shutoff rotational speed N0), while the second lower limit value L2 is set to be lower than the shutoff rotational speed N0. Specifically, the first lower limit value L1 is a value of 105% of the shutoff rotational speed N0 ($N0 \times 1.05$) and is slightly higher than the shutoff rotational speed N0. The second lower limit value L2 is a value of 95% of the shutoff rotational speed N0 ($N0 \times 0.95$) and is slightly lower than the shutoff rotational speed N0. These coefficients 105%, 95% are given by way of example only. The present invention is not limited to these numerical values, and they may be changed within an operationally trouble-free range in which a detection time for the low-flow-rate state is not too long. The shutoff rotational speed N0 is a rotational speed of the pump 1 required for the pump 1 to achieve the predetermined target pressure PA when the pump 1 is in the shutoff operation, i.e., when the flow rate is 0. This shutoff rotational speed N0 is stored in advance in the controller 10.

[0026] The controller 10 has a function to switch the lower limit of the rotational speed of the pump 1 between the first lower limit value L1 and the second lower limit value L2 during the operation of the pump 1. In a normal pump operation, the lower limit of the rotational speed of the pump 1 is set to the first lower limit value L1, so that the pump 1 is controlled to operate according to the feedback control within a speed range that is not less than the first lower limit value L1. Specifically, the rotational speed of the pump 1 is controlled by the controller 10 such that the discharge-side pressure of the pump 1 is maintained at the preset target pressure PA.

[0027] The pump 1 is operated at an operating point indicated by black dots in FIG. 2. As the flow rate of the water decreases, the rotational speed of the pump 1 also decreases and eventually it reaches the first lower limit value L1. As the flow rate of the water further decreases, the operating point of the pump 1 comes onto a pump

performance curve that represents the first lower limit value L1, as shown in FIG. 2. In the low-flow-rate state, particularly in the shutoff state (when the flow rate is 0), the present discharge-side pressure measured by the pressure sensor 16 is higher than the target pressure PA, without exception. The controller 10 sends to the inverter 3 a rotational-speed command value that is equal to or lower than the shutoff rotational speed N0 in order to eliminate the difference between the present discharge-side pressure and the target pressure PA. Therefore, when the lower limit of the rotational speed of the pump 1 is switched from the first lower limit value L1 to the second lower limit value L2, the rotational speed of the pump 1 quickly decreases to a speed equal to or lower than the shutoff rotational speed N0. Such a decrease in the rotational speed of the pump 1 is indicated as a decrease in the command value for the rotational speed of the pump 1. The controller 10 can detect the decrease in the rotational speed of the pump 1 from the command value for the rotational speed generated by the controller 10 itself.

[0028] As described above, when the lower limit of the rotational speed of the pump 1 is switched from the first lower limit value L1 to the second lower limit value L2 in the low-flow-rate state (and in the shutoff state), the rotational speed of the pump 1 quickly drops according to the feedback control that functions to maintain the target pressure PA. Therefore, the controller 10 is able to detect the low-flow-rate state from such a drop in the rotational speed of the pump 1.

[0029] According to the conventional method of detecting the low-flow-rate state, the control mode is switched from the feedback control to the fixed-rotational-speed control. In contrast, the controller 10 according to the present invention performs the feedback control for maintaining the target pressure PA even when the low-flow-rate state is detected. Specifically, the rotational speed of the pump 1 is controlled according to the feedback control when the operation of the water supply apparatus is switched from a normal water-supply operation to the operation of detecting the low-flow-rate state and also when the operation of the water supply apparatus is returned from the operation of detecting the low-flow-rate state to the normal water-supply operation. Consequently, the rotational speed of the pump 1 does not change suddenly, and therefore the pump 1 can perform a smooth water-supply operation.

[0030] Details of the operation of detecting the low-flow-rate state will be described below with reference to FIG. 3. FIG. 3 is a flowchart showing the operation of detecting the low-flow-rate state. As shown in FIG. 3, the controller 10 determines whether the command value for the rotational speed of the pump 1 is not more than the first lower limit value L1 (step 1). If the command value for the rotational speed of the pump 1 is not more than the first lower limit value L1, the controller 10 compares the present discharge-side pressure obtained from the pressure sensor 16 with a predetermined management

value, and determines whether the present discharge-side pressure is higher than the management value or not (step 2). This management value is the same value as the target pressure PA at the shutoff operation.

[0031] If the command value for the rotational speed of the pump 1 is not more than the first lower limit value L1 and the present discharge-side pressure is higher than the management value, the controller 10 repeats the processes of the step 1 and the step 2 until a preset confirmation time (e.g., 10 seconds) elapses (step 3). If the command value for the rotational speed of the pump 1 has been not more than the first lower limit value L1 continuously for the confirmation time and the present discharge-side pressure has been higher than the management value continuously for the confirmation time, the controller 10 switches the lower limit of the rotational speed of the pump 1 from the first lower limit value L1 to the second lower limit value L2 (step 4). The controller 10 then determines whether the command value for the rotational speed of the pump 1 is not more than the shutoff rotational speed N0 (step 5). The controller 10 further determines whether the command value for the rotational speed of the pump 1 has decreased to a value that is not more than the shutoff rotational speed N0 within a predetermined detection time (e.g., 2 seconds) (step 6). When the water is being discharged at a certain flow rate, the rotational speed of the pump 1 is lowered slowly (e.g., over a time longer than 2 seconds), even after the lower limit of the rotational speed of the pump 1 is switched from the first lower limit value L1 to the second lower limit value L2. Therefore, in such a case, the controller 10 does not determine that the pump 1 is in the low-flow-rate state.

