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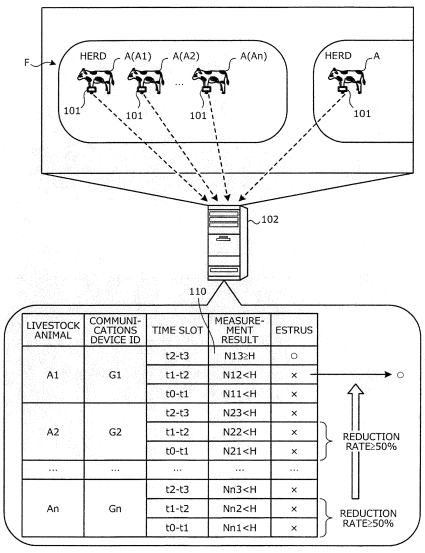
# (54) ESTRUS NOTIFICATION METHOD, ESTRUS NOTIFICATION DEVICE, AND ESTRUS NOTIFICATION PROGRAM

(57) It is assumed that the step count (N13) of a livestock animal (A1) in a time slot (t2 to t3) is greater than or equal to a threshold value. An estrus notifying apparatus (102) calculates a degree of reduction of the step count of other livestock animals (A2 to An) in the same herd for a previous time slot. The degree of reduction is a value indicative of a level of reduction of a measurement value (N) of the livestock animals (A2 to An) for the previous time slot (t1 to t2) from a measurement value (N) for a time slot (t0 to t1) before the previous time slot and is a reduction rate, for example. It is assumed that, for example, the step counts of the livestock animals (A2 to An) are half or less for the time slot (t1 to t2) relative to the time slot (t0 to t1). The estrus notifying apparatus (102) considers that the measurement value becomes less than the threshold value due to eating even though the livestock animal (A1) is in estrus in the time slot (t1 to t2), and determines that the livestock animal (A1) is in estrus during the time slot (t1 to t2). The estrus notifying apparatus (102) outputs information indicating that the estrus of the livestock animal (A1) started in the time slot (t1 to t2).

FIG.1

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## Description

### TECHNICAL FIELD

**[0001]** The present invention relates to an estrus notifying method, an estrus notifying apparatus, and an estrus notifying program.

### BACKGROUND ART

**[0002]** Conventionally, when livestock animals such as cattle are raised on a pasture, a worker of the livestock farm periodically goes to the pasture area to check whether livestock animals have an abnormality. For example, to manage estrus of pastured cows, a worker goes to the pasture area almost every day to actually visually check the presence of a cow exhibiting estrous behavior. In another case, a pedometer is attached to a cow and if a count of the pedometer increases by a predetermined amount, it is determined that the cow is in estrus and the worker is notified.

**[0003]**

Patent Document 1: Japanese Laid-Open Patent Publication No. 2002-139775
Patent Document 2: Japanese Laid-Open Patent Publication No. 2007-167024

### DISCLOSURE OF INVENTION

### PROBLEM TO BE SOLVED BY THE INVENTION

**[0004]** The step count of a livestock animal may vary due to other factors other than estrus and therefore, if estrus is detected only from the step count a livestock animal, detection accuracy of estrus detection may be reduced. For example, if step count of a cow decreases due to eating, an increase in the step count is suppressed even in estrus and a cow in estrus may not be detected from the number of the steps. Alternatively, for example, an increase in the step count of a cow due to the appearance of another animal such as a wild dog may cause a problem of false detection of a cow in estrus.

**[0005]** The present invention solves the problem of the conventional techniques and an object of the present invention is to provide an estrus notifying method, an estrus notifying apparatus, and an estrus notifying program capable of achieving improvement in detection accuracy of a livestock animal in estrus.

### MEANS FOR SOLVING PROBLEM

**[0006]** According to one aspect of the present invention, an estrus notifying method, an estrus notifying apparatus, and an estrus notifying program that determine estrus based on a step count measurement result from a step count measurement unit attached to each livestock animal among a plurality of livestock animals are proposed. The estrus notifying method, the estrus notifying apparatus, and the estrus notifying program collect the step count measurement result of each livestock animal at certain intervals; detect a change time slot in which a change rate of the step count measurement result relative to an immediately preceding time slot is greater than or equal to a predetermined value among a predetermined proportion or more of the plurality of livestock animals; determine for each livestock animal and based on the step count measurement results excluding the step count measurement result corresponding to the change time slot, whether the livestock animal is in estrus; and output identification information of the livestock animal determined as being in the estrus.

