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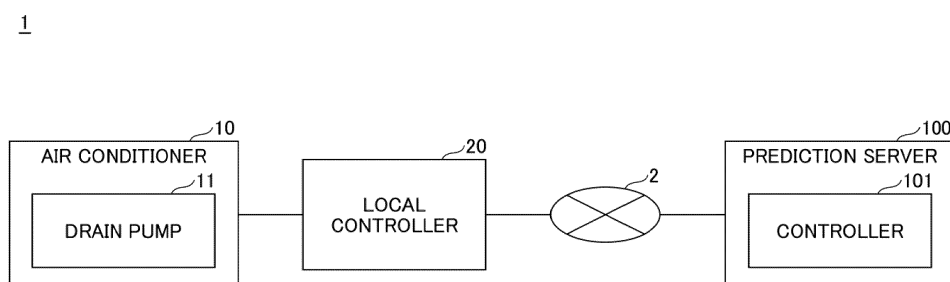
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(54) **PREDICTION SYSTEM, PREDICTION METHOD, AND PROGRAM**

(57) In order to enable more accurate prediction of an anomaly of a drain pump provided in an air conditioner, a prediction system includes an air conditioner including a drain pump and a controller, and the controller acquires data of a number of revolutions of the drain pump or a

current value of the drain pump, and outputs a prediction result indicating that an anomaly of the drain pump is predicted, based on a change in data for a predetermined period in the data.

FIG.1



Description

TECHNICAL FIELD

[0001] The present disclosure relates to a prediction system, a prediction method, and a program.

BACKGROUND

[0002] In an air conditioner including a drain pump, a technique for determining the degree of contamination of the drain pump is known. For example, a technique of detecting a current value or the number of revolutions of a drain pump and determining that contamination of the drain pump is at a level requiring maintenance when the current value of the drain pump is greater than or equal to a predetermined value or the number of revolutions of the drain pump is less than or equal to a predetermined value is known (See, for example, Patent Document 1).

Related Art Document

Patent Document

[0003] [Patent Document 1] Japanese Laid-open Patent Application Publication No. 2005-283057

SUMMARY OF THE INVENTION

Problem to be solved by the invention

[0004] However, the current value (or the number of revolutions) of the drain pump fluctuates significantly from drain pump to drain pump, and thus there is a problem that erroneous detection is likely to occur if only the anomaly is determined based on the instantaneous value of the current value (or the number of revolutions) as in the related art.

[0005] The present disclosure enables an anomaly of a drain pump provided in an air conditioner to be predicted with higher accuracy.

Means for Solving the Problem

[0006] A prediction system according to a first aspect of the present disclosure is a prediction system including an air conditioner including a drain pump and a controller. The controller is configured to acquire data of a number of revolutions of the drain pump or a current value of the drain pump, and output a prediction result indicating that an anomaly of the drain pump is predicted, based on a change in data for a predetermined period in the data.

[0007] According to the first aspect of the present disclosure, the anomaly of the drain pump provided in the air conditioner can be predicted with higher accuracy.

[0008] A second aspect of the present disclosure is the prediction system as described in the first aspect, and the controller outputs the prediction result based on a repre-

sentative value of the data for the predetermined period.

[0009] A third aspect of the present disclosure is the prediction system as described in the first aspect or the second aspect, and the controller predicts the anomaly of the drain pump based on an average value of data for a first predetermined period in the data and an average value of data for a second predetermined period in the data. The second predetermined period is shorter than the first predetermined period.

[0010] A fourth aspect of the present disclosure is the prediction system as described in the third aspect, and the controller outputs the prediction result indicating that the anomaly of the drain pump is predicted, when a divergence between the average value of the data for the first predetermined period and the average value of the data for the second predetermined period exceeds a threshold.

[0011] A fifth aspect of the present disclosure is the prediction system as described in any one of the first to fourth aspects, and the controller predicts the anomaly of the drain pump based on environmental data. The environmental data includes temperature data or humidity data. With this, the prediction system can predict the anomaly of the drain pump with higher accuracy.

[0012] A sixth aspect of the present disclosure is the prediction system as described in any one of the first to fifth aspects, and when the air conditioner or the drain pump is not operating, the controller predicts the anomaly of the drain pump, using, instead of data for a period during which the air conditioner or the drain pump is not operating in the data, data before the period in the data. With this, the prediction system can predict the anomaly of the drain pump with higher accuracy.

[0013] A seventh aspect of the present disclosure is the prediction system as described in the sixth aspect, and the controller determines the period during which the drain pump is not operating, based on environmental data. The environmental data includes temperature data or humidity data.

[0014] An eighth aspect of the present disclosure is the prediction system as described in any one of the first to fifth aspects, and the controller determines, from environmental data, whether drain water is generated, the environmental data including temperature data or humidity data, and predicts the anomaly of the drain pump, excluding data for a period during which the drain water is not generated in the data of the number of revolutions of the drain pump or the current value of the drain pump.

[0015] A ninth aspect of the present disclosure is the prediction system as described in the eighth aspect, and the controller further uses information indicating whether the air conditioner is operating in a predetermined mode to determine whether the drain water is generated.

[0016] A tenth aspect of the present disclosure is the prediction system as described in any one of the first to ninth aspects, and the prediction system includes an edge device configured to collect the data from the air conditioner, and the controller acquires data obtained by

the air conditioner or the edge device averaging the data.

[0017] An eleventh aspect of the present disclosure is the prediction system as described in the first aspect, and the controller predicts the anomaly of the drain pump by using a learned prediction model obtained by performing machine learning using data when the drain pump is in a normal state in the data and data when the drain pump is in an anomaly state in the data as training data.

[0018] A twelfth aspect of the present disclosure is the prediction system as described in the first aspect, and the controller predicts the anomaly of the drain pump by using a learned prediction model obtained by performing machine learning using an image representing data when the drain pump is in a normal state in the data and an image representing data when the drain pump is in an anomaly state in the data as training data.

[0019] A prediction method according to a thirteen aspect of the present disclosure includes, in a prediction system including an air conditioner that includes a drain pump; and a controller, acquiring, by the controller, data of a number of revolutions of the drain pump or a current value of the drain pump, and outputting, by the controller, a prediction result indicating that an anomaly of the drain pump is predicted, based on a change in data for a predetermined period in the data.

[0020] A program according to a fourteenth aspect of the present disclosure causes a computer to perform a process in a prediction system including an air conditioner and a controller, and the air conditioner includes a drain pump. The process includes acquiring data of a number of revolutions of the drain pump or a current value of the drain pump, and outputting a prediction result indicating that an anomaly of the drain pump is predicted, based on a change in data for a predetermined period in the data.

[0021] Another aspect of the present disclosure is realized by a recording medium in which the program according to the fourteenth aspect is recorded.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022]

[FIG. 1] FIG. 1 is a diagram illustrating an example of a system configuration of a prediction system according to an embodiment.

[FIG. 2] FIG. 2 is a graph (1) for explaining an outline of a prediction process according to the embodiment.

[FIG. 3] FIG. 3 is a graph (2) for explaining the outline of the prediction process according to the embodiment.

[FIG. 4] FIG. 4 is a diagram illustrating an example of a computer hardware configuration according to the embodiment.

[FIG. 5] FIG. 5 is a sequence diagram illustrating an example of a process of a prediction system according to a first embodiment.

[FIG. 6] FIG. 6 is a sequence diagram illustrating an example of a process of a prediction system according to a second embodiment.

[FIG. 7] FIG. 7 is a flowchart illustrating an example of a drain water determination process according to the second embodiment.

[FIG. 8] FIG. 8 is a diagram illustrating an example of a system configuration of a prediction system according to a third embodiment.

[FIG. 9] FIG. 9 is a sequence diagram illustrating an example of a process of a prediction system according to the third embodiment.

[FIG. 10] FIG. 10 is a sequence diagram illustrating an example of a process of a prediction system according to a fourth embodiment.

DESCRIPTION OF THE EMBODIMENTS

[0023] In the following, embodiments will be described below with reference to the attached drawings. Here, in the present specification and the drawings, components having substantially the same functional configuration will be denoted by the same reference numerals, and duplicate description will be omitted.

<System Configuration>

[0024] FIG. 1 is a diagram illustrating an example of a system configuration of a prediction system according to an embodiment. The prediction system 1 includes an air conditioner 10 including a drain pump 11 and a controller 101. The prediction system 1 is a system in which the controller 101 acquires data of the number of revolutions (or a current value) of the drain pump 11 and predicts an anomaly of the drain pump based on a change in data for a predetermined period.

[0025] In the example illustrated in FIG. 1, the prediction system 1 includes a local controller 20 communicably connected to the air conditioner 10 via a predetermined communication interface and configured to control the air conditioner 10. Additionally, the prediction system 1 includes a prediction server 100 including the controller 101 and configured to communicate with the local controller 20 via a communication network 2, such as the Internet or a local area network (LAN).

[0026] Here, the system configuration of the prediction system 1 illustrated in FIG. 1 is an example. The local controller 20 may include the controller 101, for example. Additionally, the prediction server 100 may include multiple information processing devices. Here, as an example, the following description will be provided on the assumption that the prediction server 100 includes the controller 101.

