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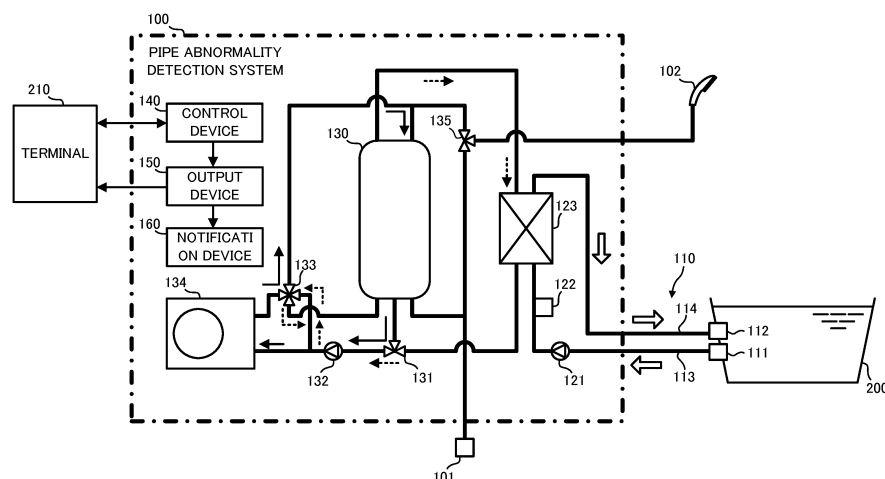
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(54) **PIPE ABNORMALITY DETECTION SYSTEM, PIPE ABNORMALITY DETECTION METHOD AND PROGRAM**

(57) A pipe abnormality detection system (100) is provided with: a pipe (110) which includes a flow inlet (111) into which water in a bathtub (200) flows, and a flow outlet (112) through which water flows out to the bathtub (200); a pump (121) which circulates the water between the pipe (110) and the bathtub (200); a pressure detection sensor (122) which detects the internal pressure of the pipe (110); and an output device (150) which

outputs a signal indicating that an abnormality of the pipe (110) is detected when at least one among a difference between the pressure detected by the pressure detection sensor (122) when the pump (121) is stopped and the pressure detected by the pressure detection sensor (122) when the pump (121) is operating, and a rate of change in the difference relative to a rotational frequency of the pump (121), deviates from a predetermined range.

FIG.1



Description

Technical Field

[0001] The present disclosure relates to a pipe abnormality detection system, a pipe abnormality detection method and program.

Background Art

[0002] Water heaters in recent years have increasing functionality enabling not only the mere generation of hot water but also (i) adjusting temperature of the hot water to be supplied such that the hot water has an optimal temperature and (ii) filling a bathtub with an optimal quantity of hot water. Also, a water heater has appeared that can reheat bathwater and recover heat from the bathwater by conveying the bathwater with a pump and exchanging heat between the bathwater and water previously stored.

[0003] The above addition of high functionality to the water heaters causes an increase in the number of components of the water heaters and an increase in cost of such water heaters. For example, in order to fill the bathtub with an optimal quantity of hot water, a water level sensor for detecting a water level in the bathtub is used. Also, a flow switch for detecting hot water conveyed by the pump during operation of the pump is used.

[0004] Accordingly, simplified configurations of such water heaters are proposed (refer to Patent Literature 1 for example). A flow switch is conventionally used for determination of whether water is in the bathtub. However, in Patent Literature 1, the above determination is made using the water level sensor. As a result, whether water is in the bathtub can be determined even if the flow switch is omitted from the water heater.

Citation List

Patent Literature

[0005] Patent Literature 1: Unexamined Japanese Patent Application Kokai Publication No. H09-49659

Summary of Invention

Technical Problem

[0006] However, the flow switch may be used for detecting a pipe abnormality in addition to use in making the above determination. The technique described in Patent Literature 1 fails to consider detection of a pipe abnormality in a water heater from which the flow switch is omitted, and thus such configuration may make detection of the abnormality of the pipe difficult without using the flow switch.

[0007] In order to solve problems such as those described above, an objective of the present disclosure is

to detect an abnormality of the pipe without using any flow switch.

Solution to Problem

[0008] In order to achieve the above objective, a pipe abnormality detection system according to the present disclosure includes:

a pipe including a flow inlet into which water in a bathtub flows and a flow outlet through which the water passes into the bathtub;
a pump configured to circulate the water between the pipe and the bathtub;
detection means for detecting a pressure of an inside of the pipe; and
output means for outputting a signal indicating that an abnormality of the pipe is detected, when at least one of (i) a difference between the pressure detected by the detection means during stoppage of the pump and the pressure detected by the detection means during operation of the pump or (ii) a rate of change in the difference with respect to a rotational frequency of the pump is outside of a predetermined range.

Advantageous Effects of Invention

[0009] According to the present disclosure, when at least one of the difference between pressure of the inside of the pipe during stoppage of the pump and pressure of the inside of the pipe during operation of the pump or the rate of change in the difference is outside of the predetermined range, the signal indicating that an abnormality of the pipe is detected is output. As a result, the abnormality of the pipe can be detected without using any flow switch.

Brief Description of Drawings

[0010]

FIG. 1 is a drawing illustrating a configuration of a pipe abnormality detection system according to Embodiment 1;

FIG. 2 is a drawing illustrating a hardware configuration of a control device;

FIG. 3 is a drawing illustrating a functional configuration of the control device;

FIG. 4 is a view illustrating the relationship between the rotational frequency of the pump and a detected pressure in Embodiment 1;

FIG. 5 is a flow chart illustrating a process of detecting an abnormality of the pipe in Embodiment 1;

FIG. 6 is a flow chart illustrating a process of detecting an abnormality of the pipe in Embodiment 2;

FIG. 7 is a view illustrating the relationship between the rotational frequency of the pump and a pressure difference in Embodiment 2;

FIG. 8 is a drawing illustrating a configuration of a pipe abnormality detection system according to Embodiment 3;

FIG. 9 is a view illustrating the relationship between the rotational frequency of the pump and a detected pressure in Embodiment 3;

FIG. 10 illustrates a flow chart illustrating a process of detecting an abnormality of the pipe in Embodiment 3; and

FIG. 11 is a view for explaining a case in which the rate of change in the pressure difference is used instead of the pressure difference used in Embodiment 3.

Description of Embodiments

[0011] Embodiments of the present disclosure are described below in detail with reference to drawings. Hereinafter, "hot water", "high temperature water", "warm water", "low temperature water", and "cold water", are collectively called "water". The "hot water", "high temperature water" and "warm water" mean, for example, water obtained by heating municipal tap water or water having a temperature that is higher than the 36°C normal temperature of the human body. The "low temperature water" and "cold water" mean, for example, water obtained without heating the municipal tap water or water having a temperature of 36°C or less.

Embodiment 1

[0012] FIG. 1 illustrates a pipe abnormality detection system 100 according to Embodiment 1. The pipe abnormality detection system 100 is a heat pump-type water heating system configured to supply from a hot water-supply port 102 high temperature water obtained by heating the municipal tap water supplied from a water supply port 101 and to reheat water in a bathtub 200. In FIG. 1, thick solid lines denote pipes.

[0013] For example, municipal tap water, water supplied from waterworks, well water or water prepared by a user itself who uses the pipe abnormality detection system 100 is supplied to the water supply port 101. The hot water-supply port 102 is, for example, a tap arranged in a kitchen or a bathroom, a faucet, or a showerhead. In FIG. 1, the showerhead is illustrated as one example of the hot water-supply port 102. Hot water supplied from the hot water-supply port 102 is also supplied to the bathtub 200.

[0014] Also, the pipe abnormality detection system 100 detects abnormality of the pipe by using a pressure detecting sensor 122 instead of a flow switch. Abnormalities of the water pipe detected by the pipe abnormality detection system 100 include, for example, an abnormality caused by pipe collapse or pipe clogging such as pipe constriction or pipe blockage occurring in a pipe 110 connecting the pipe abnormality detection system 100 and the bathtub 200. Also, the abnormalities of the water pipe

detected can include abnormalities caused by filter clogging occurring in a filter arranged inside a water pipe, precipitation or deposition of a substance dissolving in water, and corrosion of the water pipe.

[0015] The pipe abnormality detection system 100 includes the pipe 110 for circulating water contained in the bathtub 200, a pump 121 to convey water in the pipe 110, the pressure detecting sensor 122 to detect pressure of the inside of the pipe 110, a heat exchanger 123 to exchange heat between the water in the bathtub 200 and water in a hot water storage tank 130, the hot water storage tank 130 for storing the high temperature water, a three-way valve 131 to switch a flow path connected to the bottom of the hot water storage tank 130, a pump 132 for circulating the water stored in the hot water storage tank 130, a four-way valve 133 to switch a flow path connected to an exhaust port of the pump 132, a heat pump unit 134 to heat the water stored in the hot water storage tank 130, a mixing valve 135 to mix the high temperature water acquired from the top portion of the hot water storage tank 130 and the water supplied from the water supply port 101 together, a control device 140 to control components of the pipe abnormality detection system 100, an output device 150 to output a signal indicating that an abnormality of the pipe 110 is detected, and a notification device 160 to notify a user of the abnormality of the pipe 110.

[0016] The pipe 110 includes a flow inlet 111 into which the water in the bathtub 200 flows and a flow outlet 112 through which water passes into the bathtub 200, and the pipe 110 forms a circulation path for circulating the water contained in the bathtub 200. The pipe 110 may include a tube or a pipe.

[0017] The pump 121 is, for example, a centrifugal pump or a diffuser pump that includes a motor and gears. The pump 121 is arranged at a predetermined position in the pipe 110. The pump 121 according to the present embodiment is arranged between the flow inlet 111 and the pressure detecting sensor 122. That is, the pump 121 is arranged on the upstream relative to the pressure detecting sensor 122. The pump 121 operates at a rotational frequency selected by the control device 140 to circulate water between the pipe 110 and the bathtub 200. More specifically, the pump 121 includes an inverter circuit as a driving device and changes a water flow rate in conveying the water by changing the driving rotational frequency in accordance with a control value indicated by a control signal transmitted from the control device 140. FIG. 1 illustrates directions of water flows generated by driving the pump 121, where the directions of water flows are represented by outlined-type arrows.

[0018] The pressure detecting sensor 122 is arranged at a specific position in the pipe 110. The pressure detecting sensor 122 according to the present embodiment is arranged between the pump 121 and the heat exchanger 123. That is, the pressure detecting sensor 122 is arranged on the downstream side relative to the pump 121 and on the upstream side relative to the heat exchanger

123. The pressure detecting sensor 122 is used as a water level sensor detecting a water level of the water stored in the bathtub 200 by detecting pressure of water in the pipe 110. Additionally, the pressure detecting sensor 122 is used for detecting an abnormality of the pipe 110. The pressure detecting sensor 122 has a gauge pressure detection range having both a positive pressure detection range and a negative pressure detection range. In the present embodiment, the positive pressure detection range is wider than the negative pressure detection range.

[0019] A first pipe portion 113 is defined by a portion of the pipe 110 extending from the flow inlet 111 to the specific position of the pressure detecting sensor 122 arranged, and a second pipe portion 114 is defined by a portion of the pipe 110 extending from the specific position to the flow outlet 112. The first pipe portion 113 is a return pipe for returning the water from the bathtub, and the second pipe portion 114 is a supply pipe by which water is supplied to the bathtub.