[0032] If the command value for the rotational speed of the pump 1 has decreased to a value that is not more than the shutoff rotational speed N0 within the detection time, the controller 10 repeats the processes of the step 5 and the step 6 until a preset monitoring time (e.g., 2 seconds) elapses (step 7). If the pump 1 is in the low-flow-rate state or in the shutoff state, the discharge-side pressure is retained by the check valve 15. Therefore, the difference between the present discharge-side pressure and the target pressure PA does not become zero. The controller 10 generates a command value for the rotational speed of the pump 1 for lowering the present discharge-side pressure to the target pressure PA. As a result, the rotational speed of the pump 1 reaches a value that is not more than the shutoff rotational speed N0. If the command value for the rotational speed of the pump 1 has been not more than the shutoff rotational speed N0 continuously for the predetermined monitoring time, the controller 10 determines the low-flow-rate state (step 8). After determining the low-flow-rate state, the controller 10 performs a pressure accumulating operation, which is an operation of temporarily speeding up the pump 1 to increase the pressure in a pressure tank 18 (step 9). Thereafter, the controller 10 stops the pump 1 (step 10).

[0033] The above-discussed operation of the controller 10 for detecting the low-flow-rate state is applicable to not only the constant-discharge-pressure control, but also to the constant-estimated-terminal pressure control. FIG. 4 is diagram showing pump performance curves illustrating the constant-estimated-terminal pressure control. The constant-estimated-terminal pressure control is a control technique in which a target pressure is varied in accordance with a pipe resistance so that the pressure of the water supplied to a terminal water tap is kept constant. In FIG. 4, a curved line R represents target pressure that varies in accordance with the pipe resistance. The pipe resistance increases in accordance with the flow rate. The target pressure at a maximum rotational speed N3 of the pump 1 is denoted by PA, and the target pressure at the shutoff operation is denoted by PB. The target pressure gradually increases from PB to PA in accordance with the flow rate.

[0034] In this example also, the first lower limit value L1 of the rotational speed of the pump 1 is also set to be slightly higher than the shutoff rotational speed N0 which is a required speed for achieving the target pressure PB in the shutoff operation. The second lower limit value L2 is set to be slightly lower than the shutoff rotational speed N0. For example, the first lower limit value L1 is set to 105% of the shutoff rotational speed N0, and the second lower limit value L2 is set to 95% of the shutoff rotational speed N0.

[0035] As the flow rate decreases, the rotational speed of the pump 1 also decreases and eventually it reaches the first lower limit value L1. As the flow rate of the water further decreases, the operating point of the pump 1 comes onto a pump performance curve that represents the first lower limit value L1, as shown in FIG. 4. In the low-flow-rate state, particularly in the shutoff state (when the flow rate is 0), the present discharge-side pressure measured by the pressure sensor 16 is higher than the target pressure corresponding to the flow rate, without exception. The controller 10 sends to the inverter 3 a rotational-speed command value that is equal to or lower than the shutoff rotational speed N0 in order to eliminate the difference between the present discharge-side pressure and the target pressure. Therefore, when the lower limit of the rotational speed of the pump 1 is switched from the first lower limit value L1 to the second lower limit value L2, the rotational speed of the pump 1 quickly decreases to a speed equal to or lower than the shutoff rotational speed N0. The controller 10 detects the low-flow-rate state from such a decrease in the rotational speed of the pump 1.

[0036] The water supply apparatus shown in FIG. 1 is designed to draw in the water from a water receiving tank. The present invention is also applicable to a so-called direct-coupling-type water supply apparatus that is directly connected to a water main pipe. FIG. 5 is a diagram showing a direct-coupling-type water supply apparatus. The direct-coupling-type water supply apparatus has the same basic structure as the water supply apparatus

shown in FIG. 1, except that it has a suction-side pressure sensor 20 disposed at a suction side of the pump 1 for measuring a suction-side pressure, and further has a backflow prevention device 21 for preventing the water from flowing backward from the water supply apparatus into the water main pipe. The suction-side pressure sensor 20 is connected to controller 10, so that the suction-side pressure sensor 20 can send a measured value of the suction-side pressure to the controller 10. The controller 10 is configured to detect the low-flow-rate state according to the process discussed above.