[0027] The air conditioner 10 is configured such that, for example, during a cooling operation, condensation water (drain) is generated by a heat exchanger provided in the air conditioner 10, and the generated condensation water accumulates in a saucer called a drain pan.

[0028] The drain pump 11 is a pump configured to suction up the condensation water accumulated in the drain pan, and discharges it to the outside via a drain hose. When an anomaly occurs in the drain pump, the condensation water accumulates inside the air conditioner 10, and when the amount of the accumulated condensation water exceeds an allowable range, the air conditioner 10 detects an anomaly (a drain pump failure) and stops operation.

[0029] When the drain pump failure occurs, the user cannot use the cooling operation. Thus, the prediction system 1 outputs a prediction result indicating that the anomaly of the drain pump is predicted in advance so that, for example, a service person or the like can respond to the problem on the spot before the drain pump 11 is completely clogged.

[0030] The local controller 20 has a computer configuration, for example, and controls the air conditioner 10 by executing a predetermined program recorded (stored) in a recording medium. Additionally, the local controller 20 according to the present embodiment has a function of acquiring measurement data including the number of revolutions of the drain pump 11 or the current value of the drain pump 11, which is measured by the air conditioner 10 periodically (for example, every minute), every predetermined time (for example, every hour). Furthermore, the local controller 20 has a function of transmitting measurement data (second measurement data) obtained by averaging the measurement data (first measurement data) acquired from the air conditioner 10 every predetermined time, to the prediction server 100 via the communication network 2. Here, the local controller 20 is an example of an edge device.

[0031] As another example, the air conditioner 10 may average the measurement data every predetermined time, and the local controller 20 may acquire the averaged measurement data from the air conditioner 10. In this case, the first measurement data acquired by the local controller 20 from the air conditioner 10 and the second measurement data transmitted by the local controller 20 to the prediction server 100 may be the same data.

[0032] The prediction server 100 has a computer configuration, and performs a prediction process for predicting the anomaly of the drain pump 11 by executing a predetermined program recorded (stored) in a recording medium.

(Outline of Prediction Process)

[0033] FIGS. 2 and 3 are graphs for explaining an outline of the prediction process according to the embodiment. In a graph 200 illustrated in FIG. 2, the horizontal axis represents the number of days elapsed since the measurement has started, and the vertical axis represents the number of revolutions of the drain pump 11. Additionally, in the graph 200, measurement data (raw data) 201 of the number of revolutions of the drain pump

11, a cumulative average 202 of the measurement data 201, and a three-day moving average 203 of the measurement data 201 are plotted.

[0034] As for the number of revolutions of the drain pump, for example, the number of pulses are measured, and the number of revolutions can be calculated from the measured number of pulses. In this case, for example, if 1 pulse is 24 rpm, the number of revolutions is measured at 24 rpm intervals. Additionally, the measurement data 201 of the number of revolutions includes, for example, a measurement fluctuation 204 of ± 48 rpm (± 2 pulses) as illustrated in FIG. 2.

[0035] As described above, the measurement data 201 of the number of revolutions of the drain pump 11 has a large fluctuation, and there is also a fluctuation (individual difference) for each drain pump 11, and thus there is a problem that erroneous detection is likely to occur if the anomaly is determined only by the instantaneous value of the number of revolutions as in the related art.

[0036] Therefore, the controller 101 according to the present embodiment stores (accumulates) the measurement data 201 transmitted by the local controller 20 every 1 hour in a storage unit, for example. Here, the storage unit for storing the measurement data 201 may be, for example, a storage device provided by the prediction server 100, or a storage server or the like outside of the prediction server 100.

[0037] Additionally, the controller 101 calculates the cumulative average 202 of the measurement data 201 stored in the storage unit and the three-day moving average 203 of the measurement data 201. Here, the three-day moving average 203 is an average value (a moving average) of the measurement data 201 for the most recent three days. Here, three days are an example of a predetermined period (a second predetermined period) used for predicting the anomaly of the drain pump 11. The second predetermined period may be a number of days other than three days (for example, 1 to 5 days).

[0038] Additionally, the cumulative average 202 is, for example, an average value of the measurement data 201 for a first predetermined period sufficiently longer than the second predetermined period. The cumulative average 202 may be, for example, an average value (a moving average value) of the measurement data 201 for the most recent 30 days, a cumulative moving average value from the time of starting the measurement, or the like. Here, the following description will be provided on the assumption that the cumulative average 202 is an average value of the measurement data 201 for 30 days.

[0039] When the drain pump 11 has a tendency to become clogged, as illustrated in FIG. 2, the number of revolutions of the drain pump gradually decreases, and the value of the three-day moving average 203 gradually decreases. In contrast, the cumulative average 202 is an average value for a period sufficiently longer than three days, a change in the value is less than the change in the three-day moving average 203.

[0040] Therefore, the controller 101 according to the present embodiment outputs a prediction result indicating that the anomaly of the drain pump 11 is predicted, based on the cumulative average 202 (the average value of the data for the first predetermined period) and the three-day moving average 203 (the average value of the data for the second predetermined period that is shorter than the first predetermined period). For example, if a divergence between the cumulative average 202 (the average value of the data for the first predetermined period) and the three-day moving average 203 (the average value of the data for the second predetermined period) exceeds a threshold, the controller 101 outputs a prediction result indicating that the anomaly of the drain pump 11 is predicted.

[0041] As a specific example, as illustrated in FIG. 3, the controller 101 calculates a difference 301 between the three-day moving average 203 and the cumulative average 202, and outputs a prediction result indicating that the anomaly of the drain pump 11 is predicted, when the calculated difference 301 exceeds a threshold 302. Here, the threshold 302 is determined in advance based on, for example, how many days before the anomaly of the drain pump 11 the prediction result is output, or the like.

[0042] By using the above-described process, according to the prediction system 1 of the present embodiment, the anomaly of the drain pump 11 provided in the air conditioner 10 can be predicted with higher accuracy.

[0043] Here, in the above description, the number of revolutions of the drain pump 11 (the number of revolutions of a motor provided in the drain pump) is used as the measurement data 201, but the measurement data 201 may be the current value of the drain pump 11 (the current value flowing in the drain pump 11).

[0044] Here, when the drain pump 11 has a tendency to become clogged, the number of revolutions of the drain pump 11 decreases and the current value of the drain pump 11 increases. In either case, the controller 101 only needs to output a prediction result indicating that the anomaly of the drain pump 11 is predicted, when a divergence between the three-day moving average 203 of the measurement data 201 and the cumulative average 202 of the measurement data 201 exceeds a threshold.

[0045] Here, the prediction result indicating that the anomaly of the drain pump 11 is predicted may, for example, be provided by notification to the air conditioner 10 or the local controller 20 to perform a predetermined display, or may be provided by notification to the manager or the like who manages the air conditioner 10. Additionally, the prediction result may be, for example, a message such as "The drain pump is contaminated, so please check it.", information indicating a period until an anomaly occurs in the drain pump 11, or the like.

<Hardware Configuration>

[0046] The prediction server 100 and the local controller 20 have a hardware configuration of a computer 400 as illustrated in FIG. 4, for example. Here, the prediction server 100 may be configured by multiple computers 400.

[0047] FIG. 4 is a diagram illustrating an example of a hardware configuration of a computer according to the embodiment. The computer 400 includes, for example, the controller 101, a memory 401, a storage device 402, a communication device 403, a display device 404, an input device 405, a drive device 406, a bus 408, and the like.

[0048] The controller 101 is, for example, a processor, such as a central processing unit (CPU) that realizes various functions by executing predetermined programs stored in a storage medium (recording medium), such as the storage device 402 or the memory 401. Here, in addition to the CPU, the controller 101 may include a processor such as a graphics processing unit (GPU) or a digital signal processor (DSP). Additionally, the controller 101 may be, for example, a device such as an application specific integrated circuit (ASIC) or a field programmable gate array (FPGA).

[0049] The memory 401 includes, for example, a random access memory (RAM), which is a volatile memory used as a work area or the like of the controller 101, and a read only memory (ROM), which is a nonvolatile memory for storing a program for starting the controller 101 and the like. The storage device 402 is a large-capacity storage device for storing programs, such as an operating system (OS) and applications, various data, information, and the like, and is realized by, for example, a solid state drive (SSD) or a hard disk drive (HDD).

[0050] The communication device 403 includes one or more communication interfaces or communication devices for communicating with external devices. For example, the communication device 403 includes a network interface card (NIC) or the like for connecting the computer 400 to the communication network 2 and communicating with other devices. Additionally, the communication device 403 may include, for example, a communication interface or the like for connecting the air conditioner 10 or the like to the computer 400.

[0051] The display device 404 is a display device or apparatus for displaying a display screen. The input device 405 is, for example, an input device for receiving an external input, such as a keyboard, a pointing device, or a touch panel. Here, the display device 404 and the input device 405 may be an integrated display input device, such as a touch panel display.

[0052] The drive device 406 is a device for connecting, to the computer 400, a recording medium 407 in which a predetermined program is recorded (stored). The recording medium 407 herein includes, for example, a medium for recording information optically, electrically, or magnetically, such as a CD-ROM, a flexible disk, or a magneto-optical disk. Additionally, the recording medium 407 may

include, for example, a semiconductor memory or the like for recording information electrically, such as a ROM or a flash memory. The bus 408 is commonly connected to the above-described components, and transmits, for example, address signals, data signals, various control signals, and the like.