[0020] The heat exchanger 123 is arranged at a predetermined position in the pipe 110. The heat exchanger 123 according to the present embodiment is arranged between the pressure detecting sensor 122 and the flow outlet 112. That is, the heat exchanger 123 is arranged on the downstream side relative to the pressure detecting sensor 122. A water pipe for circulating the water of the hot water storage tank 130 passes through the primary side of the heat exchanger 123 and the pipe 110 passes through the secondary side of the heat exchanger 123. The heat exchanger 123 exchanges heat between the water in the bathtub 200 and the high temperature water in the hot water storage tank 130 and thus is used for reheating the water of the bathtub 200. The heat exchanger 123 may retrieve heat from the high temperature water of the bathtub 200 to heat the water of the hot water storage tank 130.

[0021] The hot water storage tank 130 is made of a metal represented by stainless steel or resin. The hot water storage tank 130 stores the high temperature water generated by the heat pump unit 134. The surface of the hot water storage tank 130 is covered with insulation and thus the high temperature water in the hot water storage tank 130 is kept hot over a long period of time. The bottom portion of the hot water storage tank 130 is connected to the water supply port 101 via a water pipe and the low temperature water is appropriately supplied via this water pipe.

[0022] Also, the bottom portion of the hot water storage tank 130 is connected to the three-way valve 131 via a water pipe. The three-way valve 131 switches a flow path in accordance with an instruction from the control device 140 by connecting a suction port of the pump 132 to one of the bottom portion of the hot water storage tank 130 and an outlet of the primary side of the heat exchanger 123. More specifically, during performing a water heating operation in which the water in the hot water storage tank 130 is heated, the three-way valve 131 forms a flow path

connecting the suction port of the pump 132 and the bottom portion of the hot water storage tank 130, as illustrated by solid-line arrows in FIG. 1. Also, during performing a reheating operation in which the water in the bathtub 200 is reheated, the three-way valve 131 forms a flow path connecting the suction port of the pump 132 and the outlet of the primary side of the heat exchanger 123, as illustrated by dashed-line arrows in FIG. 1.

[0023] Also, the bottom portion of the hot water storage tank 130 is connected to the four-way valve 133 via a water pipe. The four-way valve 133 forms, in accordance with an instruction from the control device 140, a first flow path connecting an exhaust port of the heat pump unit 134 and the top portion of the hot water storage tank 130 or a second flow path connecting an exhaust port of the pump 132 and the bottom portion of the hot water storage tank 130. More specifically, during performing the water heating operation, the four-way valve 133 forms the first flow path, as illustrated by solid-line arrows in FIG. 1, and, during performing the reheating operation, the four-way valve 133 forms the second flow path, as illustrated by dashed-line arrows in FIG. 1. When the first flow path is formed, the second flow path is closed and thus is not formed, and when the second flow path is formed, the first flow path is closed and thus is not formed.

[0024] The heat pump unit 134 is a device to heat water by circulating refrigerant represented by CO₂ or a hydrofluorocarbon (HFC) in accordance with an instruction from the control device 140. The heat pump unit 134 includes (i) a refrigerant circuit constituted by a compressor, a first heat exchanger to exchange heat between the refrigerant and the water, an expansion valve, and a second heat exchanger to exchange heat between outside air and the refrigerant that are connected to one another in that order, (ii) a blower to send air to the second heat exchanger, (iii) a temperature sensor to measure temperature of the refrigerant, temperature of the water, or temperature of the outside air, and (iv) a control board to control the components of the heat pump unit 134. A rotational frequency of the compressor, a level of opening of the expansion valve, and a rotational frequency of the blower are based on control values indicated by control signals sent from the control device 140.

[0025] The mixing valve 135 is connected to the water supply port 101, the top portion of the hot water storage tank 130 and the hot water-supply port 102. The mixing valve 135 mixes, with the low temperature water supplied from the water supply port 101, the high temperature water acquired from the top portion of the hot water storage tank 130, at a mixing ratio based on an instruction from the control device 140 and then sends the mixed water to the hot water-supply port 102.

[0026] The control device 140 is a computer built in the pipe abnormality detection system 100. The control device 140 is communicatively connected to a terminal 210 external to the pipe abnormality detection system 100 and controls each component of the pipe abnormality detection system 100 as a hot water supply system in

accordance with the contents of an operation by a user that are received by the terminal 210. The control device 140 performs the water heating operation and the reheating operation. Also, the control device 140 adjusts the mixing ratio for the mixing valve 135 such that hot water having a temperature desired by the user is supplied from the hot water-supply port 102 and then performs a filling operation in which an optimal amount of hot water is supplied from the hot water-supply port 102 to the bathtub 200 so that the bathtub is filled with the optimum amount of hot water. Additionally, the control device 140 makes the terminal 210 display (i) an operational condition of the pipe abnormality detection system 100 as a hot water supply system or (ii) an operation screen. Also, upon detecting an abnormality of the pipe 110, the control device 140 outputs a detection result to the output device 150.

[0027] As illustrated in FIG. 2, the control device 140 includes, as a hardware configuration, a processor 141, a random access memory (RAM) 142, a read only memory (ROM) 143, a data storage 144, and a communication unit 145. The RAM 142, the ROM 143, the data storage 144, and the communication unit 145 are connected to the processor 141 via an internal bus 146.

[0028] The processor 141 is configured to include a central processing unit (CPU) or a micro processing unit (MPU). The processor 141 fulfills various functions by executing a program 149 stored in the data storage 144.

[0029] The program 149 is loaded from the data storage 144 into the RAM 142. The RAM 142 is used as a work area of the processor 141. The ROM 143 stores firmware or data used during executing the firmware.

[0030] The data storage 144 is non-volatile and non-temporary storage means represented by an electrically erasable programmable read-only memory (EEPROM), a flash memory and a hard disk drive. The data storage 144 stores (i) the program 149 for controlling an operation of the pipe abnormality detection system 100 and (ii) data used by the processor 141 during executing the program 149. The data used during executing the program 149 includes data indicating the correspondence of operation modes of the pipe abnormality detection system 100 to operation of and stoppage of the pumps 121 and 132 and their rotational frequencies, an operational condition of the heat pump unit 134, flow paths switched by the three-way valve 131 and the four-way valve 133, and a mixing ratio by the mixing valve 135, and a threshold as a parameter used for a below-described process.

[0031] The communication unit 145 includes a network interface card (NIC) controller for performing wired or wireless communication. The communication unit 145 is communicably connected to the terminal 210, the pumps 121 and 132, the heat pump unit 134, the three-way valve 131, the four-way valve 133 and the mixing valve 135.

[0032] Various functions of the control device 140 are achieved by cooperation of the above hardware components of the control device 140. FIG. 3 illustrates the functional configuration of the control device 140. As illustrated in FIG. 3, the control device 140 includes, as a func-

tional configuration, a user interface (UI) module 31 to receive information from a user or to present information to the user, an acquisition module 32 to acquire data from each component of the pipe abnormality detection system 100, an execution module 33 to execute each operation mode of the pipe abnormality detection system 100 as a hot water supply system, and a determination module 34 to detect whether an abnormality of the pipe 110 occurs.

[0033] The UI module 31 executes a user interface process via the terminal 210 and the output device 150. That is, the UI module 31 receives an operation of the user inputted into the terminal 210. Also, the UI module 31 transmits information to the terminal 210 and the output device 150 to make the terminal 210 display the information or to make the notification device 160 provide notification of the information. This information includes, for example, information indicating the operational condition of the hot water supply system.

[0034] The acquisition module 32 acquires, at regular intervals, an operational condition of the heat pump unit 134, a measurement value by the temperature sensor not illustrated in the drawings, and a detection value by the pressure detecting sensor 122, and the acquisition module 32 acquires, from the driving devices for the pumps 121 and 132, data indicating operating states of the pumps 121 and 132. The term, "at regular intervals", means, for example, "at intervals of five seconds", "at intervals of thirty seconds", or "at intervals of one minute". Various types of data acquired by the acquisition module 32 are stored in the data storage 144 (refer to FIG. 2).

[0035] The execution module 33 reads, from the data storage 144 (refer to FIG. 2), a control target value corresponding to an operation mode selected by the user and then executes the water heating operation, the reheating operation, or the filling operation.

[0036] In FIG. 1, the directions of water flows occurring during performance of the water heating operation are represented by the solid-line arrows. As the solid-line arrows indicate, a water heating circuit is formed between the hot water storage tank 130 and the heat pump unit 134 during the water heating operation. That is, the low temperature water flowing out from the bottom portion of the hot water storage tank 130 is conveyed by the pump 132, is heated by the heat pump unit 134 to become high temperature water, and then is returned to the top portion of the hot water storage tank 130.

[0037] Also, in FIG. 1, the directions of water flows occurring during performance of the reheating operation are represented by the dashed line arrows. As the dashed line arrows indicate, a circulation path is formed between the hot water storage tank 130 and the heat exchanger 123 during performance of the reheating operation. That is, the high temperature water flowing out from the top portion of the hot water storage tank 130 by driving the pump 132 passes through the primary side of the heat exchanger 123, passes through the three-way valve 131, the pump 132 and the four-way valve 133 in order, and

then returns to the bottom portion of the hot water storage tank 130. Also, during the reheating operation, the pump 121 circulates the water between the pipe 110 and the bathtub 200 as illustrated by the outlined-type arrows. As a result, the heat exchanger 123 causes heat stored in the hot water storage tank 130 to move to the bathtub 200.

[0038] Again with reference to FIG. 3, the determination module 34 determines, on the basis of a detection value by the pressure detecting sensor 122 obtained while controlling the pump 121, whether an abnormality occurs in the pipe 110, and then notifies the output device 150 of a determination result (refer to FIG. 1). The details on a determination process performed by the determination module 34 are described below.

[0039] Again with reference to FIG. 1, the output device 150 is configured to include the network interface card (NIC) controller for performing wired or wireless communication and is communicatively connected to the control device 140, the notification device 160, and the terminal 210. In a case where the determination module 34 determines that an abnormality occurs in the pipe 110, the output device 150 outputs, to the notification device 160 and the terminal 210, a signal indicating that this abnormality is detected. As a result, notifying the user that the abnormality of the pipe 110 is detected. The output device 150 may be built, as a hardware component or a software module of the control device 140, into the control device 140 or may be configured to be integrated with the control device 140.

[0040] The notification device 160 is configured to include, for example, a light emitting diode (LED), a liquid crystal display (LCD) or a speaker. The output device 150 presents, to the user, information indicated by a signal outputted by the output device 150. The notification device 160 may be built into the control device 140 or may be configured to be integrated with the control device 140.

[0041] A summary of a method of detecting whether an abnormality occurs in the pipe 110 by the control device 140 is described below.

[0042] As the outlined-type arrows indicate in FIG. 1, upon activating the pump 121, water drawn from the bathtub 200 flows into the first pipe portion 113, the pressure of the water is increased by the pump 121, and then the water passes through the pressure detecting sensor 122 and flows into the secondary side of the heat exchanger 123. Afterward, this water passes through the second pipe portion 114 and then flows into the bathtub 200.