[0037] Furthermore, the present invention is also applicable to a water supply apparatus including a plurality of pumps. FIG. 6 is a diagram showing an embodiment of a water supply apparatus having plural sets of pumps, motors, and inverters. The water supply apparatus shown in FIG. 6 includes two pumps 1, 1 connected parallel to each other, two motors 2, 2 for rotating the pumps 1, 1, respectively, and two inverters 3, 3 for applying voltages having variable frequencies to the motors 2, 2, respectively. The inverters 3, 3 are connected to controller 10. Check valves 15, 15 are disposed at the discharge sides of the pumps 1, 1, respectively. A pressure sensor 16 and a pressure tank 18 are disposed at the discharge side of the check valves 15, 15. The controller 10 is configured to detect the low-flow-rate state according to the process discussed above.

[0038] The water supply apparatus shown in FIG. 6 is designed to draw in the water from a water receiving tank, while the present invention is also applicable to a direct-coupling-type water supply apparatus including a plurality of pumps. In such a direct-coupling-type water supply apparatus including a plurality of pumps, the suction-side pressure sensor 20 and the backflow prevention device 21 shown in FIG. 5 are disposed upstream of the pumps 1, 1.

[0039] In addition, the present invention is also applicable to a so-called flow-switch-less water supply apparatus having no flow switch, and is further applicable to a water supply apparatus including a flow switch in case a malfunction of the flow switch occurs. The latter water supply apparatus to which the present invention is applied does not need to have the malfunctioning flow switch removed, and is capable of detecting the low-flow-rate state independently of a detection signal from the flow switch. Even after the flow switch is subsequently made normal by repair or replacement, the water supply apparatus may detect the low-flow-rate state based on the flow switch or the above-discussed technique according to the present invention selectively so as to perform the water supply operation.

[0040] The previous description of embodiments is provided to enable a person skilled in the art to make and use the present invention. Moreover, various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles and specific examples defined herein may be applied to other embodiments. Therefore, the present invention is not in-

tended to be limited to the embodiments described herein but is to be accorded the widest scope as defined by limitation of the claims.

Industrial Applicability

[0041] The present invention is applicable to a water supply apparatus that pressurizes water from a water main pipe to supply the water to a building, such as an apartment building, a commercial building, or the like.

Reference Signs List

[0042]

- 1 pump
- 2 motor
- 3 inverter
- 5, 10 controller
- 15 check valve
- 16 discharge-side pressure sensor
- 18 pressure tank
- 19 flow switch
- 20 suction-side pressure sensor
- 21 backflow prevention device

Claims

1. A water supply apparatus comprising:
 - a pump (1);
 - a motor (2) configured to rotate the pump (1);
 - an inverter (3) configured to apply a voltage having a variable frequency to the motor (2);
 - a check valve (15) disposed at a discharge side of the pump (1); a discharge-side pressure sensor (16) configured to measure a discharge-side pressure of the pump (1) at a discharge side of the check valve (15); and
 - a controller (5, 10) configured to perform a feedback control of controlling a rotational speed of the pump (1) through the motor (2) and the inverter (3) based on a measured value of the discharge-side pressure of the pump (1) in order to keep the discharge-side pressure at a predetermined target pressure, **characterized in that** the controller (5, 10) is configured to store therein a first lower limit value of the rotational speed which is higher than a shutoff rotational speed, and a second lower limit value of the rotational speed which is lower than the shutoff rotational speed, the shutoff rotational speed being a rotational speed required for achieving the target pressure in a shutoff state, and the controller (5, 10) is configured to

switch a lower limit of a command value of

the rotational speed of the pump (1) from the first lower limit value to the second lower limit value if the command value of the rotational speed of the pump (1) has been not more than the first lower limit value continuously for a predetermined confirmation time, and determine that the pump (1) is in a low-flow-rate state if the command value of the rotational speed of the pump (1) becomes equal to or lower than the shutoff rotational speed within a predetermined detection time.

2. The water supply apparatus according to claim 1, wherein the controller (5, 10) is configured to switch the lower limit of the command value of the rotational speed of the pump (1) from the first lower limit value to the second lower limit value if the command value of the rotational speed of the pump (1) has been not more than the first lower limit value and the discharge-side pressure has been higher than a predetermined management value continuously for the predetermined confirmation time.
3. The water supply apparatus according to claim 2, wherein the management value is equal to the target pressure for a shutoff operation.
4. The water supply apparatus according to any one of claims 1 through 3, wherein the controller (5, 10) determines that the pump (1) is in the low-flow-rate state if the command value of the rotational speed of the pump (1) becomes equal to or lower than the shutoff rotational speed within the predetermined detection time and the command value of the rotational speed of the pump (1) has been not more than the shutoff rotational speed continuously for a predetermined monitoring time.
5. The water supply apparatus according to any one of claims 1 through 4, wherein the target pressure is constant regardless of a flow rate of water discharged from the pump (1).
6. The water supply apparatus according to any one of claims 1 through 4, wherein the target pressure is varied according to a flow rate of water discharged from the pump (1).