<Flow of Process>

[0053] Next, a flow of a process of a prediction method according to the present embodiment will be described by illustrating multiple embodiments.

[First Embodiment]

[0054] FIG. 5 is a sequence diagram illustrating an example of a process of a prediction system according to a first embodiment. This process indicates an example of the prediction process repeatedly performed by the prediction system 1 described with reference to FIG. 1.

[0055] In step S501, the air conditioner 10 collects the measurement data including the number of revolutions of the drain pump 11 provided in the air conditioner 10 or the current value of the drain pump. For example, the air conditioner 10 periodically (for example, every minute) measures the number of revolutions of the drain pump 11 and stores it in a storage unit or the like provided in the air conditioner 10.

[0056] In step S502, the local controller 20 requests the air conditioner 10 to acquire the data. In response, in step S503, the air conditioner 10 transmits the collected measurement data (the first measurement data) to the local controller 20. For example, the local controller 20 transmits a data acquisition request to the air conditioner 10 at a predetermined time interval (for example, every hour). Additionally, when receiving the data acquisition request, the air conditioner 10 transmits, to the local controller, the measurement data for the most recent predetermined period (for example, 1 hour) as the first measurement data. Alternatively, when receiving the data acquisition request, the air conditioner 10 may calculate an average value of the measurement data for the most recent predetermined period and transmit, to the local controller 20, the calculated average value as the first measurement data.

[0057] In step S504, the local controller 20 transmits, to the prediction server 100, the average value of the measurement data for the most recent predetermined period as the second measurement data, based on the data (the first measurement data) received from the air conditioner 10. For example, when the first measurement data received from the air conditioner 10 is the measurement data for the most recent predetermined period, the local controller 20 calculates the average value of the first measurement data and transmits, to the prediction server 100, the calculated average value as the second measurement data. Additionally, when the first measurement data received from the air conditioner 10 is the average

value of the measurement data for the most recent predetermined period, the local controller 20 transmits, to the prediction server 100, the first measurement data as the second measurement data.

[0058] In step S505, the controller 101 of the prediction server 100 stores (accumulates) the data (the second measurement data) received from the local controller 20 or data obtained by processing the received data in the storage unit, such as the storage device 402, for example.

[0059] For example, when the drain pump 11 is not operating (stopped), the measurement data 201 of the number of revolutions and the current value of the drain pump 11 becomes 0 (zero). Therefore, if the cumulative average 202 or the three-day moving average is calculated using the data for the period during which the drain pump 11 is not operating, there is a possibility that a correct prediction result cannot be obtained. Therefore, as an example, when the drain pump 11 is not operating, the controller 101 may replace the data for the period during which the drain pump 11 is not operating with data before this period, and store the data in the storage unit.

[0060] For example, if the operation of the drain pump 11 has been stopped for one day due to a holiday, absence, or the like, the controller 101 may replace the one-day portion of data during which the drain pump 11 has been stopped with the data mentioned above, and store the data in the storage unit. Additionally, if the drain pump 11 has been stopped for one hour, the controller 101 may replace the one-hour portion of data during which the drain pump 11 has been stopped with data for the preceding one-hour portion, and store the data in the storage unit.

[0061] However, this is one suitable example, and the controller 101 may store the data received from the local controller 20 in the storage unit without modification. In this case, for example, the controller 101 may exclude the data for the period while the drain pump 11 has been stopped and calculate the cumulative average 202 or the three-day moving average 203.

[0062] In step S506, the controller 101 calculates the cumulative average 202 and the three-day moving average 203 from the numbers of revolutions (or the current values) of the drain pump 11 included in the data stored in the storage unit, and calculates the difference 301 between the cumulative average 202 and the three-day moving average 203.

[0063] Additionally, when the calculated difference 301 exceeds the preset threshold 302, the controller 101 performs the processing of step S507. In step S507, the controller 101 outputs the prediction result indicating that the anomaly of the drain pump 11 is predicted.

[0064] By the process illustrated in FIG. 5, for example, as illustrated in FIG. 3, the prediction system 1 can output the prediction result indicating that the anomaly of the drain pump 11 is predicted, before the anomaly occurs in the drain pump 11 with higher accuracy.

[Second Embodiment]

[0065] In a second embodiment, an example of a process in which the controller 101 predicts the anomaly of the drain pump 11 based also on environmental data including temperature data or humidity data will be described.

[0066] FIG. 6 is a sequence diagram illustrating an example of a process of a prediction system according to a first embodiment. This process indicates another example of the prediction process repeatedly performed by the prediction system 1 described with reference to FIG. 1. Here, the basic flow of the process is substantially the same as that of the first embodiment, and thus a detailed description of the process contents that are substantially the same as those of the first embodiment will be omitted here.

[0067] In step S601, the air conditioner 10 collects the measurement data including the number of revolutions of the drain pump 11 provided in the air conditioner 10 or the current value of the drain pump, environmental data, and operation data. Here, the environmental data includes, for example, temperature data indicating a room temperature, humidity data indicating relative humidity, and the like. Here, if the air conditioner 10 cannot acquire the humidity data, the environmental data may include only the temperature data. Additionally, the operation data includes, for example, data indicating the operation mode (cooling, dehumidification, heating, and the like) of the air conditioner 10 and data such as evaporation temperature measured by a temperature sensor of a heat exchanger of the air conditioner 10. Here, the data of the evaporation temperature may be included in the environmental data.

[0068] In step S602, the local controller 20 requests the air conditioner 10 to acquire the data. In response to this, in step S603, the air conditioner 10 transmits, to the local controller 20, data including the collected measurement data (the first measurement data), the environmental data, the operation data, and the like.

[0069] In step S604, the local controller 20 transmits, to the prediction server 100, data including the second measurement data, which is the average value of the first measurement data received from the air conditioner 10, the environmental data, and the operation data.

[0070] In step S605, the controller 101 of the prediction server 100 stores (accumulates) the data received from the local controller 20 or data obtained by processing the received data in the storage unit, such as the storage device 402.

[0071] In step S606, the controller 101 determines a period during which no drain water is present from the data stored in the storage unit. For example, the controller 101 performs a drain water determination process as illustrated in FIG. 7.

[0072] FIG. 7 is a flowchart illustrating an example of the drain water determination process according to the second embodiment. This process indicates, for example, an example of the process performed by the con-

troller 101 in step S606 of FIG. 6. The controller 101 performs, for example, the process illustrated in FIG. 7 on data during the cooling operation of the air conditioner 10 in the data stored in the storage unit.

[0073] In step S701, the controller 101 calculates the dew point temperature (the temperature at which dew condensation occurs) using the temperature data and the humidity data, or the temperature data. For example, the controller 101 calculates a water vapor pressure from the temperature data indicating the room temperature and the humidity data indicating relative humidity, and calculates a temperature at which the water vapor pressure becomes the saturated water vapor pressure. Here, when there is no humidity data, the controller 101 calculates the dew point temperature by temporarily assuming a value of the relative humidity.

[0074] In step S702, the controller 102 obtains an evaporation temperature from the operation data. Here, the evaporation temperature is the temperature of the heat exchanger measured by the sensor of the heat exchanger of the air conditioner 10.

[0075] In step S703, the controller 101 determines whether the evaporation temperature is less than or equal to the calculated dew point temperature. If the evaporation temperature is less than or equal to the dew point temperature, dew condensation occurs, and thus in step S704, the controller 101 determines that the drain water is present. If the evaporation temperature is not less than or equal to the dew point, in step S705, the controller 101 determines that no drain water is present.

[0076] Returning to FIG. 6, the description of the sequence diagram is continued. In step S607, the controller 101 excludes the data for the period during which no drain water is present, from the measurement data stored in the storage unit (for example, the number of revolutions of the drain pump 11), and calculates the difference 301 between the cumulative average 202 and the three-day moving average 203. This is because when no drain water is present, the drain pump 11 becomes unloaded and the number of revolutions of the drain pump 11 increases. Therefore, by excluding the data for the period during which no drain water is present, the prediction accuracy for predicting the anomaly of the drain pump 11 can be further improved.

[0077] Subsequently, when the calculated difference 301 exceeds the preset threshold 302, the controller 101 performs the processing of step S608. In step S608, the controller 101 outputs the prediction result indicating that the anomaly of the drain pump 11 is predicted.

[0078] By the process of FIG. 6, the prediction system 1 can further increase the accuracy of the prediction result indicating that the anomaly of the drain pump 11 is predicted.

[Third Embodiment]

[0079] In the first and second embodiments, the controller 101 outputs the prediction result indicating that the

anomaly of the drain pump 11 is predicted, when the divergence between the cumulative average 202 and the three-day moving average 203 of the measurement data of the numbers of revolutions (or current values) of the drain pump 11 exceeds the threshold.

[0080] In a third embodiment, an example of a case where the controller 101 predicts the anomaly of the drain pump 11, using a learned prediction model obtained by performing machine learning using data for a predetermined period during which the drain pump 11 is in a normal state and data for a predetermined period during which the drain pump 11 is in an anomaly state as training data, will be described.