[0043] During the occurrence of such water flow circulating between the pipe 110 and the bathtub 200, pressure drops occur in the heat exchanger 123 and the second pipe portion 114, and thus pressure detected by the pressure detecting sensor 122 becomes higher than when the water does not flow. Arranging a flow path having high water resistance as in the heat exchanger 123 on the downstream side relative to the pressure detecting sensor 122 enables a remarkable increase from the pres-

sure detected when the water flow does not occur to the pressure detected when the water flow does occur.

[0044] In FIG. 4, pressure increased by the water flow without occurrence of an abnormality of the pipe 110 is represented by a line Lm0. As illustrated in FIG. 4, pressure detected when the pump 121 stops is a pressure "Ps", and pressure detected increases with increasing rotational frequency of the pump 121.

[0045] A case in which an abnormality occurs in the second pipe portion 114 is described here. Occurrence of an abnormality in the second pipe portion 114 causes an increase in pressure drop in the second pipe portion 114. Accordingly, in the case in which the abnormality occurs in the second pipe portion 114, pressure detected by the pressure detecting sensor 122 becomes higher in comparison to the case in which no abnormality occurs in the second pipe portion 114, under conditions in which the rotational frequencies of the pump 121 in the both cases are equal to each other.

[0046] In FIG. 4, pressure detected when an abnormality occurs in the second pipe portion 114 is represented by a line Lm2. As illustrated in FIG. 4, the pressure detected when the pump 121 stops is a pressure "Ps" that is equal to pressure detected when no abnormality occurs. The pressure detected increases with increasing rotational frequency of the pump 121, and a degree of increase in the detected pressure in the case of the occurrence of the abnormality in the second pipe portion 114 becomes higher than a degree of increase in the detected pressure in the case of no occurrence of abnormality.

[0047] Also, a case in which an abnormality occurs in the first pipe portion 113 is described. Occurrence of an abnormality in the first pipe portion 113 causes an increase in pressure drop in the first pipe portion 113. Accordingly, in the case in which the abnormality occurs in the first pipe portion 113, an amount of the water flow circulating between the pipe 110 and the bathtub 200 decreases more in comparison to a case in which no abnormality occurs in the first pipe portion 113, under the condition that the rotational frequencies of the pump 121 in the both cases are equal to each other. The decrease in the amount of the water flow causes a decrease in pressure drops in the heat exchanger 123 and the second pipe portion 114. Accordingly, in the case in which the abnormality occurs in the first pipe portion 113, pressure detected by the pressure detecting sensor 122 becomes low in comparison to the case in which no abnormality occurs, under the condition that the rotational frequencies of the pump 121 in the both cases are equal to each other.

[0048] In FIG. 4, pressure detected when an abnormality occurs in the first pipe portion 113 is represented by a line Lm1. FIG. 4 reveals that pressure detected when the pump 121 stops is the pressure "Ps" that is equal to a pressure detected when no abnormality occurs. The pressure detected increases with increasing rotational frequency of the pump 121 and a degree of increase in

the detected pressure in the case of the occurrence of the abnormality in the first pipe portion 113 becomes lower than a degree of increase in the detected pressure in the case of no occurrence of abnormality.

[0049] As described above, the pressure detected by the pressure detecting sensor 122 when the pump 121 operates varies in accordance with (i) presence or absence of an abnormality in the pipe 110 or (ii) a location where the abnormality occurs. Accordingly, presence or absence of abnormalities occurring in the first pipe portion 113 and the second pipe portion 114 can be detected.

[0050] The pressure detected by the pressure detecting sensor 122 can vary in accordance with water levels in the bathtub 200 and atmospheric pressure. By determining whether an abnormality occurs in the pipe 110 using a difference between pressure detected by the pressure detecting sensor 122 during stoppage of the pump 121 and pressure detected by the pressure detecting sensor 122 during operation of the pump 121, the influences of the water level in the bathtub 200 and the atmospheric pressure can be reduced, and thus an accuracy in detecting the abnormality can be improved. As illustrated in FIG. 4 for example, when the abnormality occurs in the second pipe portion 114, by the use of a pressure difference " ΔP " between pressure " P_m " detected when a rotational frequency of the pump 121 has a value " R_1 " and pressure " P_s " detected when the pump 121 stops, the accuracy in detecting the abnormality can be improved.

[0051] Next, a pipe abnormality detection process performed by the control device 140 and the output device 150 is described with reference to FIG. 5. The pipe abnormality detection process illustrated in FIG. 5 is executed, for example, after the filling operation for the bathtub 200 is performed.

[0052] In the pipe abnormality detection process, the determination module 34 of the control device 140 firstly stops the pump 121 (Step S101). Specifically, the determination module 34 gives an order to stop the pump 121 and then verifies that the pump 121 is stopped.

[0053] Next, the determination module 34 determines whether there is water in the bathtub 200 (Step S102). Specifically, the determination module 34 determines whether pressure detected by the pressure detecting sensor 122 is greater than a predetermined value. Also, the determination module 34 stores, in the data storage 144, the pressure detected by the pressure detecting sensor 122 as the pressure P_s detected by the pressure detecting sensor 122 when the pump 121 is stopped.

[0054] When the detection module 34 determines that there is no water in the bathtub 200 (No in Step S102), the determination module 34 repeats the determination process of Step S102. Accordingly, a detection of an abnormality occurring in the pipe is postponed until the detection module 34 determines that there is water in the bathtub 200.

[0055] When the determination module 34 determines that there is water in the bathtub 200 (Yes in Step S102),

the determination module 34 activates the pump 121 at a predetermined rotational frequency (Step S103). In order to increase a below-described pressure difference caused by an abnormality, the predetermined rotational frequency is preferably high and is, for example, the maximum rotational frequency of the pump 121.

[0056] Next, the determination module 34 acquires (i) a value of the pressure P_m detected by the pressure detecting sensor 122 when the pump 121 operates at the predetermined rotational frequency and then calculates the pressure difference " ΔP " between (i) the pressure " P_s " detected during stoppage of the pump 121 and (ii) the pressure " P_m " detected during operation of the pump 121 (Step S104). Specifically, the determination module 34 calculates the pressure difference " ΔP " by subtracting the pressure " P_s " from the pressure " P_m ".

[0057] Next, the determination module 34 compares the pressure difference ΔP with a predetermined threshold T1 to determine whether the pressure difference ΔP is less than the threshold T1 (Step S105). The threshold T1 is previously stored in the data storage 144.

[0058] In a case in which the detection module 34 determines that the pressure difference ΔP is less than the threshold T1 (Yes in Step S105), the determination module 34 determines that an abnormality occurs in the first pipe portion 113 (Step S106).

[0059] In a case in which the detection module 34 determines that the pressure difference ΔP is not less than the threshold T1 (No in Step S105), the determination module 34 compares the pressure difference ΔP with a predetermined threshold T2 to determine whether the pressure difference ΔP is greater than the threshold T2 (Step S107). The threshold T2 is previously stored in the data storage 144. The threshold T2 is a value greater than the threshold T1.

[0060] In a case in which the detection module 34 determines that the pressure difference ΔP is greater than the threshold T2 (Yes in Step S107), the determination module 34 determines that an abnormality occurs in the second pipe portion 114 (Step S108).

[0061] In a case in which the detection module 34 determines that the pressure difference ΔP is not greater than the threshold T2 (No in Step S107), the determination module 34 determines that no abnormality occurs in the pipe 110 (Step S109). That is, when the pressure difference ΔP is within a normal range defined by the threshold T1 as a lower limit and the threshold T2 as an upper limit, the determination module 34 determines that no abnormality occurs in the pipe 110, and, when the pressure difference ΔP is not within the normal range, the detection module 34 determines that an abnormality occurs in the pipe 110.

[0062] After Step S106, Step S108 and Step S109, the determination module 34 notifies the output device 150 of the determination results, and the output device 150 outputs to the terminal 210 and the notification device 160 a signal indicating a detection result (Step S110). Specifically, in Step S110 following Step S106, the output

device 150 outputs a signal indicating that an abnormality of the first pipe portion 113 is detected. Also, in Step S110 following Step S108, the output device 150 outputs a signal indicating that an abnormality of the second pipe portion 114 is detected. Also, in Step S110 following Step S109, the output device 150 outputs a signal indicating that no abnormality of the pipe 110 is detected. Afterward, the pipe abnormality detection process is completed.

[0063] As described above, in the pipe abnormality detection system 100 according to the present embodiment, the signals indicating that abnormalities of the pipe 110 are detected are output when the difference between the pressure detected by the pressure detecting sensor 122 during stoppage of the pump 121 and the pressure detected by the pressure detecting sensor 122 during operation of the pump 121 is not within the predetermined range. As a result, the abnormalities of the pipe 110 can be detected in a hot water supply system that does not include the flow switch that is conventionally arranged in the pipe 110.

[0064] Also, when an abnormality occurs in the pipe 110, the pipe abnormality detection system 100 distinguishes an abnormality of the first pipe portion 113 from an abnormality of the second pipe portion 114 depending on whether the pressure difference ΔP is greater or less, and then outputs a signal. As a result, a location at which the abnormality occurs can easily be identified.

[0065] Also, the pressure detecting sensor 122 is arranged between the pump 121 and the heat exchanger 123. As a result, remarkable pressure change is caused by the abnormality of the pipe 110, and thus the accuracy in detecting the abnormality can be improved.

[0066] Also, the pipe abnormality detection process illustrated in FIG. 5 is performed after the filling operation for the bathtub 200 is performed. As a result, the abnormality of the pipe 110 can be detected in a situation where water is reliably contained in the bathtub 200. That is, the presence or absence of the abnormality of the pipe can be reliably determined.

Embodiment 2

[0067] Next, Embodiment 2 is described with a focus on differences from Embodiment 1 described above. Components that are the same as or equivalent to those of Embodiment 1 are assigned the same reference sign and the descriptions of these components are omitted or these components are briefly described. A pipe abnormality detection system 100 according to the present embodiment is different from the system according to Embodiment 1 in that an abnormality of the pipe 110 is detected on the basis of a rate of change in the pressure difference ΔP relative to the rotational frequency of the pump 121 instead of the pressure difference ΔP .

[0068] FIG. 6 illustrates a pipe abnormality detection process according to the present embodiment. As illustrated in FIG. 6, upon an affirmative determination in Step S102 (Yes in Step S102), the determination module 34

operates the pump 121 at a predetermined rotational frequency F1 (Step S201). The rotational frequency F1 is, for example, a half of the maximum rotational frequency of the pump 121.

[0069] Next, the determination module 34 acquires a value of a pressure Pm1 detected by the pressure detecting sensor 122 during operation of the pump 121 at the rotational frequency F1 and then calculates a pressure difference $\Delta P1$ between a pressure Ps detected during stoppage of the pump 121 and the pressure Pm1 detected during operation of the pump 121 (Step S202). Specifically, the determination module 34 calculates the pressure difference ΔP by subtracting the pressure Ps from the pressure Pm1.

[0070] Next, the determination module 34 operates the pump 121 at a predetermined rotational frequency F2 (Step S203). The rotational frequency F2 is a value greater than the rotational frequency F1 and is, for example, the maximum rotational frequency of the pump 121.