Patentansprüche

1. Wasserversorgungsvorrichtung, die Folgendes aufweist.
 - eine Pumpe (1);
 - einen Motor (2), der konfiguriert ist, um die Pumpe (1) zu drehen;
 - einen Inverter bzw. Wechselrichter (3), der konfigu-

riert ist, um eine Spannung mit einer variablen Frequenz an den Motor (2) anzulegen;
ein Rückschlagventil (15), welches auf einer Auslassseite der Pumpe (1) angeordnet ist;
einen Auslassseitendrucksensor (16), der konfiguriert ist, um einen Auslassseitendruck der Pumpe (1) an einer Auslassseite des Rückschlagventils (15) zu messen; und

eine Steuervorrichtung (5, 10), die konfiguriert ist, um eine Rückkoppelungssteuerung bzw. Regelung zum Steuern einer Drehzahl der Pumpe (1) durch den Motor (2) und den Inverter (3) auszuführen, und zwar basierend auf einem gemessenen Wert des Auslassseitendruckes der Pumpe (1), um den Auslassseitendruck auf einem vorbestimmten Zieldruck zu halten,

dadurch gekennzeichnet, dass

die Steuervorrichtung (5, 10) konfiguriert ist, darin einen ersten unteren Grenzwert der Drehzahl zu speichern, der höher ist als eine Abschaltzahl, und einen zweiten unteren Grenzwert der Drehzahl, der niedriger ist als die Abschaltzahl, wobei die Abschaltzahl eine Drehzahl ist,

die erforderlich ist, um den Zieldruck in einem Abschaltzustand zu erreichen, und

die Steuervorrichtung (5, 10) konfiguriert ist zum Schalten einer unteren Grenze eines Befehlswertes der Drehzahl der Pumpe (1) von dem ersten unteren Grenzwert zu dem zweiten unteren Grenzwert, wenn der Befehlswert der Drehzahl der Pumpe (1) kontinuierlich für eine vorbestimmte Bestätigungszeit nicht größer als der erste untere Grenzwert gewesen ist und

Bestimmen, dass die Pumpe (1) in einem Zustand mit niedriger Flussrate ist, wenn der Befehlswert der Drehzahl der Pumpe (1) innerhalb einer vorbestimmten Detektionszeit gleich oder niedriger als die Abschaltzahl wird.

2. Wasserversorgungsvorrichtung nach Anspruch 1, wobei die Steuervorrichtung (5, 10) konfiguriert ist, um die untere Grenze des Befehlswertes der Drehzahl der Pumpe (1) von dem ersten unteren Grenzwert zu dem zweiten unteren Grenzwert zu schalten, wenn der Befehlswert der Drehzahl der Pumpe (1) nicht größer als der erste untere Grenzwert gewesen ist und der Auslassseitendruck höher als ein vorbestimmter Managementwert gewesen ist, und zwar kontinuierlich für die vorbestimmte Bestätigungszeit.
3. Wasserversorgungsvorrichtung nach Anspruch 2, wobei der Managementwert gleich dem Zieldruck für einen Abschaltvorgang ist.
4. Wasserversorgungsvorrichtung nach einem der Ansprüche 1 bis 3, wobei die Steuervorrichtung (5, 10) bestimmt, dass die Pumpe (1) in einem Zustand mit niedrigem Fluss ist, wenn der Befehlswert der Dreh-

zahl der Pumpe (1) innerhalb der vorbestimmten Detektionszeit gleich der oder niedriger als die Abschaltzahl wird, und der Befehlswert der Drehzahl der Pumpe (1) kontinuierlich für eine vorbestimmte Überwachungszeit nicht größer als die Abschaltzahl gewesen ist.

5. Wasserversorgungsvorrichtung nach einem der Ansprüche 1 bis 4, wobei der Zieldruck ungeachtet einer Flussrate des Wassers, welches aus der Pumpe (1) ausgelassen wird, konstant ist.

6. Wasserversorgungsvorrichtung nach einem der Ansprüche 1 bis 4, wobei der Zieldruck gemäß einer Flussrate des Wassers variiert wird, welches aus der Pumpe (1) ausgegeben wird.

Revendications

1. Dispositif d'alimentation en eau, comprenant :

une pompe (1) ;
un moteur (2) agencé pour faire tourner la pompe (1) ;
un onduleur (3) agencé pour appliquer au moteur (2) une tension ayant une fréquence variable ;
un clapet anti-retour (15) disposé au niveau d'un côté de refoulement de la pompe (1) ;
un capteur de pression du côté refoulement (16) agencé pour mesurer une pression du côté refoulement de la pompe (1) au niveau d'un côté de refoulement du clapet anti-retour (15) ; et
un contrôleur (5, 10) agencé pour réaliser un contrôle de rétroaction dans la commande de la vitesse de rotation de la pompe (1) par l'intermédiaire du moteur (2) et de l'onduleur (3) sur la base d'une valeur mesurée de la pression du côté refoulement de la pompe (1) afin de maintenir la pression du côté refoulement à une pression cible prédéterminée,

caractérisé en ce que le contrôleur (5, 10) est agencé pour mémoriser une première valeur limite inférieure de la vitesse de rotation qui est supérieure à une vitesse de rotation de coupure, et une deuxième valeur limite inférieure de la vitesse de rotation qui est inférieure à la vitesse de rotation de coupure, la vitesse de rotation de coupure étant une vitesse de rotation requise pour atteindre la pression cible dans un état de coupure, et
le contrôleur (5, 10) est agencé pour

commuter une limite inférieure d'une valeur de commande de la vitesse de rotation de la pompe (1) à partir de la première valeur limite inférieure vers la deuxième valeur li-