### EFFECT OF THE INVENTION

**[0007]** According to one aspect of the present invention, an effect is achieved in that the accuracy in detecting a livestock animal in estrus can be improved.

### BRIEF DESCRIPTION OF DRAWINGS

**[0008]**

FIG. 1 is an explanatory view of an example of an estrus notifying method according to a first embodiment;
FIG. 2 is an explanatory view of a system configuration example of an estrus notifying system 200;
FIG. 3 is a block diagram of a hardware configuration example of a communications device 101;
FIG. 4 is a block diagram of a hardware configuration example of a relay device 211;
FIG. 5 is a block diagram of a hardware configuration of an estrus notifying apparatus 102, etc.;
FIG. 6 is an explanatory view of an example of storage contents of a measurement result information table 201;
FIG. 7 is an explanatory view of an example of storage contents of a step count information DB 202;
FIG. 8 is an explanatory diagram of an example of storage contents of a herd management DB 203;
FIG. 9 is a block diagram of a functional configuration example of the estrus notifying apparatus 102;
FIG. 10 is an explanatory diagram of an example of a screen displayed on a client device 230;
FIG. 11 is an explanatory diagram of an example (part one) of estrus determination;
FIG. 12 is an explanatory diagram of an example (part two) of the estrus determination;
FIG. 13 is an explanatory diagram of an example (part three) of the estrus determination;
FIG. 14 is an explanatory diagram of an example (part four) of the estrus determination;
FIG. 15 is a flowchart of an example of a communication process procedure of the relay device 211;
FIG. 16 is a flowchart (part one) of an example of an

estrus notifying process procedure of the estrus notifying apparatus 102;

FIG. 17 is a flowchart (part one) of an example of an estrus determining process procedure of the estrus notifying apparatus 102;

FIG. 18 is a flowchart (part two) of an example of the estrus determining process procedure of the estrus notifying apparatus 102;

FIG. 19 is a flowchart of an example of the estrus notifying process procedure for the client device 230;

FIG. 20 is a block diagram of a functional configuration of an estrus notifying apparatus 2000 according to a second embodiment; and

FIG. 21 is a flowchart of an example of the estrus determining process procedure of the estrus notifying apparatus 2000.

## BEST MODE(S) FOR CARRYING OUT THE INVENTION

**[0009]** Embodiments of an estrus notifying method, an estrus notifying apparatus, and an estrus notifying program according to the present invention will be described in detail below with reference to the accompanying drawings.

### (First Embodiment)

**[0010]** FIG. 1 is an explanatory view of an example of an estrus notifying method according to a first embodiment. In FIG. 1, livestock animals A are raised on the premises of a farm F managed by a worker. The livestock animals A form herds. The worker is a person engaged in livestock farming. The farm F refers to facilities including the pasture area for pasturing the livestock animals A. The livestock animals A are animals capable of moving inside the site of the farm F, for example, the pasture area of the farm F. For example, the livestock animals A may be animals moving by ambulation such as cattle, pigs, and horses.

**[0011]** The livestock animals A1 to An are equipped with respective communications devices 101. In this case, the communications devices 101 are portable computers that measure the step counts of the livestock animals A. For example, when walking, the livestock animals A first put out a right leg toward the ground in the direction of travel. When the right leg is planted on the ground, the livestock animals A then put out a left leg toward the ground in the direction of travel. When the left leg is planted on the ground, the livestock animals A repeat the motion such as putting out a right leg again. In particular, the step counts of the livestock animals A can be defined as the numbers of times the livestock animals A put out a right leg or a left leg toward the ground in the direction of travel.

**[0012]** For example, when the livestock animal A is in estrus, the number of step taken by the livestock animal A per unit time increases as compared to a normal time. The estrus refers to an excited state associated with reproductive activity of the livestock animal A.