[0071] Next, the determination module 34 acquires a value of pressure Pm2 detected by the pressure detecting sensor 122 during operation of the pump 121 at the rotational frequency F2 and then calculates a pressure difference $\Delta P2$ between the pressure Ps detected during stoppage of the pump 121 and the pressure Pm2 detected during operation of the pump 121 (Step S204). Specifically, the determination module 34 calculates the pressure difference $\Delta P2$ by subtracting the pressure Ps from the pressure Pm2.

[0072] Next, the determination module 34 calculates a rate D of change of the pressure difference (Step S205). Specifically, the determination module 34 calculates the rate D of change of the pressure difference relative to the rotational frequency of the pump 121 on the basis of a calculation formula $D = (\Delta P2 - \Delta P1) / (F2 - F1)$.

[0073] Next, the determination module 34 compares the rate D with a predetermined threshold T3 to determine whether the rate D of change is less than the threshold T3 (Step S206). The threshold T3 is previously stored in the data storage 144.

[0074] If the detection module 34 determines that the rate D of change is less than the threshold T3 (Yes in Step S206), the determination module 34 determines that an abnormality occurs in the first pipe portion 113 (Step S106).

[0075] If the detection module 34 determines that the rate D of change is not less than the threshold T3 (No in Step S206), the determination module 34 compares the rate D of change with a predetermined threshold T4 to determine whether the rate D of change is greater than the threshold T4 (Step S207). The threshold T4 is previously stored in the data storage 144. The threshold T4 is a value greater than the threshold T3.

[0076] If the detection module 34 determines that the rate D of change is greater than the threshold T4 (Yes in Step S207), the detection module 34 determines that an abnormality occurs in the second pipe portion 114 (Step S108).

[0077] If the determination module 34 determines that the rate D of change is not greater than the threshold T4 (No in Step S207), the determination module 34 determines that no abnormality occurs in the pipe 110 (Step S109). That is, when the rate D of change is within a normal range defined by the threshold T3 as a lower limit and the threshold T4 as an upper limit, the determination module 34 determines that no abnormality occurs in the pipe 110, and when the rate D of change is not within the normal range, the detection module 34 determines that an abnormality occurs in the pipe 110.

[0078] The use of the rate D of change instead of the pressure difference ΔP according to Embodiment 1 is described with reference to FIG. 7. In FIG. 7, the relationships between the pressure difference ΔP and the rotational frequency of the pump 121 are represented by lines Lm10, Lm11, and Lm12. The line Lm10 corresponds to the case in which no abnormality occurs in the pipe 110, the line Lm11 corresponds to the case in which an abnormality occurs in the first pipe portion 113, and the line Lm12 corresponds to the case in which an abnormality occurs in the second pipe portion 114. As illustrated in FIG. 4, the pressure difference ΔP can be obtained by subtracting the pressure Ps from the detected pressure. Accordingly, the lines Lm10, Lm11, and Lm12 are respectively equal to the lines Lm0, Lm1, and Lm2 when the point Ps illustrated in FIG. 4 is regarded as the origin of the vertical axis.

[0079] Also, FIG. 7 illustrates a rate D0 of change for the case in which no abnormality occurs in the pipe 110, a rate D1 of change for the case in which an abnormality occurs in first pipe portion 113, and a rate D2 of change for the case in which an abnormality occurs in the second pipe portion 114. As understood from FIG. 7, the rate D1 of change is less than the rate D0 of change. That is, in the case in which the abnormality occurs in the first pipe portion 113, in the same manner as the case of the pressure difference ΔP , the rate of change in the pressure difference ΔP decreases more in comparison to the case in which no abnormality occurs in the pipe. Also, the rate D2 of change is greater than the rate D0 of change. That is, in the case in which the abnormality occurs in the second pipe portion 114, the rate of change in the pressure difference ΔP increases more, as well as the pressure difference ΔP , in comparison to the case in which no abnormality occurs in the pipe. Accordingly, even though the rate D of change is used instead of the pressure difference ΔP used in Embodiment 1, it is possible to determine presence or absence of an abnormality occurring in the pipe 110 as well as Embodiment 1.

[0080] As described above, the pipe abnormality detection system 100 according to the present embodiment detects an abnormality of the pipe 110 on the basis of the rate D of change of the pressure difference relative to the rotational frequency of the pump 121. The rate D of change for the case in which the abnormality occurs in the pipe 110 is different from the rate D of change for the case in which no abnormality occurs in the pipe 110.

Accordingly, in the same manner as in Embodiment 1, the abnormality of the pipe 110 in the hot water supply system from which a flow switch conventionally arranged in the pipe 110 is omitted can be detected.

[0081] Also, when the abnormality occurs in the pipe 110, the pipe abnormality detection system 100 outputs a signal while distinguishing the abnormality of the first pipe portion 113 from the abnormality of the second pipe portion 114 on the basis of whether the rate D of change increases or decreases. As a result, it is possible to easily identify a location at which the abnormality occurs.

Embodiment 3

[0082] Next, Embodiment 3 is described with a focus on differences from Embodiment 1 described above. Components that are the same as or equivalent to those of Embodiment 1 are assigned the same reference sign and the descriptions of these components are omitted or these components are briefly described. As illustrated in FIG. 8, a pipe abnormality detection system 100 according to the present embodiment is different from the system according to Embodiment 1 in that the heat exchanger 123, the pressure detecting sensor 122, and the pump 121 are arranged in order from the upstream side of the pipe 110.

[0083] The pump 121 is arranged between the pressure detecting sensor 122 and the flow outlet 112. That is, the pump 121 is arranged on the downstream side relative to the pressure detecting sensor 122. The pressure detecting sensor 122 is arranged between the pump 121 and the heat exchanger 123. That is, the pressure detecting sensor 122 is arranged on the upstream side relative to the pump 121 and on the downstream side relative to the heat exchanger 123. In a range of gauge pressure detected by the pressure detecting sensor 122 according to the present embodiment, a negative pressure detection range is wider than a positive pressure detection range. The heat exchanger 123 is arranged between the flow inlet 111 and the pressure detecting sensor 122. That is, the heat exchanger 123 is arranged on the upstream side relative to the pressure detecting sensor 122.

[0084] Next, a summary of a method of detecting presence or absence of an abnormality of the pipe 110 by the control device 140 according to the present embodiment is described.

[0085] As the outlined-type arrows indicate in FIG. 8, upon activating the pump 121, water drawn from the bathtub 200 flows into the first pipe portion 113 and passes through the heat exchanger 123 and the pressure detecting sensor 122, and then the pressure of the water is increased by the pump 121. Afterward, this water passes through the second pipe portion 114 and then flows into the bathtub 200.

[0086] When such water flow circulates between the pipe 110 and the bathtub 200 in this manner, a pressure drops occur in the heat exchanger 123 and the first pipe

portion 113, and thus pressure detected by the pressure detecting sensor 122 becomes lower in comparison to a case in which the water flow does not occur. Arranging a flow path having high water resistance as in the heat exchanger 123 on the upstream side relative to the pressure detecting sensor 122 makes possible a remarkable decrease from the pressure detected when the water flow does not occur relative to the pressure detected when the water flow occurs.

[0087] In FIG. 9, pressure decreased by the water flow without occurrence of an abnormality of the pipe is represented by a line Lm20. As understood from FIG. 9, the pressure detected when the pump 121 stops is Ps, and the pressure detected decreases with increasing rotational frequency of the pump 121.

[0088] A case in which an abnormality occurs in the first pipe portion 113 is described here. Occurrence of an abnormality in the first pipe portion 113 causes an increase in pressure drop in the first pipe portion 113. Accordingly, in the case in which the abnormality occurs in the first pipe portion 113, the pressure detected by the pressure detecting sensor 122 becomes lower in comparison to the case in which no abnormality occurs in the first pipe portion 113, under the condition that the rotational frequencies of the pump 121 in the both cases are equal to each other.

[0089] In FIG. 9, pressure detected when an abnormality occurs in the first pipe portion 113 is represented by a line Lm21. As may be understood from FIG. 9, the pressure detected when the pump 121 stops is the pressure "Ps" that is equal to the pressure detected when no abnormality occurs. The pressure detected decreases with increasing rotational frequency of the pump 121, and a degree of decrease in the detected pressure in the case of the occurrence of the abnormality in the first pipe portion 113 is higher than a degree of decrease in the detected pressure in the case of no occurrence of abnormality.

[0090] Also, a case in which an abnormality occurs in the second pipe portion 114 is described. Occurrence of an abnormality in the second pipe portion 114 causes an increase in pressure drop in the second pipe portion 114. Accordingly, in the case in which the abnormality occurs in the second pipe portion 114 an amount of the water flow circulating between the pipe 110 and the bathtub 200 decreases in comparison with a case in which no abnormality occurs in the second pipe portion 114, under the condition that the rotational frequencies of the pump 121 in the both cases are equal to each other. The decrease in the amount of the water flow causes a decrease in pressure drops in the heat exchanger 123 and the first pipe portion 113. Accordingly, in the case in which the abnormality occurs in the second pipe portion 114, the pressure detected by the pressure detecting sensor 122 becomes high in comparison to the case in which no abnormality occurs, under condition that the rotational frequencies of the pump 121 in the both cases are equal to each other.

[0091] In FIG. 9, a pressure detected when an abnormality occurs in the second pipe portion 114 is represented by a line Lm22. As understood from FIG. 9 the pressure detected when the pump 121 stops is the pressure "Ps" that is equal to the pressure detected when no abnormality occurs. The pressure detected decreases with increasing rotational frequency of the pump 121, and a degree of decrease in the detected pressure in the case of the occurrence of the abnormality in the second pipe portion 114 is lower than a degree of decrease in the detected pressure in the case of no occurrence of abnormality.

[0092] As described above, the pressure detected by the pressure detecting sensor 122 when the pump 121 operates varies in accordance with (i) presence or absence of an abnormality in the pipe 110 and (ii) a location at which the abnormality occurs. Accordingly, presence or absence of abnormalities occurring in the first pipe portion 113 and the second pipe portion 114 can be detected.

[0093] As in Embodiment 1, presence or absence of an abnormality occurring in the pipe 110 can be detected while reducing the influences of the water level in the bathtub 200 and the atmospheric pressure by using the pressure difference between the pressure during stoppage of the pump 121 and the pressure during operation of the pump 121. As illustrated in FIG. 9 for example, when the abnormality occurs in the first pipe portion 113, the abnormality occurring in the first pipe portion 113 can be accurately detected by the use of the pressure difference ΔP that has a negative value and is obtained by subtracting the pressure Ps detected during stoppage of the pump 121 from the pressure Pm detected during operation of the pump 121 at the rotational frequency R2.

[0094] FIG. 10 illustrates a pipe abnormality detection process according to the present embodiment. As illustrated in FIG. 10, the determination module 34 compares the pressure difference ΔP with a predetermined threshold T5 after Step S104 to determine whether the pressure difference ΔP is less than the threshold T5 (Step S301). The threshold T5 is a negative value and is previously stored in the data storage 144.

[0095] In the case in which the detection module 34 determines that the pressure difference ΔP is less than the threshold T5 (Yes in Step S301), the determination module 34 determines that an abnormality occurs in the first pipe portion 113 (Step S106).