- mite inférieure si la valeur de commande de la vitesse de rotation de la pompe (1) n'a pas été supérieure à la première valeur limite inférieure de manière continue pendant un temps de confirmation prédéterminé, et
 déterminer que la pompe (1) est dans un état de faible débit si la valeur de commande de la vitesse de rotation de la pompe (1) devient égale ou inférieure à la vitesse de rotation de coupure dans un délai de détection prédéterminé.
2. Dispositif d'alimentation en eau selon la revendication 1, dans lequel le contrôleur (5, 10) est agencé pour commuter la limite inférieure de la valeur de commande de la vitesse de rotation de la pompe (1) à partir de la première valeur limite inférieure vers la deuxième valeur limite inférieure si la valeur de commande de la vitesse de rotation de la pompe (1) n'a pas été supérieure à la première valeur limite inférieure et la pression du côté refoulement a été supérieure à une valeur de gestion prédéterminée de manière continue pendant le temps de confirmation prédéterminé.
3. Dispositif d'alimentation en eau selon la revendication 2, dans lequel la valeur de gestion est égale à la pression cible pour une opération de coupure.
4. Dispositif d'alimentation en eau selon l'une quelconque des revendications 1 à 3, dans lequel le contrôleur (5, 10) détermine que la pompe (1) est dans l'état de faible débit si la valeur de commande de la vitesse de rotation de la pompe (1) devient égale ou inférieure à la vitesse de rotation de coupure dans le délai de détection prédéterminé et la valeur de commande de la vitesse de rotation de la pompe (1) n'a pas été supérieure à la vitesse de rotation de coupure de manière continue pendant un temps de surveillance prédéterminé.
5. Dispositif d'alimentation en eau selon l'une quelconque des revendications 1 à 4, dans lequel la pression cible est constante quel que soit le débit d'eau refoulé par la pompe (1) .
6. Dispositif d'alimentation en eau selon l'une quelconque des revendications 1 à 4, dans lequel on fait varier la pression cible en fonction du débit d'eau refoulé par la pompe (1) .