[0081] FIG. 8 is a diagram illustrating an example of a system configuration of a prediction system according to the third embodiment. As illustrated in FIG. 8, the prediction system 1 according to the third embodiment includes a prediction model 801 in addition to the system configuration of the prediction system 1 described with reference to FIG. 1.

[0082] The prediction model 801 is a learned prediction model obtained by performing machine learning to predict the anomaly of the drain pump 11, using data for a predetermined period during which the drain pump 11 is in a normal state and data for a predetermined period during which the drain pump 11 is in an anomaly state as training data. The controller 101 can obtain a prediction result indicating whether an anomaly will occur in the drain pump 11 by inputting, into the prediction model 801, measurement data for a predetermined period (for example, the cumulative average 202 and the three-day moving average 203) stored in the storage unit. Here, the measurement data for the predetermined period may be only the three-day moving average 203.

[0083] Here, the learning of the prediction model 801 may be performed by the prediction server 100 using the data stored by the controller 101 in the storage unit, or the prediction model 801 on which the learning has been performed by another information processing device may be set in the prediction server 100.

<Flow of Process>

[0084] FIG. 9 is a sequence diagram illustrating an example of a process of the prediction system according to the third embodiment. This process indicates an example of the prediction process repeatedly performed by the prediction system 1 described with reference to FIG. 8. Here, the basic flow of the process is substantially the same as that of the process of the prediction system according to the first embodiment described with reference to FIG. 5, and thus a detailed description of the process contents that are substantially the same as those of the first embodiment will be omitted here.

[0085] In step S901, the air conditioner 10 collects the measurement data including the number of revolutions of the drain pump 11 provided in the air conditioner 10 or the current value of the drain pump.

[0086] In step S902, the local controller 20 requests the air conditioner 10 to acquire the data. In response, in step S903, the air conditioner 10 transmits the collected measurement data (the first measurement data) to the local controller 20.

[0087] In step S904, the local controller 20 transmits, to the prediction server 100, the average value of the measurement data for the most recent predetermined period as the second measurement data, based on the data (the first measurement data) received from the air conditioner 10.

[0088] In step S905, the controller 101 of the prediction server 100 stores (accumulates) the data (the second measurement data) received from the local controller 20 or data obtained by processing the received data, in the storage unit, such as the storage device 402.

[0089] In step S906, the controller 101 inputs, into the learned prediction model 801, the measurement data for the predetermined period stored in the storage unit. For example, the controller 101 calculates the cumulative average 202 and the three-day moving average 203 of the measurement data of the number of revolutions (or the current value) of the drain pump 11 stored in the storage unit, and inputs the calculated data into the learned prediction model 801. With this, the learned prediction model 801 outputs a prediction result indicating whether an anomaly will occur in the drain pump 11.

[0090] Subsequently, if it is predicted that an anomaly will occur in the drain pump 11, the controller 101 performs the processing of step S907. In step S907, the controller 101 outputs the prediction result indicating that the anomaly of the drain pump 11 is predicted.

[0091] As described, the prediction system 1 may predict the anomaly of the drain pump 11 by using the learned prediction model 801 obtained by performing machine learning using the data when the drain pump 11 is in a normal state and the data when the drain pump 11 is in an anomaly state as the training data.

[0092] Here, the process described with reference to FIG. 9 is an example. For example, in the process of the prediction system according to the third embodiment, as in the second embodiment described with reference to FIG. 6, the anomaly of the drain pump 11 may be predicted by excluding the data for the period during which no drain water is present from the data stored in the storage unit.

[Fourth Embodiment]

[0093] In the third embodiment, the prediction model 801 is subjected to machine learning using the data when the drain pump 11 is in a normal state and the data when the drain pump 11 is in an anomaly state as the training data.

[0094] In the fourth embodiment, the prediction model 801 is a learned prediction model obtained by performing machine learning using an image representing data when the drain pump 11 is in a normal state and an image

representing data when the drain pump 11 is in an anomaly state as the training data.

[0095] Here, as the image representing the data when the drain pump 11 is in the normal state and the image representing the data when the drain pump 11 is in the anomaly state, for example, as illustrated in FIG. 2, an image of the graph 200 in which the data of the cumulative average 202 and the three-day moving average 203 are plotted can be applied.

<Flow of Process>

[0096] FIG. 10 is a sequence diagram illustrating an example of a process of the prediction system according to the fourth embodiment. This process indicates another example of the prediction process repeatedly performed by the prediction system 1 described with reference to FIG. 8. Here, in the processing illustrated in FIG. 10, the processing of steps S901 to S905 and S907 are substantially the same as the processing of the prediction system according to the third embodiment described with reference to FIG. 9, and thus the description thereof is omitted here.

[0097] In step S1001, the controller 101 images the transitions of the cumulative average 202 and the three-day moving average 203 of the measurement data (for example, the numbers of revolutions of the drain pump 11) stored in the storage unit. For example, the controller 101 creates an image of the graph 200 illustrated in FIG. 2.

[0098] In step S1002, the controller 101 inputs the created image into the learned prediction model 801. With this, the learned prediction model 801 outputs a prediction result indicating whether an anomaly will occur in the drain pump 11.

[0099] Subsequently, if it is predicted that an anomaly will occur in the drain pump 11, the controller 101 performs the processing of step S907.

[0100] As described, the prediction system 1 may predict the anomaly of the drain pump 11, using the learned prediction model 801 obtained by performing machine learning using the image of the data when the drain pump 11 is in the normal state and the image of the data when the drain pump 11 is in the anomaly state as the training data.

[0101] Here, in the process of the prediction system according to the fourth embodiment, as in the second embodiment described with reference to FIG. 6, the anomaly of the drain pump 11 may be predicted by excluding the data for the period during which no drain water is present from the data stored in the storage unit.

[0102] As described above, according to the embodiments of the present disclosure, the anomaly of the drain pump 11 provided in the air conditioner 10 can be predicted with higher accuracy.

[0103] Although the embodiments have been described above, it will be understood that various changes in the form and details can be made without departing

from the spirit and scope of the claims.

[0104] For example, in the above-described embodiments, the anomaly of the drain pump 11 is predicted using the average value, such as the cumulative average 202 and the three-day moving average. However, the embodiments are not limited thereto, and the average value may be another representative value, such as a median value or a modal value, for example.

[0105] Additionally, in the above-described embodiments, the prediction server 100 includes the controller 101, but the local controller 20 may include the controller 101. Additionally, the controller 101 may be implemented by, for example, a virtual computer on a cloud or the like.

[0106] This application claims the priority to Basic Application No. 2022-136193 filed with the Japan Patent Office on August 29, 2022. Its entire contents are hereby incorporated by reference.

Description of reference symbols

[0107]

1	prediction system
2	communication network
10	air conditioner
11	drain pump
20	local controller
100	prediction server
101	controller
200	graph
202	cumulative average
203	three-day moving average
302	threshold
400	computer
407	recording medium
801	prediction model

Claims

1. A prediction system comprising:

an air conditioner including a drain pump; and
a controller,
wherein the controller is configured to:

acquire data of a number of revolutions of the drain pump or a current value of the drain pump; and
output a prediction result indicating that an anomaly of the drain pump is predicted, based on a change in data for a predetermined period in the data.

2. The prediction system as claimed in claim 1, wherein the controller outputs the prediction result based on a representative value of the data for the predetermined period.

3. The prediction system as claimed in claim 1 or 2, wherein the controller predicts the anomaly of the drain pump based on an average value of data for a first predetermined period in the data and an average value of data for a second predetermined period in the data, the second predetermined period being shorter than the first predetermined period.
4. The prediction system as claimed in claim 3, wherein the controller outputs the prediction result indicating the anomaly of the drain pump when a divergence between the average value of the data for the first predetermined period and the average value of the data for the second predetermined period exceeds a threshold.
5. The prediction system as claimed in any one of claims 1 to 4, wherein the controller predicts the anomaly of the drain pump based on environmental data, the environmental data including temperature data or humidity data.
6. The prediction system as claimed in any one of claims 1 to 5, wherein when the air conditioner or the drain pump is not operating, the controller predicts the anomaly of the drain pump, using, instead of data for a period during which the air conditioner or the drain pump is not operating in the data, data before the period in the data.
7. The prediction system as claimed in claim 6, wherein the controller determines the period during which the drain pump is not operating, based on environmental data, the environmental data including temperature data or humidity data.
8. The prediction system as claimed in any one of claims 1 to 5, wherein the controller determines, from environmental data, whether drain water is generated, the environmental data including temperature data or humidity data, and predicts the anomaly of the drain pump, excluding data for a period during which the drain water is not generated in the data of the number of revolutions of the drain pump or the current value of the drain pump.
9. The prediction system as claimed in claim 8, wherein the controller further uses information indicating whether the air conditioner is operating in a predetermined mode to determine whether the drain water is generated.
10. The prediction system as claimed in any one of claims 1 to 9,

wherein the prediction system comprises an edge device configured to collect the data from the air conditioner, and

wherein the controller acquires data obtained by the air conditioner or the edge device averaging the data.