[0096] In the case in which the detection module 34 determines that the pressure difference ΔP is not less than the threshold T5 (No in Step S301), the determination module 34 compares the pressure difference ΔP with a predetermined threshold T6 to determine whether the pressure difference ΔP is greater than the threshold T6 (Step S302). The threshold T6 is a negative value and is previously stored in the data storage 144. The threshold T6 is greater than the threshold T5.

[0097] In the case in which the detection module 34 determines that the pressure difference ΔP is greater

than the threshold T6 (Yes in Step S302), the determination module 34 determines that an abnormality occurs in the second pipe portion 114 (Step S108).

[0098] In the case in which the detection module 34 determines that the pressure difference ΔP is not greater than the threshold T6 (No in Step S302), the determination module 34 determines that no abnormality occurs in the pipe 110 (Step S109). That is, when the pressure difference ΔP is within a normal range defined by the threshold T5 as a lower limit and the threshold T6 as an upper limit, the determination module 34 determines that no abnormality occurs in the pipe 110, and when the pressure difference ΔP is not within this range, the detection module 34 determines that an abnormality occurs in the pipe 110.

[0099] As described above, in a manner similar to Embodiment 1, the pipe abnormality detection system 100 according to the present embodiment can detect an abnormality of the pipe 110 in a hot water supply system from which a flow switch conventionally arranged in the pipe 110 is omitted.

[0100] In the present embodiment, in a manner similar to Embodiment 2, an abnormality of the pipe 110 may be detected on the basis of the rate of change in the pressure difference ΔP relative to the rotational frequency of the pump 121 instead of the pressure difference ΔP .

[0101] In FIG. 11, the relationships between the pressure difference ΔP and the rotational frequency of the pump 121 are represented by lines Lm30, Lm31 and Lm32. The line Lm30 corresponds to the case in which no abnormality occurs in the pipe 110, the line Lm31 corresponds to the case in which an abnormality occurs in the first pipe portion 113, and the line Lm32 corresponds to the case in which an abnormality occurs in the second pipe portion 114. As indicated in FIG. 9, the pressure difference ΔP can be obtained by subtracting the pressure P_s from the detected pressure. Accordingly, the lines Lm30, Lm31 and Lm32 are respectively equal to the lines Lm20, Lm21 and Lm22 when the point P_s illustrated in FIG. 9 is regarded as the origin of the vertical axis in FIG. 9.

[0102] Also, FIG. 11 illustrates a negative rate D10 of change for the case in which no abnormality occurs in the pipe 110, a negative rate D11 of change for the case in which an abnormality occurs in the first pipe portion 113, and a negative rate D12 of change for the case in which an abnormality occurs in the second pipe portion 114. These rates of change are calculated on the basis of a calculation formula, $(\Delta P_4 - \Delta P_3) / (F_4 - F_3)$, using the predetermined rotational frequencies F_3 and F_4 of the pump, where F_4 is greater than F_3 , the pressure difference ΔP_3 for the case in which the rotational frequency of the pump 121 is F_3 , and the pressure difference ΔP_4 for the case in which the rotational frequency of the pump 121 is F_4 that is greater than F_3 .

[0103] As illustrated in FIG. 11, although the absolute value of the rate D11 of change is greater than that of the rate D10 of change, both of the rates D10 and D11

of change are negative values, and thus the rate D11 of change is less than the rate D10 of change. That is, as in the case of the use of the pressure difference ΔP , the rate of change in the pressure difference ΔP for the case of occurrence of an abnormality of the first pipe portion 113 is less than that for the case in which no abnormality occurs. Also, although the absolute value of the rate D12 of change is less than that of the rate D10 of change, both the rates D10 and D12 of change are negative values and thus the rate D12 of change is greater than the rate D10 of change. That is, as in the case of the use of the pressure difference ΔP , the rate of change in the pressure difference ΔP for the case of occurrence of an abnormality of the second pipe portion 114 is greater than that for the case in which no abnormality occurs. Accordingly, even if the rate D of change is used instead of the pressure difference ΔP in Embodiment 3, the presence or absence of an abnormality of the pipe 110 is detectable in a manner similar to Embodiment 3.

[0104] Although the embodiments of the present disclosure are described above, the present disclosure is not limited to the above embodiments.

[0105] For example, although the heat pump unit 134 is used as a heat source for performing the water heating operation in the above embodiments, an electric heater or a gas-fired device may be used as a heat source.

[0106] Also, the hot water storage tank 130 may be omitted from the pipe abnormality detection system 100. Additionally, the heat exchanger 123 may be omitted from the pipe abnormality detection system 100. For example, the pipe abnormality detection system 100 may be configured to use, instead of the heat exchanger 123, a heat source for reheating water in the bathtub 200. Alternatively, the heat source may be omitted from the circulation path formed between the pipe 110 and the bathtub 200, and the circulation path may be used not for reheating the water in the bathtub but for cleaning the water in the bathtub 200.

[0107] Also, the number of the water supply ports 101 and the number of the hot water-supply ports 102 are not limited to those illustrated in FIG. 1, and the number of the water supply ports 101 used and the number of the hot water-supply ports 102 used may be freely selected. Although the water pipe connected to the hot water-supply port 102 is independent from the pipe 110 in the aforementioned embodiment, this water pipe may be connected to the pipe 110.

[0108] Also, the thresholds T1 to T6 may be determined on the basis of pressures that were detected by the pressure detection sensor 122 in the past. As a result, a threshold appropriate for the actual environment of usage of the pipe abnormality detection system 100 can be set. For example, the thresholds T1 and T2 may be determined from variations in a pressure difference between a pressure detected during stoppage of the pump 121 and a pressure detected during operation of the pump 121 at a predetermined rotational frequency, where these pressures have been already detected for

a certain past period.

[0109] Also, in the above embodiment, although a structure for inputting information by the user is limited to the terminal 210, the control device 140 may include such a structure.

[0110] Also, a device able to perform the above processes can be configured by storing, in a computer-readable recording medium such as a flexible disk, a compact disc read-only memory (CD-ROM), a digital versatile disc (DVD), a magneto-optical (MO) disk, the program 149 stored in the data storage 144, distributing the recording medium storing the program, and installing the program 149 in a computer.

[0111] Also, the program 149 may be stored in advance in a disk drive that is included in a server on a communication network represented by the Internet, and then the program 149 may be downloaded to a computer, for example, by superimposing the program 149 on a carrier wave.

[0112] Also, the above process may be achieved by activating and executing the program 149 while transmitting the program 149 via a network represented by the Internet.

[0113] Additionally, the above process may be achieved by executing the whole of or a portion of the program 149 on the server and executing the program 149 while the computer is transmitting and receiving information about that process via the communication network.

[0114] Moreover, in the case of achievement of the above functions by achieving a portion of the above functions by an operating system (OS) or in the case of achievement of the above functions in cooperation between the OS and an application, portions of the program other than a portion of the program stored in the OS may be stored in the recording medium and the recording medium may be distributed or, alternatively, the portions of the program other than the portion of the program stored in the OS may be downloaded to the computer.

[0115] Also, means for achieving the functions of the pipe abnormality detection system 100 are not limited to software, a portion of or the whole of the functions may be achieved by dedicated hardware. For example, when each module illustrated in FIG. 3 is composed of a circuit represented by a field programmable gate array (FPGA) or an application specific integrated circuit (ASIC), power consumption of the control device 140 can be reduced.

[0116] The foregoing describes some example embodiments for explanatory purposes. Although the foregoing discussion has presented specific embodiments, persons skilled in the art will recognize that changes may be made in form and detail without departing from the broader spirit and scope of the invention. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense. This detailed description, therefore, is not to be taken in a limiting sense, and the scope of the invention is defined only by the included claims, along with the full range of equiva-

lents to which such claims are entitled.

Industrial Applicability

- 5 **[0117]** The present disclosure is suitable for detection of an abnormality occurring in a pipe.

Reference Signs List

10 **[0118]**

100	Pipe abnormality detection system
101	Water supply port
102	Hot water-supply port
110	Pipe
111	Flow inlet
112	Flow outlet
113	First pipe portion
114	Second pipe portion
121	Pump
122	Pressure detecting sensor
123	Heat exchanger
130	Hot water storage tank
131	Three-way valve
132	Pump
133	Four-way valve
134	Heat pump unit
135	Mixing valve
140	Control device
141	Processor
142	RAM
143	ROM
144	Data storage
145	Communication unit
146	Internal bus
147	Communication unit
149	Program
150	Output device
160	Notification device
200	Bathtub
210	Terminal
31	UI module
32	Acquisition module
33	Execution module
34	Determination module

Claims

- 50 1. A pipe abnormality detection system comprising:
- 55 a pipe comprising a flow inlet into which water in a bathtub flows and a flow outlet through which the water passes into the bathtub;
- a pump configured to circulate the water between the pipe and the bathtub;
- detection means for detecting a pressure of an inside of the pipe; and

- output means for outputting a signal indicating that an abnormality of the pipe is detected, when at least one of (i) a difference between the pressure detected by the detection means during stoppage of the pump and the pressure detected by the detection means during operation of the pump or (ii) a rate of change in the difference with respect to a rotational frequency of the pump is outside of a predetermined range.
2. The pipe abnormality detection system according to claim 1, wherein
the detection means is a pressure sensor arranged at a specific location in the pipe,
the pipe comprises a first pipe portion extending from the flow inlet to the specific location and a second pipe portion extending from the specific location to the flow outlet,
when the difference obtained by subtracting the pressure detected by the detection means during stoppage of the pump from the pressure detected by the detection means during operation of the pump is less than a first threshold, the output means outputs a signal indicating that an abnormality of the first pipe portion is detected, and
when the difference is greater than a second threshold, the output means outputs a signal indicating that an abnormality of the second pipe portion is detected.
3. The pipe abnormality detection system according to claim 1 or 2, wherein
the detection means is a pressure sensor arranged at a specific location in the pipe,
the pipe comprises a first pipe portion extending from the flow inlet to the specific location and a second pipe portion extending from the specific location to the flow outlet,
when a rate of change in the difference obtained by subtracting the pressure detected by the detection means during stoppage of the pump from the pressure detected by the detection means during operation of the pump is less than a third threshold, the output means outputs a signal indicating that an abnormality of the first pipe portion is detected, and
when the rate of change is greater than a fourth threshold, the output means outputs a signal indicating that an abnormality of the second pipe portion is detected.
4. The pipe abnormality detection system according to any one of claims 1 to 3, wherein the range is determined based on a pressure previously detected by the detection means.
5. The pipe abnormality detection system according to any one of claims 1 to 4, wherein the detection means is a pressure sensor arranged between the pump

and a heat exchanger that are arranged on the pipe.

6. A method of detecting an abnormality of a pipe, the method comprising:

a first detection step of detecting a pressure of an inside of the pipe during stoppage of a pump, the pump being configured to circulate water between the pipe and a bathtub, the pipe comprising a flow inlet into which the water in the bathtub flows and a flow outlet through which the water passes into the bathtub;
a second detection step of detecting the pressure of the inside of the pipe during operation of the pump; and
an outputting step of outputting a signal indicating that an abnormality of the pipe is detected, when at least one of (i) a difference between the pressure detected in the first detection step and the pressure detected in the second detection step or (ii) a rate of change in the difference with respect to a rotational frequency of the pump is outside of a predetermined range.