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FIG. 1

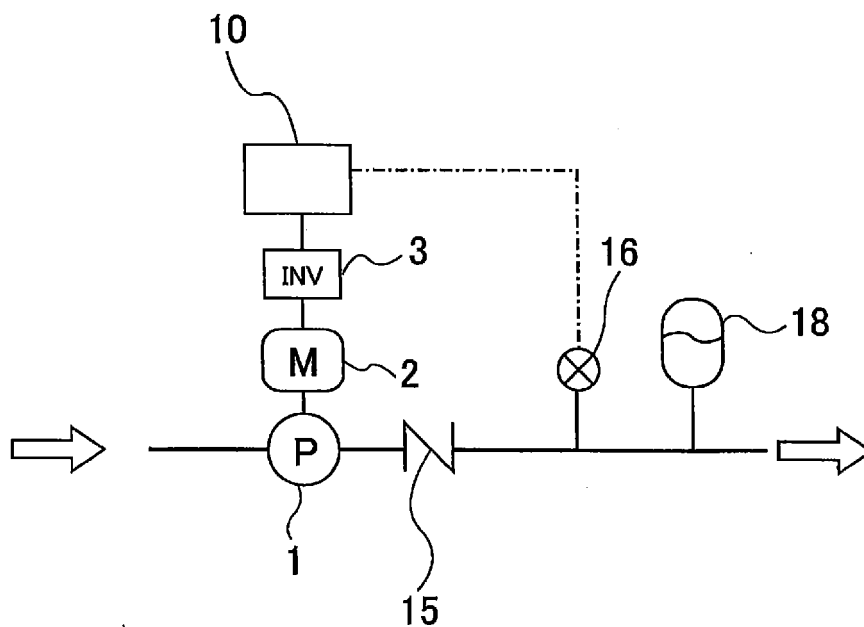


FIG. 2

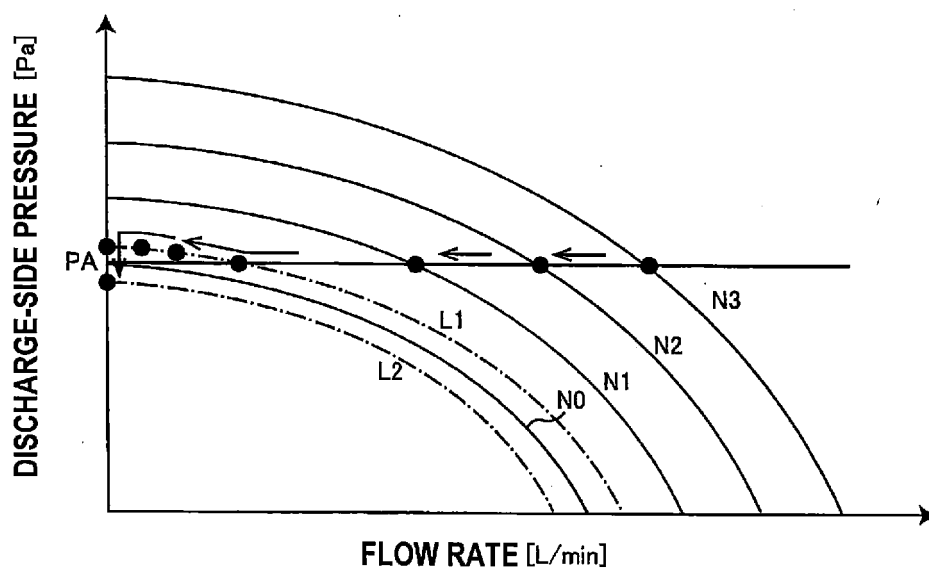


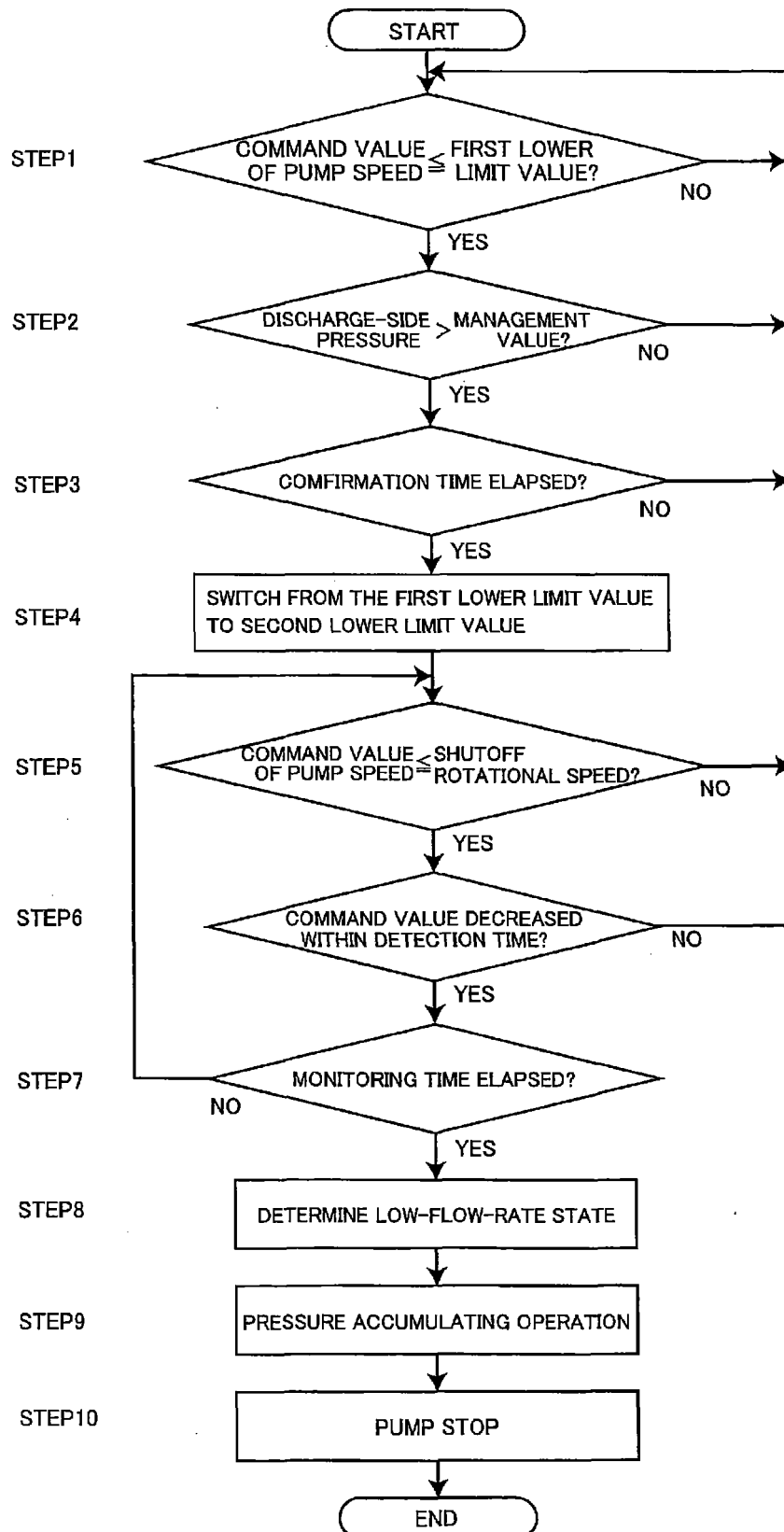