11. The prediction system as claimed in claim 1, wherein the controller predicts the anomaly of the drain pump by using a learned prediction model obtained by performing machine learning using data when the drain pump is in a normal state in the data and data when the drain pump is in an anomaly state in the data as training data.
12. The prediction system as claimed in claim 1, wherein the controller predicts the anomaly of the drain pump by using a learned prediction model obtained by performing machine learning using an image representing data when the drain pump is in a normal state in the data and an image representing data when the drain pump is an anomaly state in the data as training data.
13. A prediction method in a prediction system including an air conditioner that includes a drain pump; and a controller, the prediction method comprising:
 - acquiring, by the controller, data of a number of revolutions of the drain pump or a current value of the drain pump; and
 - outputting, by the controller, a prediction result indicating that an anomaly of the drain pump is predicted, based on a change in data for a predetermined period in the data.
14. A program for causing a computer to perform a process in a prediction system including an air conditioner and a controller, the air conditioner including a drain pump, and the process including:
 - acquiring data of a number of revolutions of the drain pump or a current value of the drain pump; and
 - outputting a prediction result indicating that an anomaly of the drain pump is predicted, based on a change in data for a predetermined period in the data.

FIG.1

1

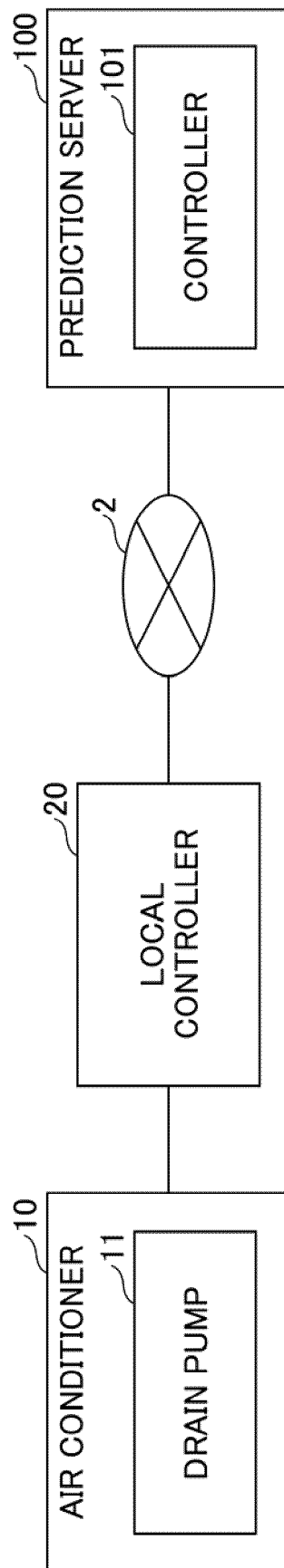


FIG.2

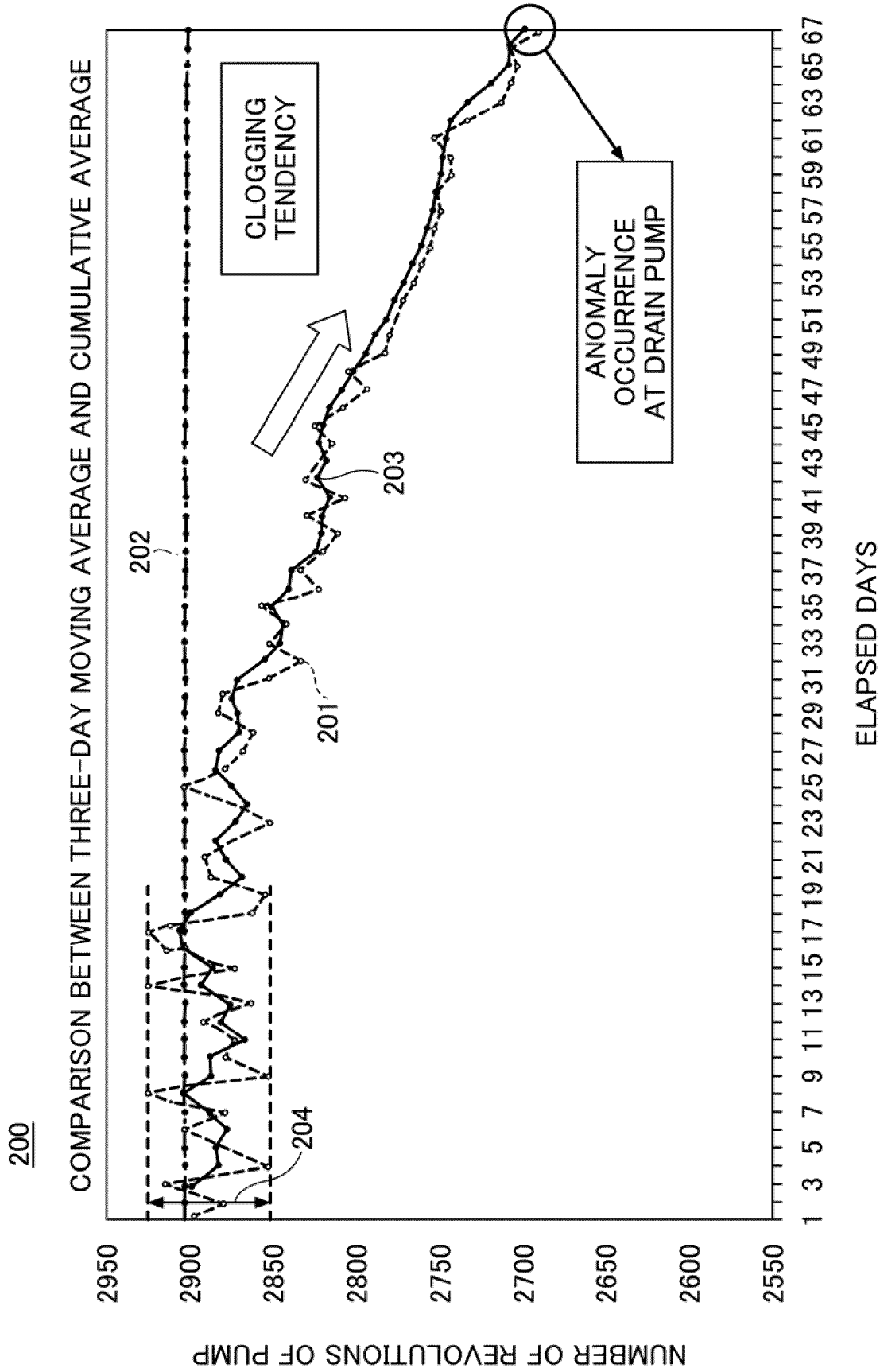


FIG.3

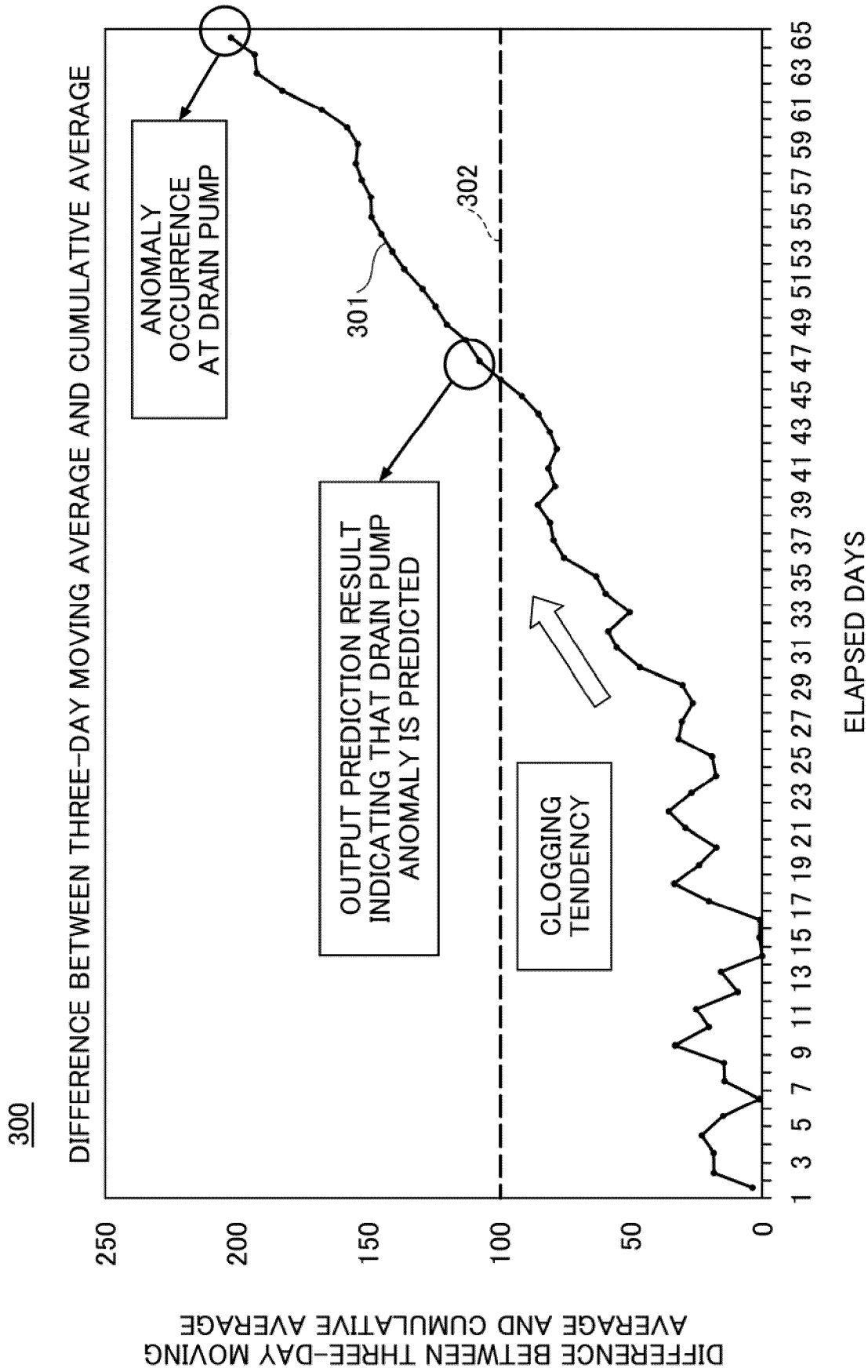
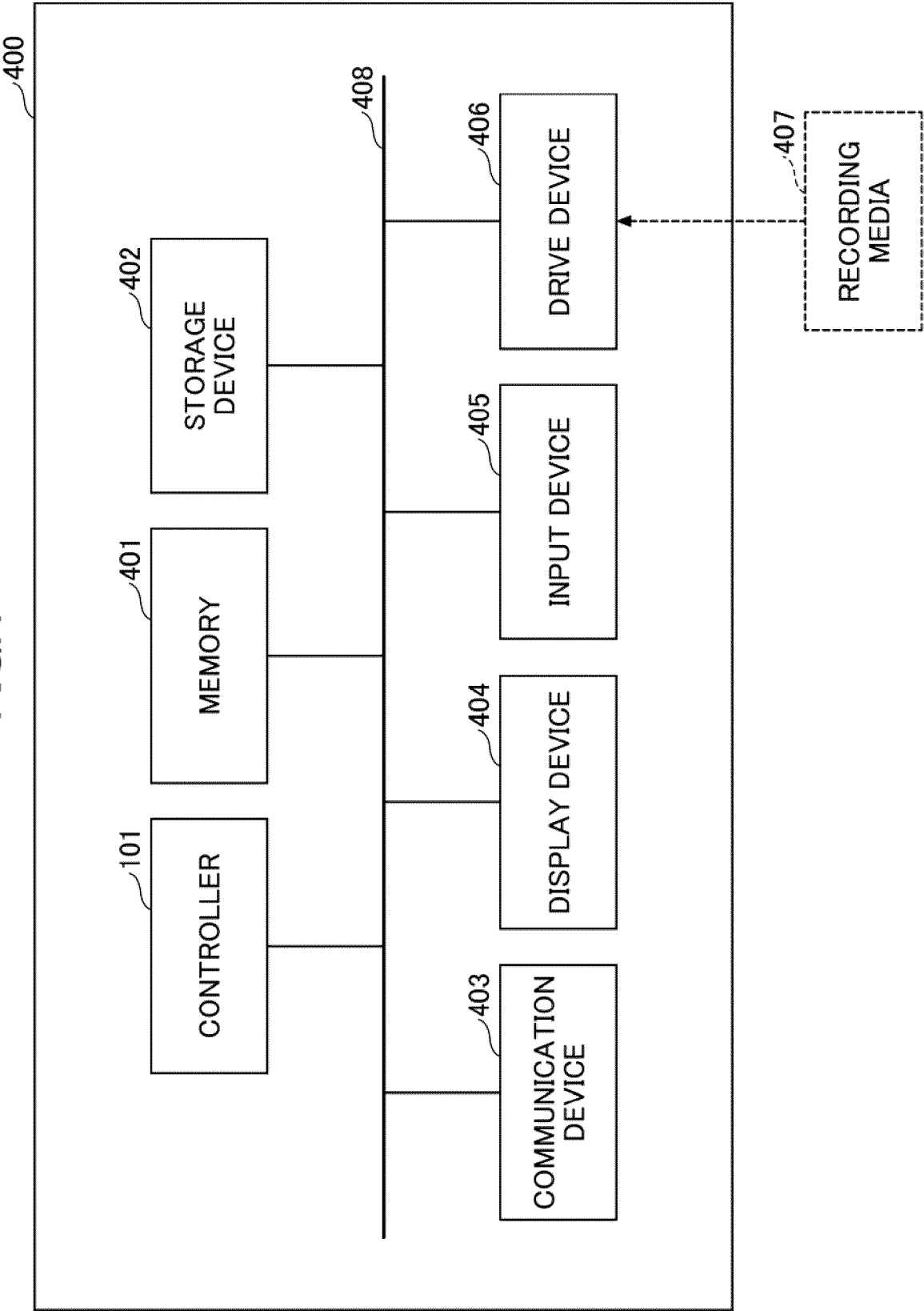