7. A program for causing a computer to:

acquire a first detection value indicating a pressure of an inside of a pipe detected during stoppage of a pump, the pump being configured to circulate water between the pipe and a bathtub, the pipe comprising a flow inlet into which the water in the bathtub flows and a flow outlet through which the water passes into the bathtub;
acquire a second detection value indicating the pressure of the inside of the pipe detected during operation of the pump; and
output a signal indicating that an abnormality of the pipe is detected, when at least one of (i) a difference between the first detection value and the second detection value or (ii) a rate of change in the difference with respect to a rotational frequency of the pump is outside of a predetermined range.

FIG.1

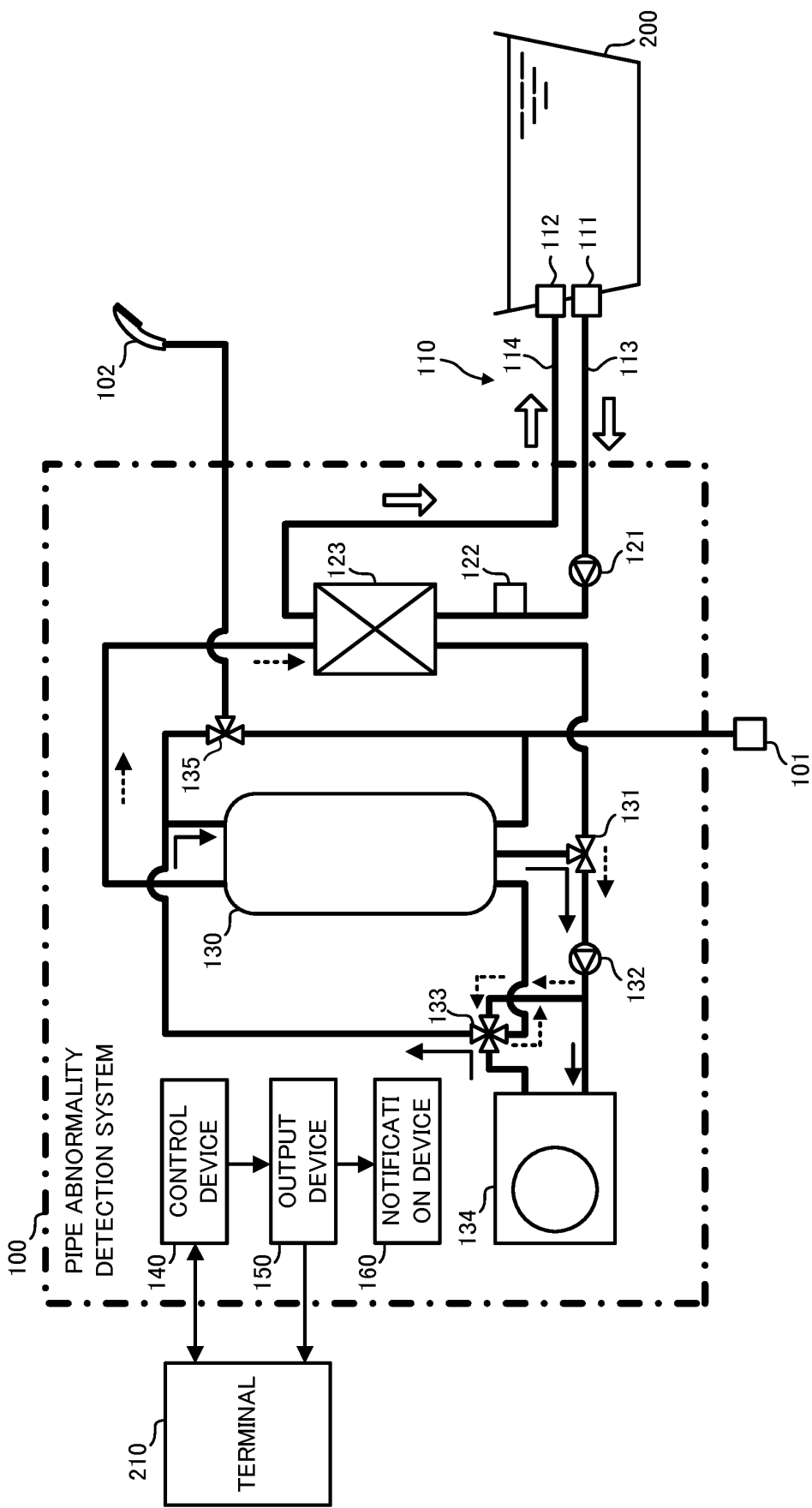


FIG.2

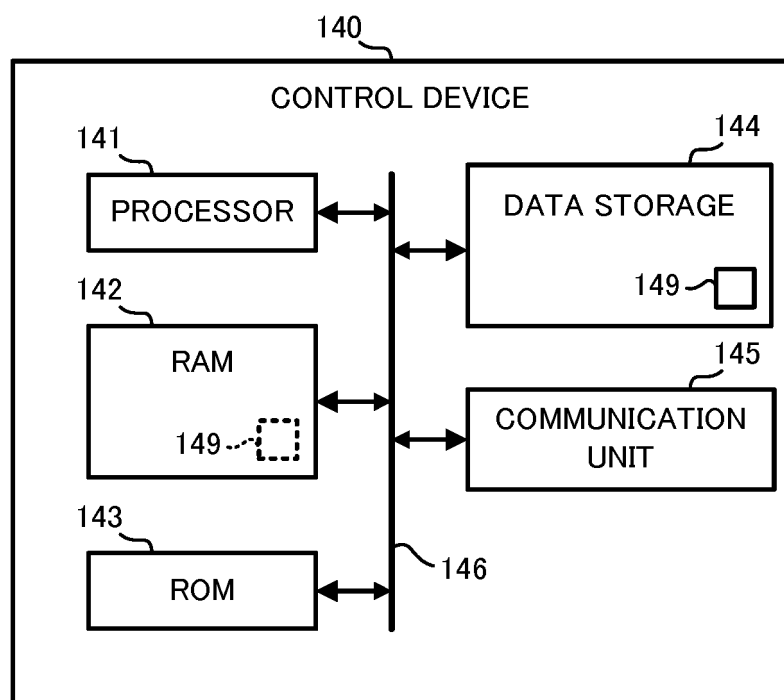


FIG.3

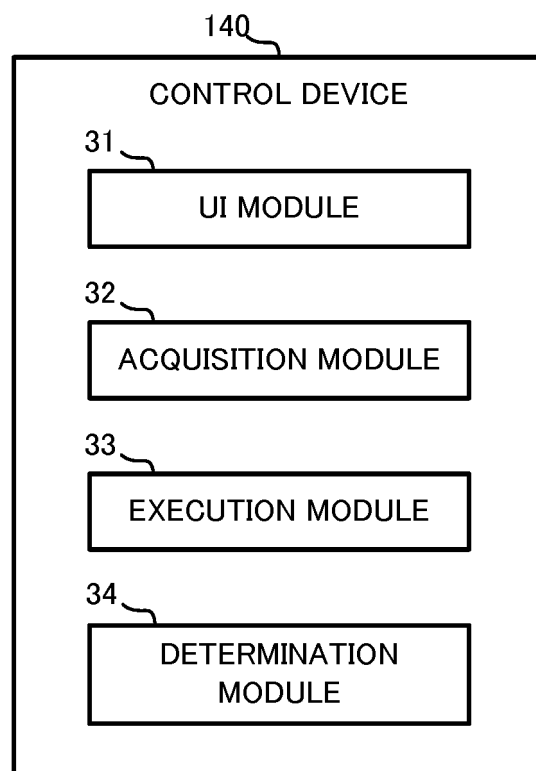


FIG.4

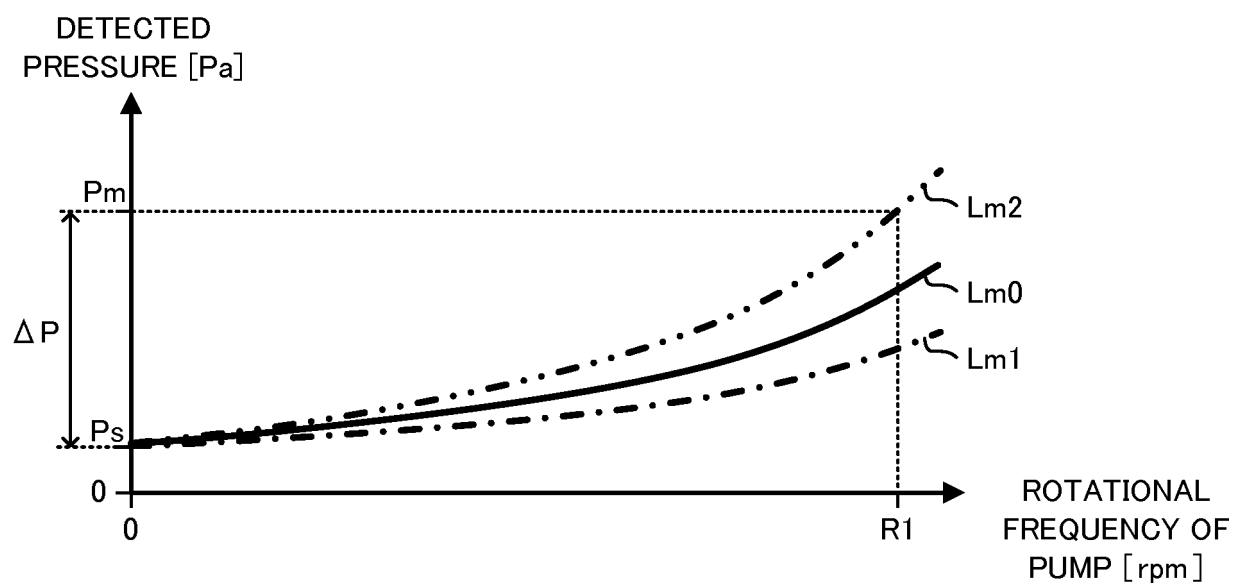