FIG. 3

FIG. 4

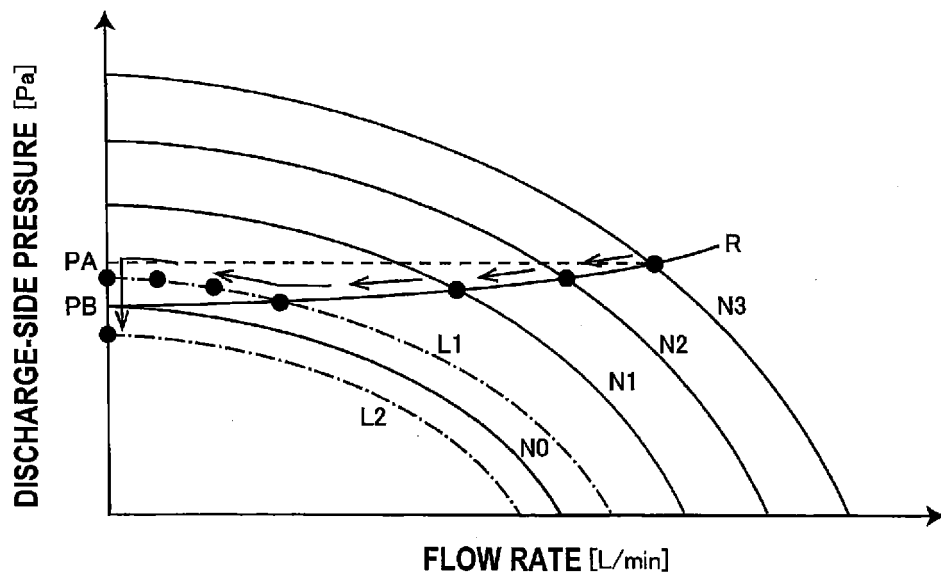


FIG. 5

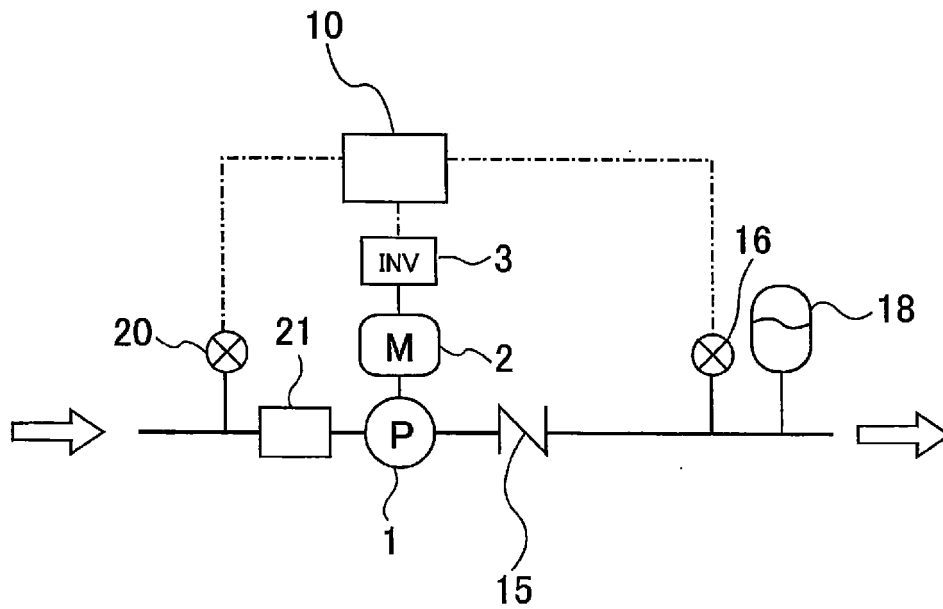


FIG. 6

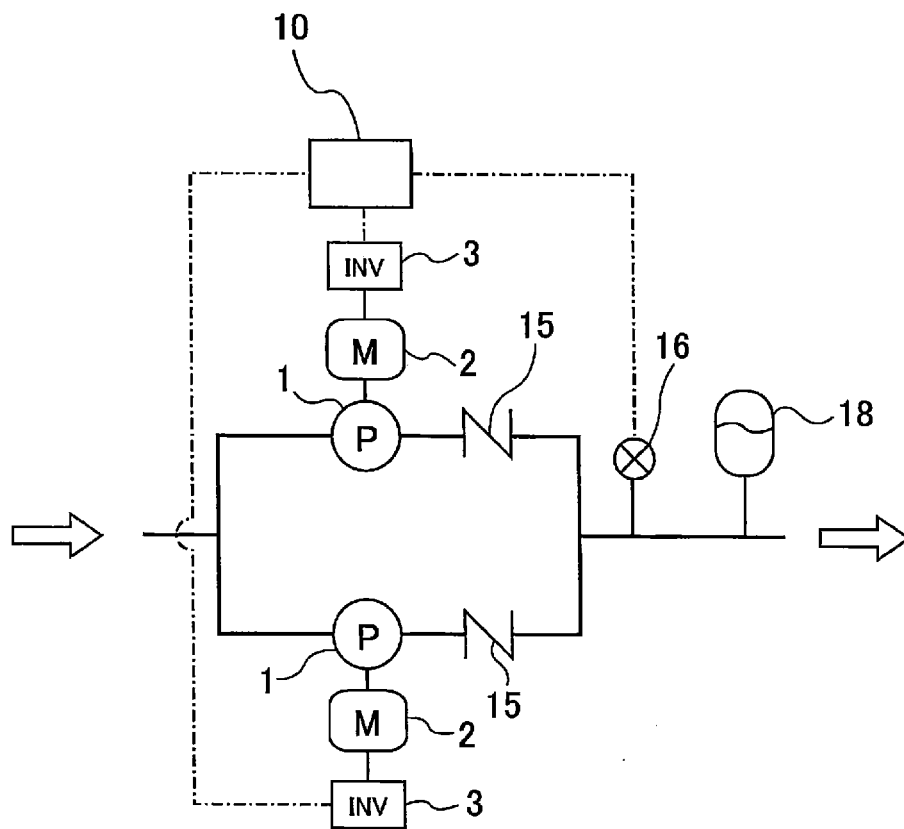


FIG. 7