FIG.4



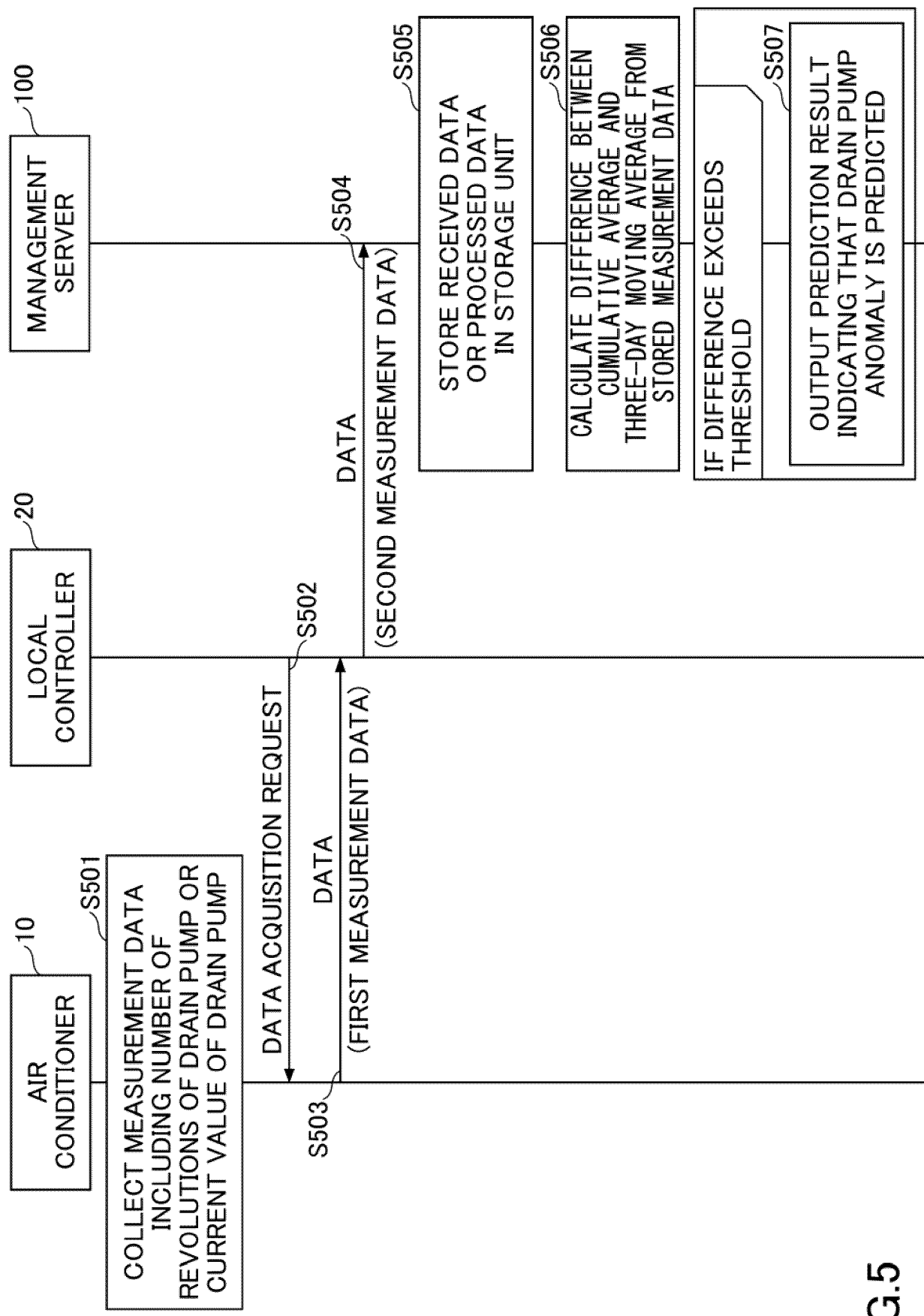


FIG.5

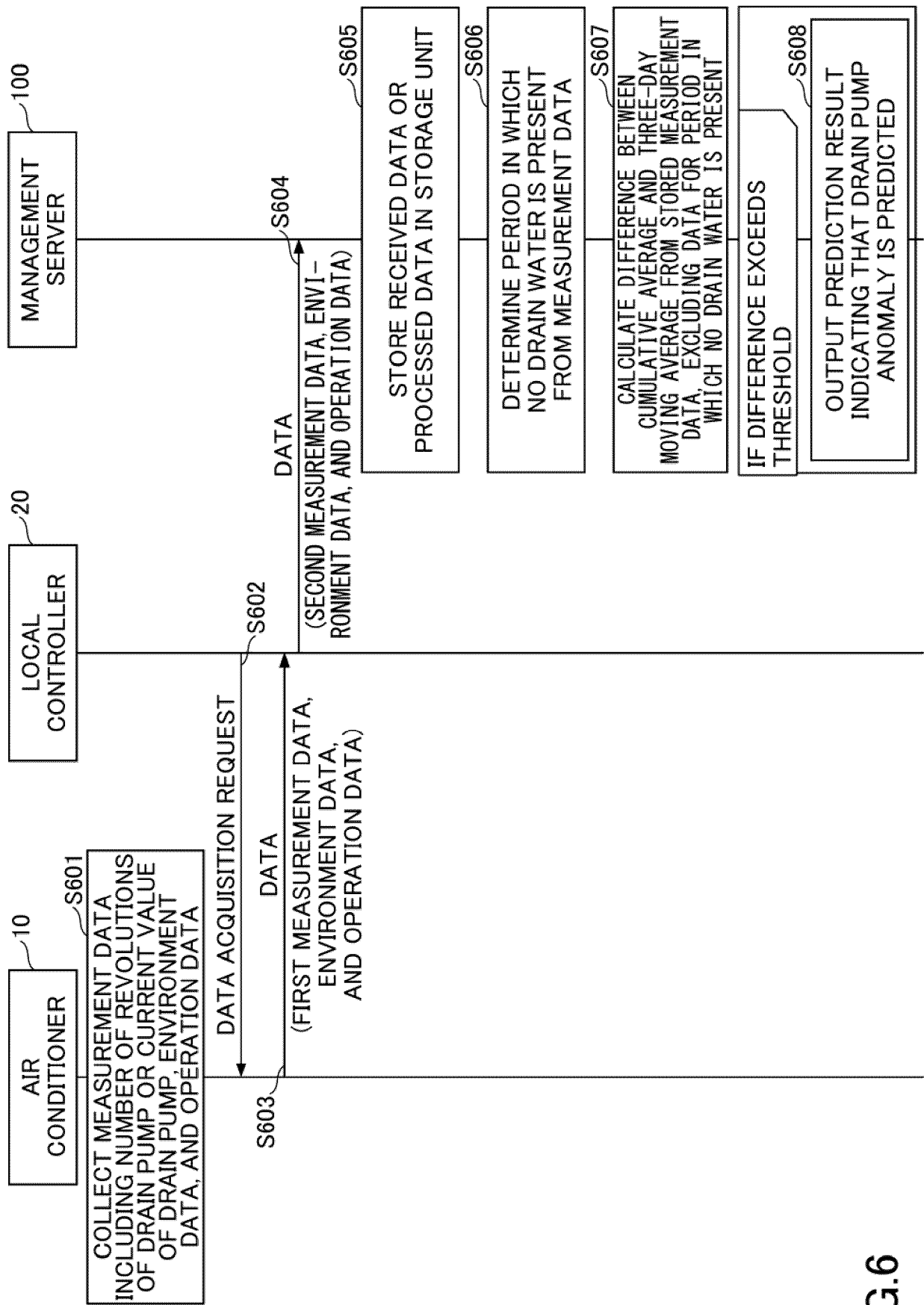


FIG.6

FIG. 7

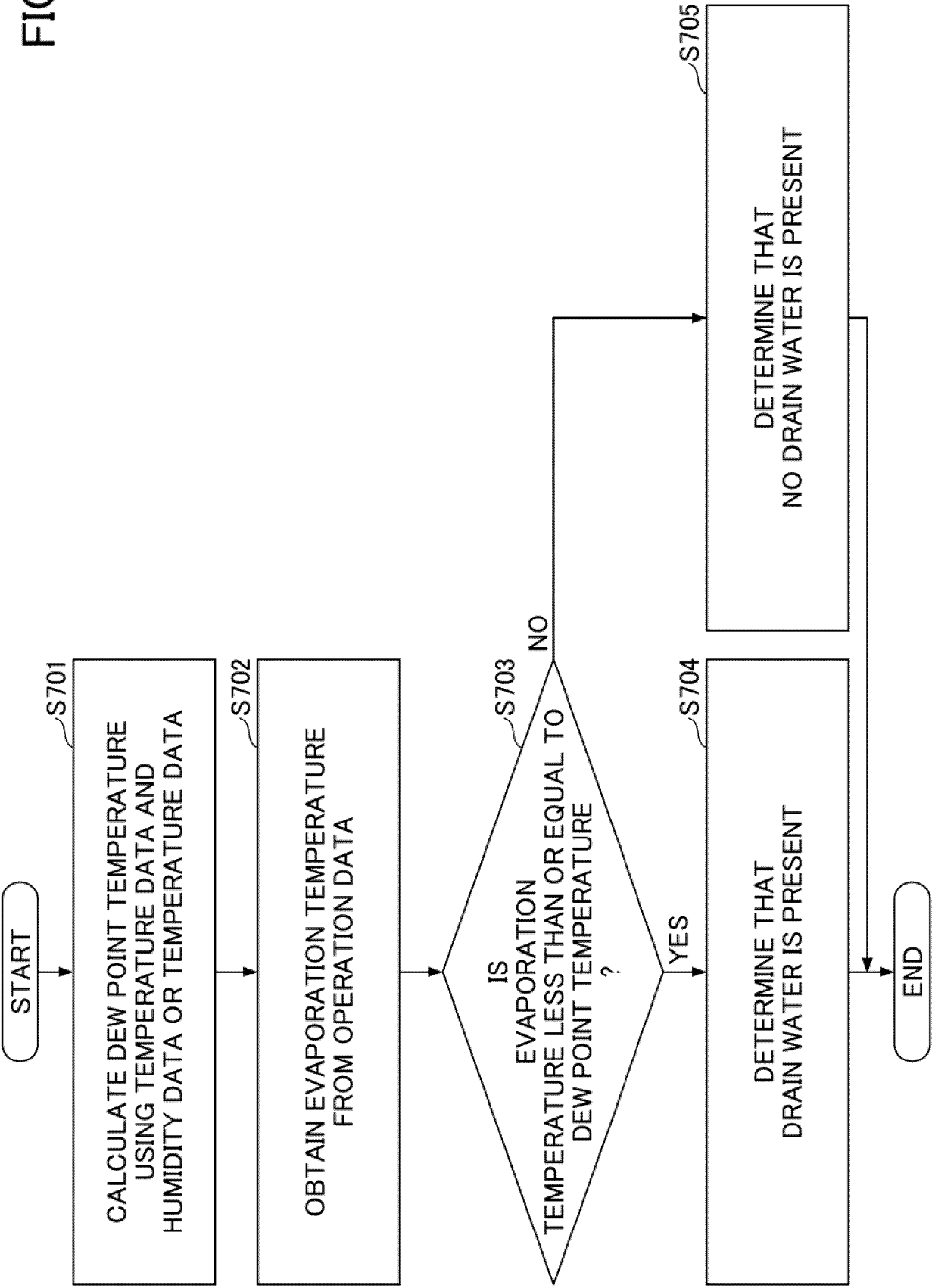
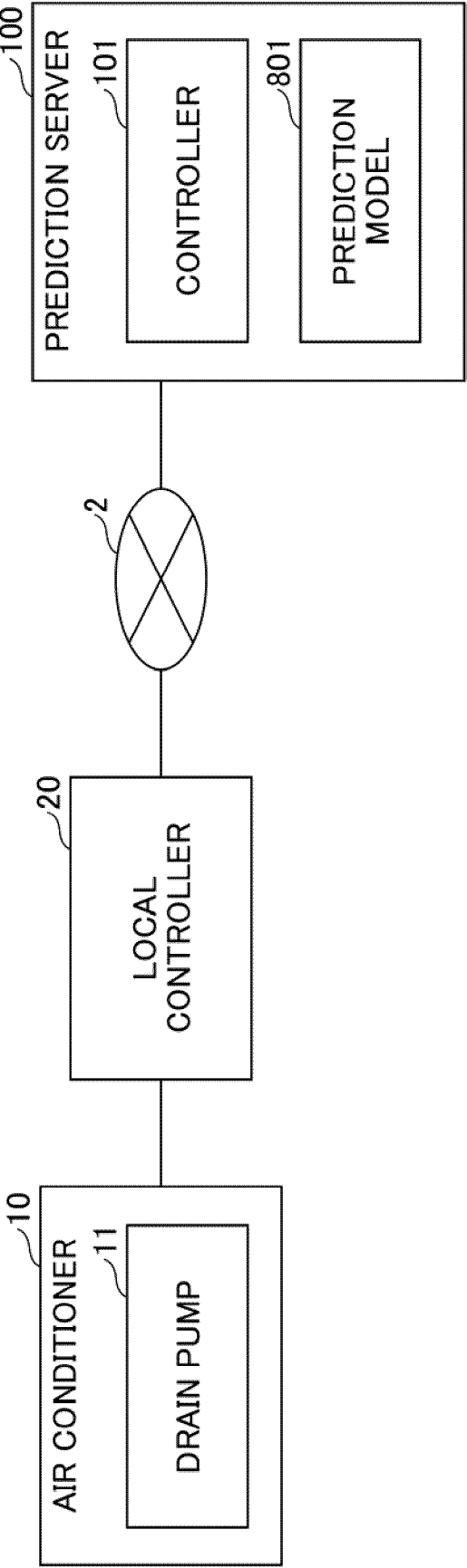