FIG.5

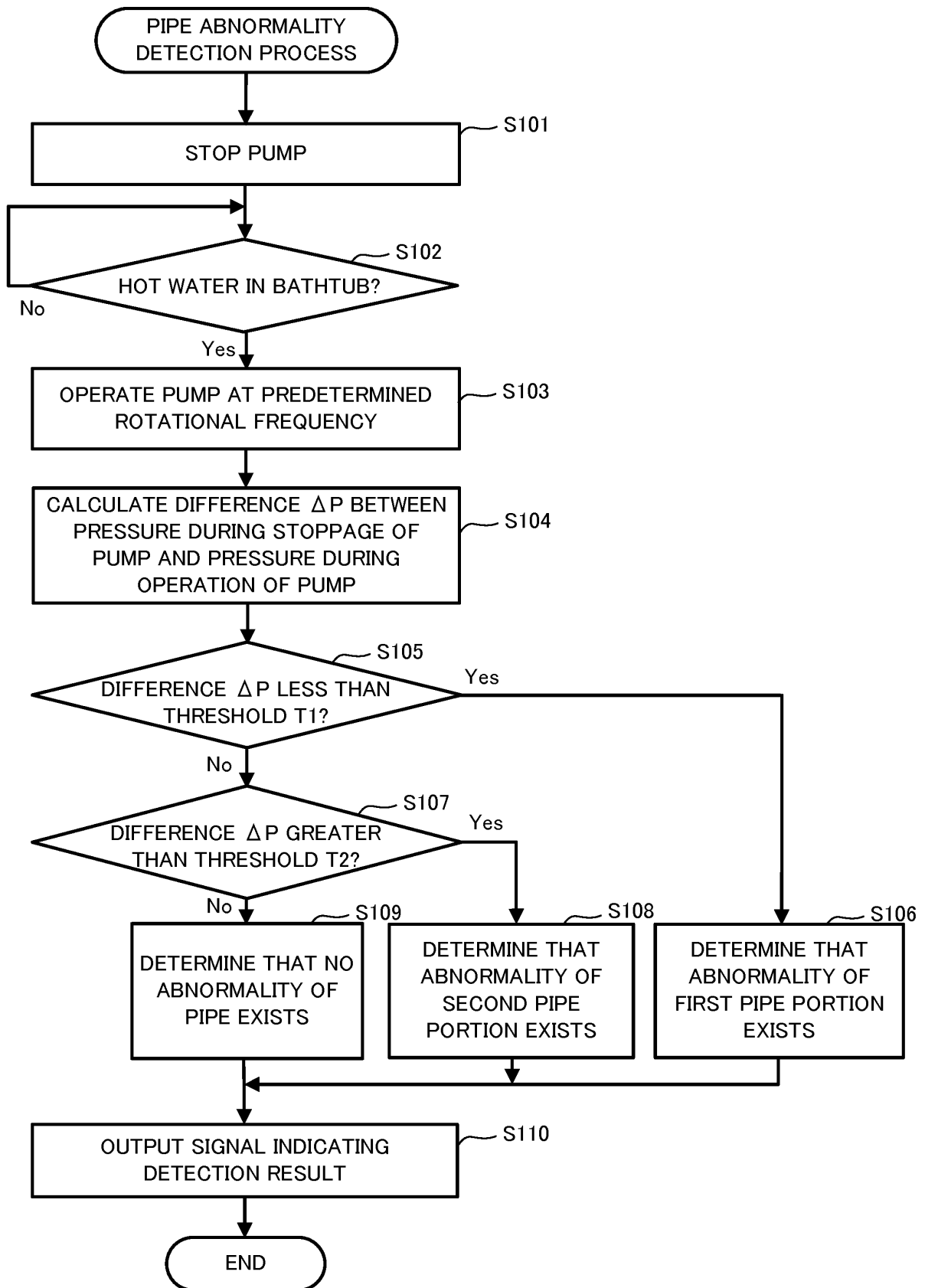


FIG.6

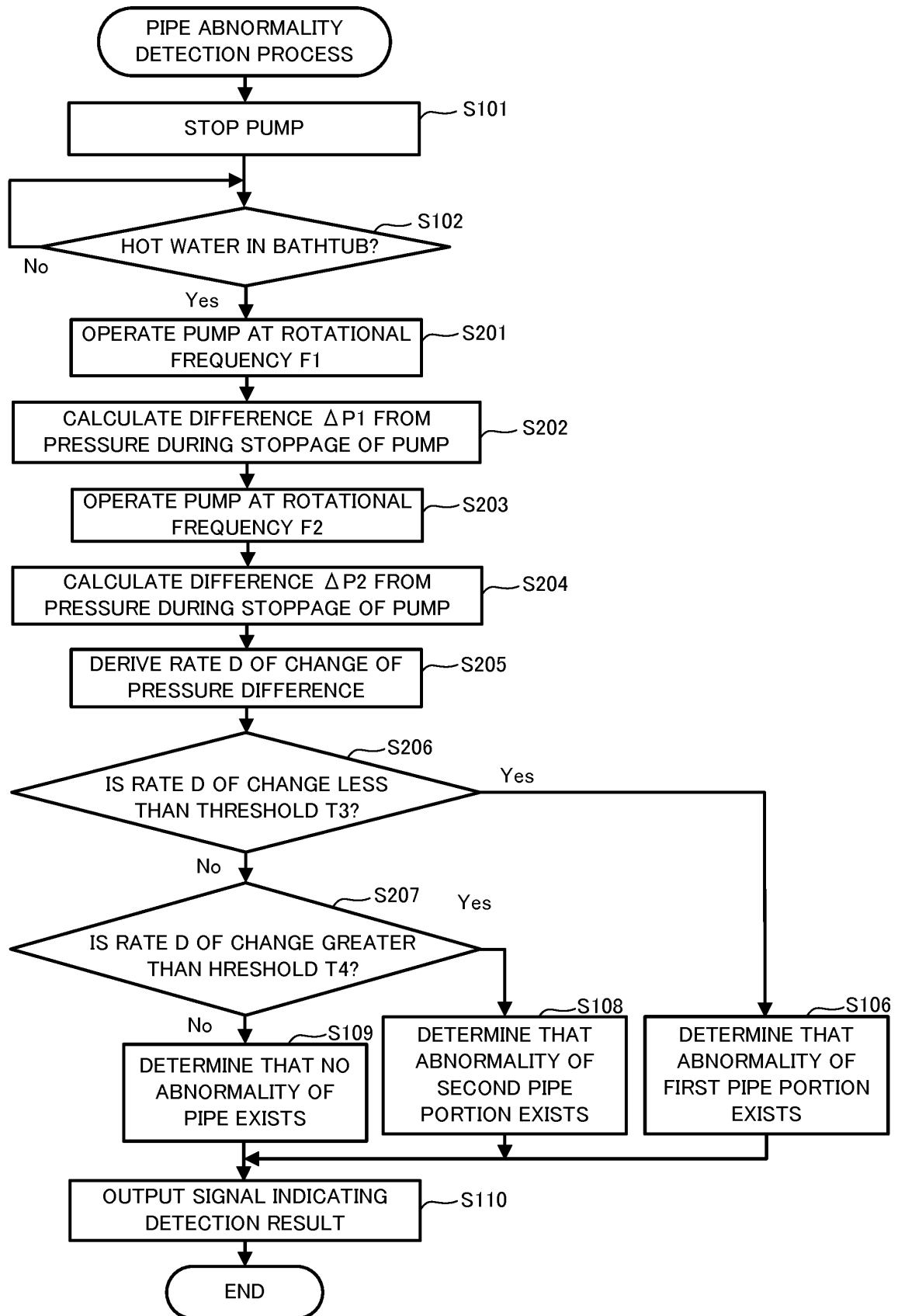


FIG.7

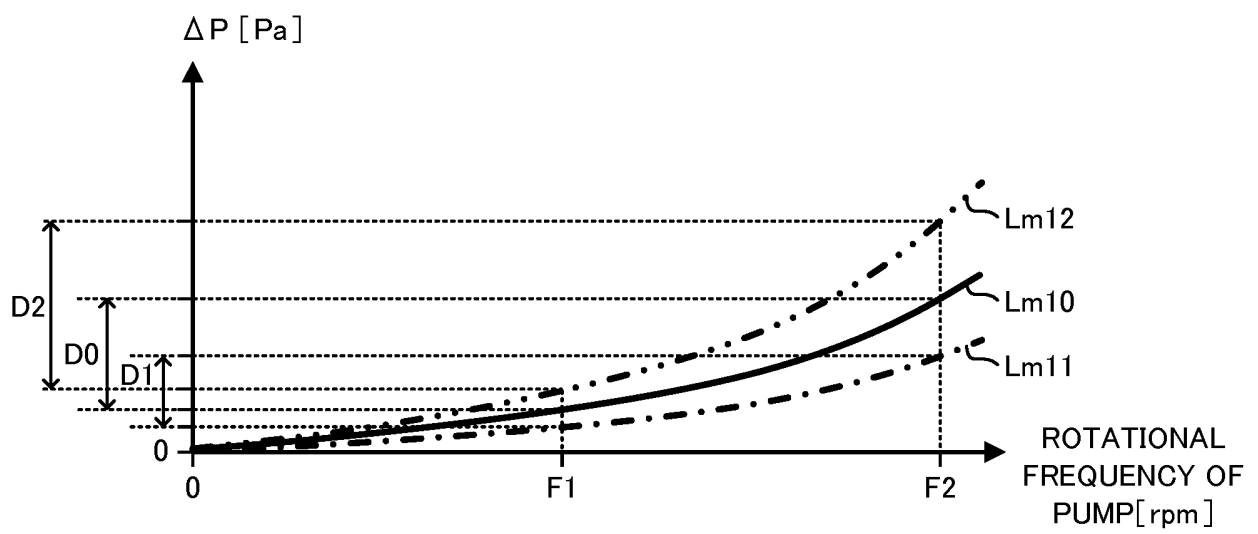


FIG.8

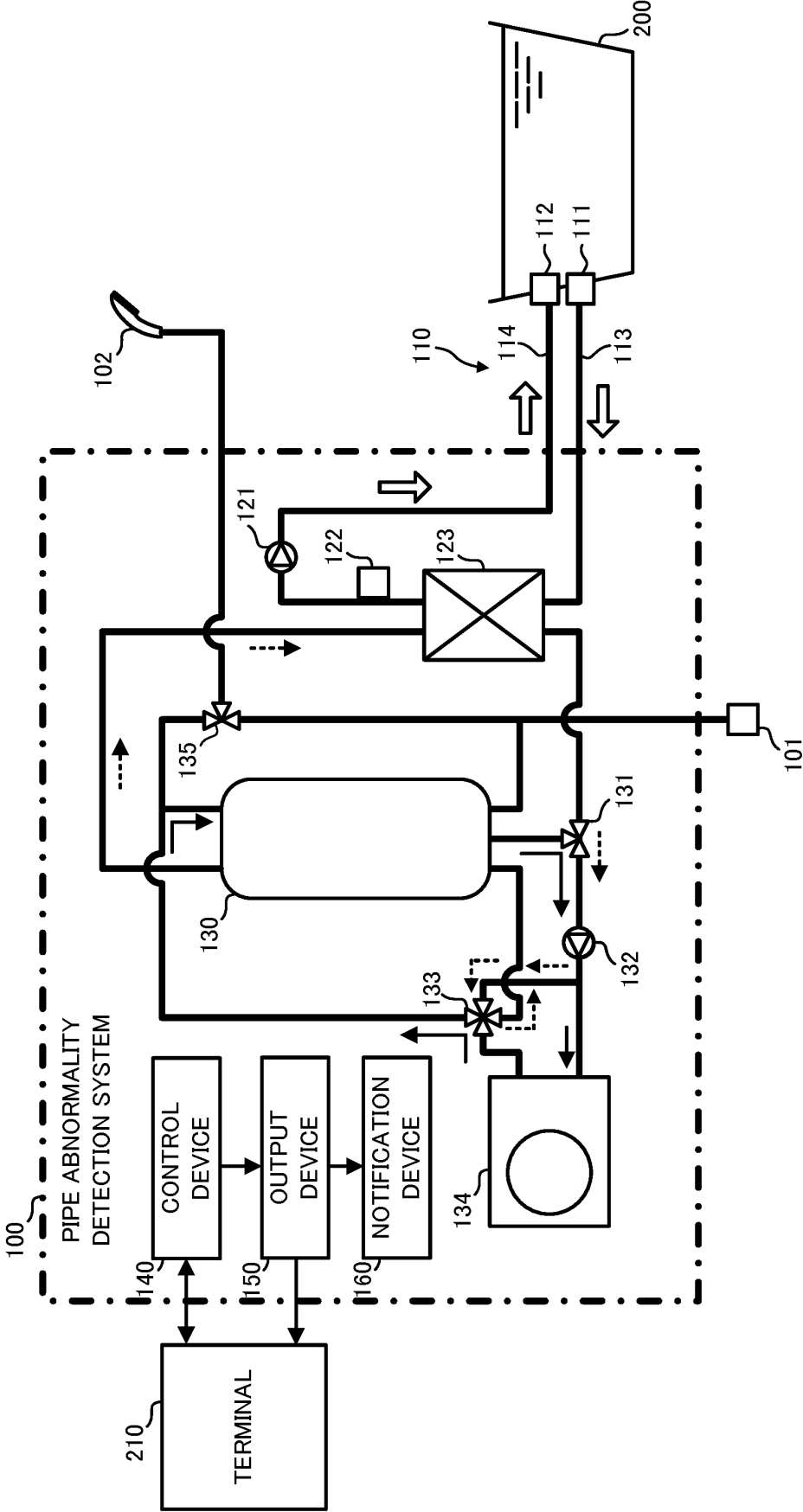


FIG.9

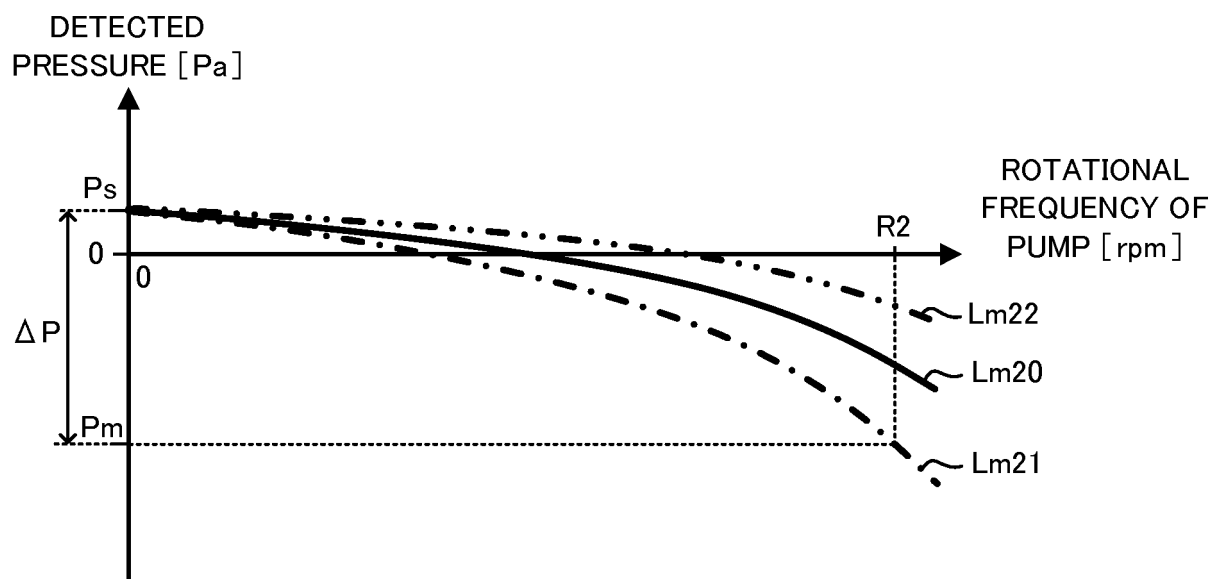


FIG.10

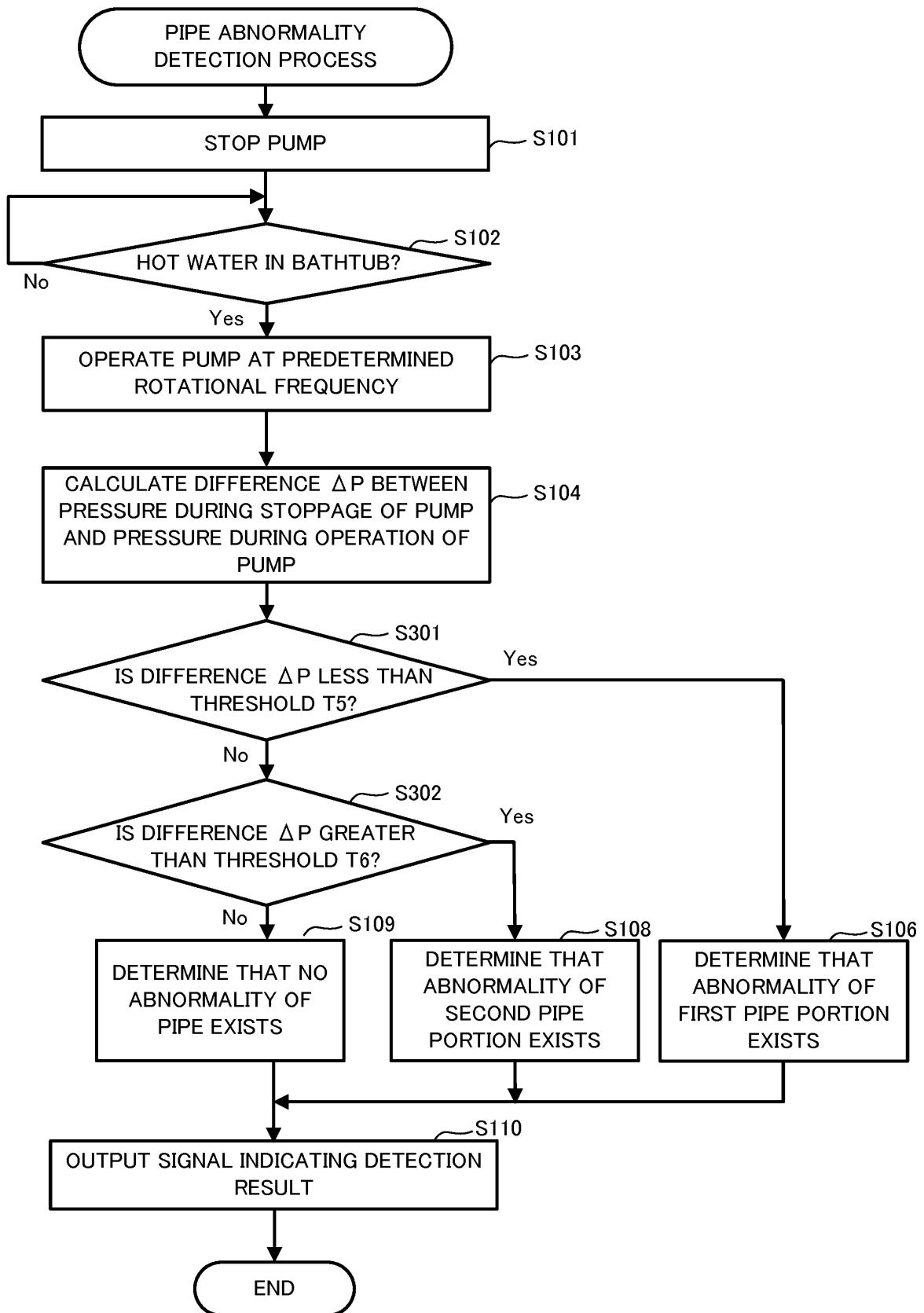
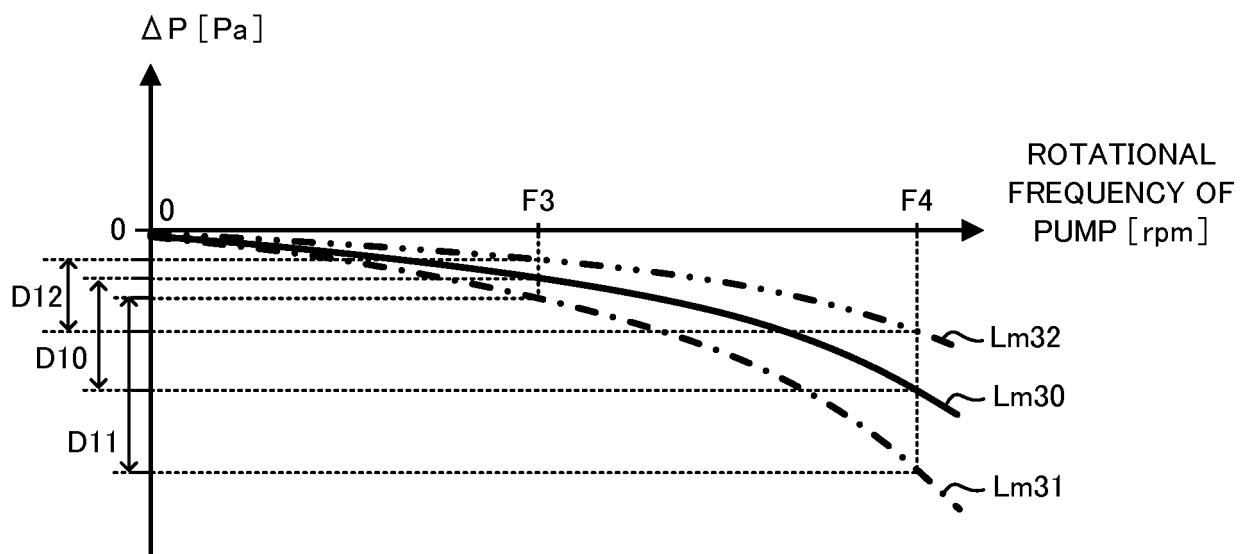


FIG.11



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/087434

A. CLASSIFICATION OF SUBJECT MATTER

F24H1/00(2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F24H1/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2017
 Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 2012-180972 A (Mitsubishi Electric Corp.), 20 September 2012 (20.09.2012), paragraphs [0032] to [0048]; fig. 1 to 10 (Family: none)	1, 4-7 2 3
X Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 039004/1991 (Laid-open No. 125155/1992) (Gastar Co., Ltd.), 16 November 1992 (16.11.1992), claims; paragraphs [0010] to [0026]; fig. 1 to 6 (Family: none)	1, 4, 6-7 2

☒ Further documents are listed in the continuation of Box C.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 11-294845 A (Toshiba Electric Appliances Co., Ltd.), 29 October 1999 (29.10.1999), claims; paragraphs [0081] to [0091]; fig. 1 to 13 (Family: none)	1, 6-7 2
X Y	JP 2001-324216 A (Tokyo Gas Co., Ltd.), 22 November 2001 (22.11.2001), claims; paragraphs [0016] to [0025]; fig. 1 to 2 (Family: none)	1, 6-7 2
Y	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 062062/1991 (Laid-open No. 008339/1993) (Corona Industries Ltd.), 05 February 1993 (05.02.1993), paragraphs [0006], [0022]; fig. 1 to 6 (Family: none)	2
A	JP 2001-133038 A (Toshiba Electric Appliances Co., Ltd.), 18 May 2001 (18.05.2001), entire text; all drawings (Family: none)	1-7
A	JP 2004-044902 A (Matsushita Electric Industrial Co., Ltd.), 12 February 2004 (12.02.2004), entire text; all drawings (Family: none)	1-7

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Patent documents cited in the description

- JP H0949659 B [0005]