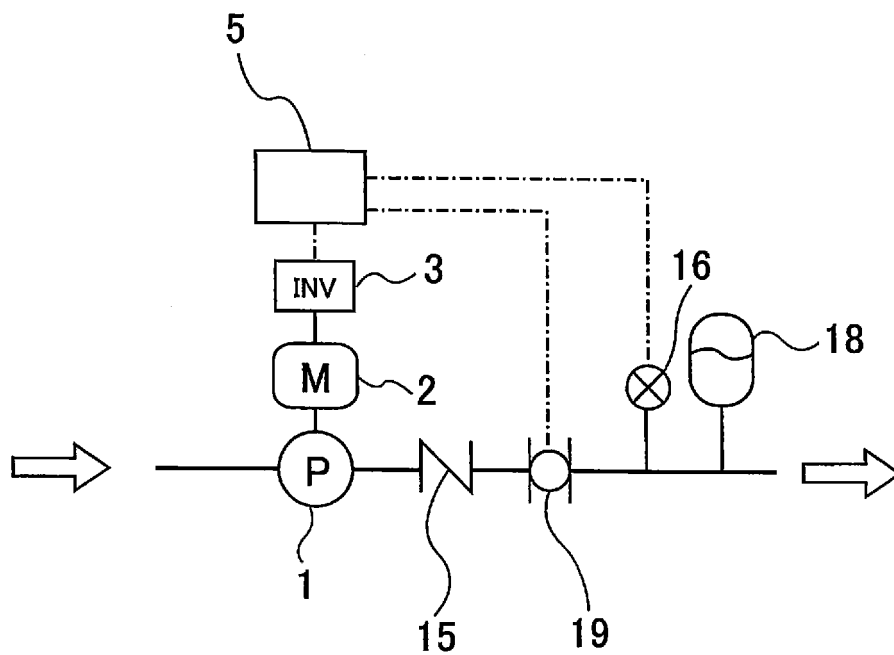
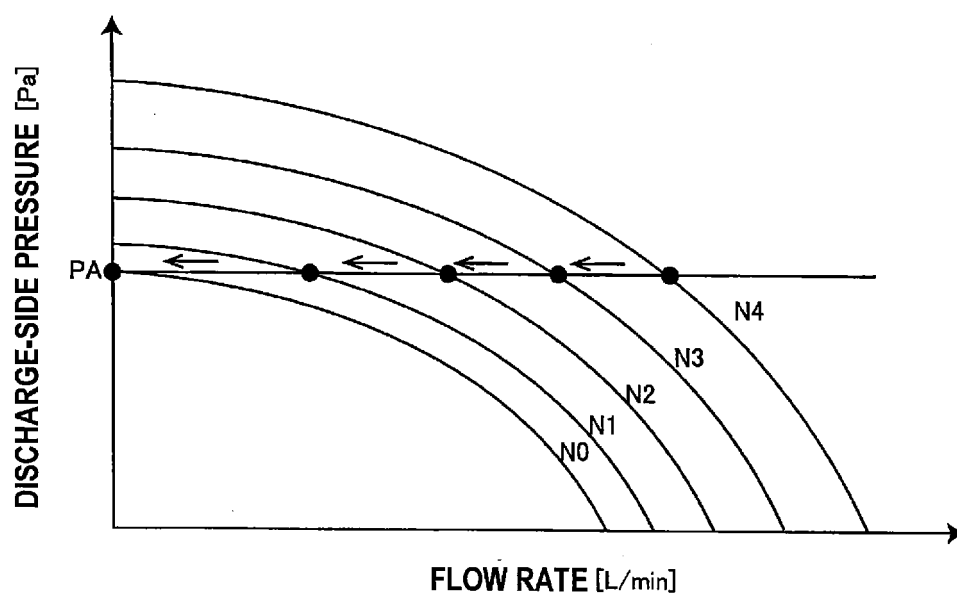


FIG. 8



REFERENCES CITED IN THE DESCRIPTION

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