FIG.8

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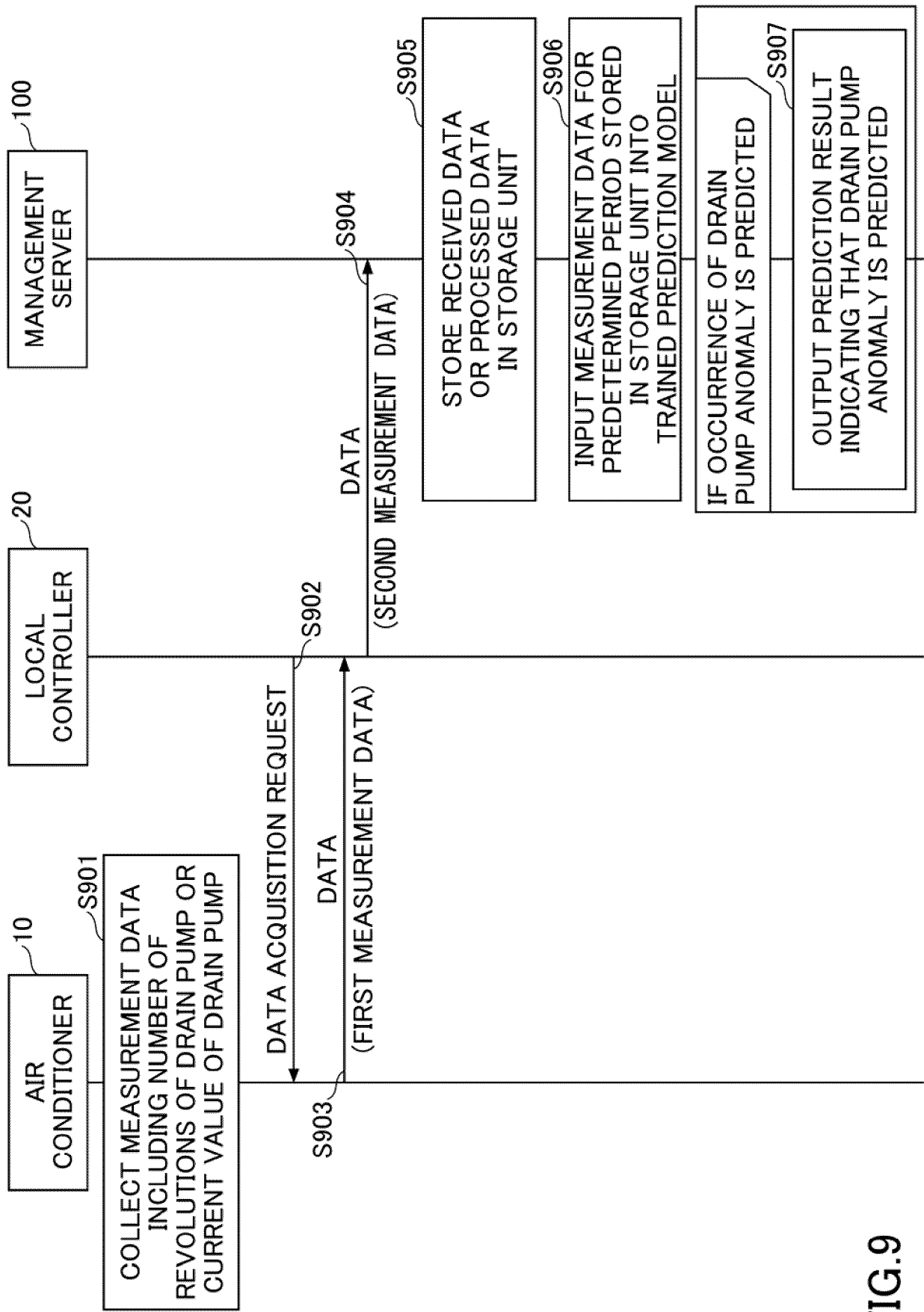


FIG.9

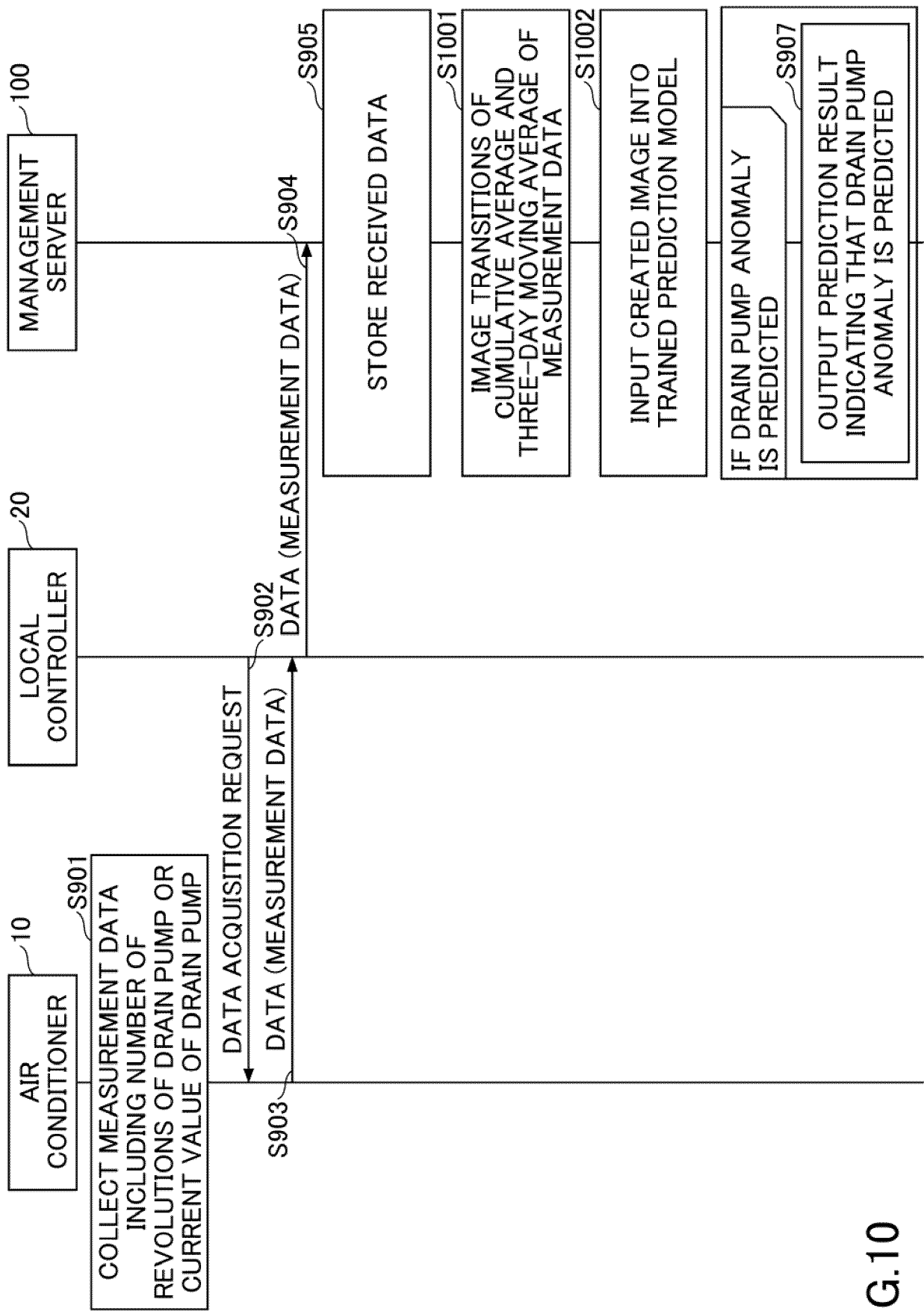


FIG.10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2023/021242

A. CLASSIFICATION OF SUBJECT MATTER

F24F 11/38(2018.01)i; *F24F 13/22*(2006.01)i; *F24F 110/10*(2018.01)n; *F24F 110/20*(2018.01)n
 FI: F24F11/38; F24F1/0007 361F; F24F1/02 371F; F24F110:10; F24F110:20

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)

F24F11/38; F24F13/22; F24F110/10; F24F110/20

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

Published examined utility model applications of Japan 1922-1996
 Published unexamined utility model applications of Japan 1971-2023
 Registered utility model specifications of Japan 1996-2023
 Published registered utility model applications of Japan 1994-2023

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.
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Y	JP 2003-83592 A (SANYO ELECTRIC CO LTD) 19 March 2003 (2003-03-19) paragraph [0039]	3-10
Y	JP 2020-139673 A (DAIKIN IND LTD) 03 September 2020 (2020-09-03) paragraphs [0095], [0119]-[0126]	5-12
Y	JP 2022-53265 A (DAIKIN IND LTD) 05 April 2022 (2022-04-05) paragraph [0042]	10

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

16 August 2023

Date of mailing of the international search report

29 August 2023

Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)
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Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2023/021242

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JP 2020-139673 A	03 September 2020	US 2021/0389015 A1 paragraphs [0112], [0150]- [0159]	
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REFERENCES CITED IN THE DESCRIPTION

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- JP 2022136193 A [0106]