**[0013]** The communications device 101 can communicate with multiple relay devices disposed on the premises of the farm F and is a computer capable of communication with an estrus notifying apparatus 102 via a corresponding relay device. The relay devices are respectively disposed at a different position on the farm F and each of the relay devices forms a communication area having a radius of 150 m, for example. The communications device 101 transmits measurement result information indicative of a measurement result and a communications device ID specific to the communications device 101 to any communicable one of the relay devices.

**[0014]** The estrus notifying apparatus 102 is a computer capable of receiving from the communications device 101, the measurement result information and the communications device ID of the communications device 101, via the relay device. The estrus notifying apparatus 102 stores for each communications device ID, hourly measurement result information correspond to a predetermined period. The estrus notifying apparatus 102 uses the measurement result information for each communications device ID to determine whether a livestock animal A in estrus is present.

**[0015]** It is assumed that a livestock animal is determined as being in estrus if the measurement result acquired for each time slot is continuously greater than or equal to a threshold value by utilizing a characteristic that the step count of the livestock animal A increases when the livestock animal A is in estrus. However, even if a livestock animal is in estrus, the livestock animal cannot be determined as being in estrus with such a determination while eating, which reduces the step count. For example, even when estrus starts during a time slot of t0 to t1, if the step count becomes less than the threshold value due to eating and then becomes greater than or equal to the threshold value again during a time slot of t1 to t2, an estrus starting time slot is determined as t1 to t2.

**[0016]** When estrus is detected, comprehending the estrus starting time slot is important in terms of improving the probability of impregnation and sex-choice birth. For example in the case of cattle, mating within 24 hours from the start of estrus is desirable for increasing the probability of impregnation and, if mating cannot be achieved within this period or a cow does not become pregnant, mating must be delayed by one month until the next estrus period, resulting in an economic loss.

**[0017]** With regard to the sex-choice birth of cattle, mating within a period of 8 to 16 hours after the start of estrus tends to give birth to a female and mating within a period of 16 to 24 hours tends to give birth to a male. For example, in the case of Holstein cattle having white and black patches, since a female is raised as a milk cow and a male is raised as beef cattle, food and a raising method differ depending on sex and the sex-choice birth is important for livestock farmers.

**[0018]** Therefore, in the first embodiment, when the step count of one livestock animal A at this time is greater than or equal to a threshold value and the step count at the previous time is less than the threshold value, if the step counts of other livestock animals A decrease by a predetermined amount at the previous time as compared to the time before the previous time, it is considered that the step count decreased at the previous time due to eating, and the livestock animal A is determined as being in estrus. As a result, the detection accuracy of cattle in estrus is improved.

**[0019]** An example of the estrus notifying method of the first embodiment will be described.

**[0020]** The communications device 101 transmits the measurement result information indicative of a communications device ID identifying a livestock animal A and the step count of the livestock animal A, via a relay device, at predetermined transmission intervals. The predetermined transmission interval is one hour, for example.

**[0021]** The estrus notifying apparatus 102 receives the communications device ID and the measurement result information from the communications device 101 and stores the measurement result information of each time slot, for each communications device ID. The estrus notifying apparatus 102 determines whether the step count for each time slot is greater than or equal to a threshold value H. If the step counts for time slots are continuously greater than or equal to the threshold value H, the estrus notifying apparatus 102 determines that a livestock animal is in estrus. As indicated by reference numeral 110, it is assumed that the step count of the livestock animal A1 for a time slot of t2 to t3 is N13, which is greater than or equal to the threshold value.

**[0022]** When it is determined that the step count of the livestock animal A1 for the time slot of t2 to t3 is N13 and is greater than or equal to the threshold value, the estrus notifying apparatus 102 calculates a degree of reduction of the step counts of the other livestock animals A2 to An in the same herd in the previous time slot. The degree of reduction is a value indicative of a level of reduction of a measurement value N of the livestock animals A2 to An for a previous time slot of t1 to t2 based on the measurement value N in a time slot of t0 to t1 that is a time slot before the previous time slot. In this description, the degree of reduction is defined as a rate of a measurement result in the time slot of t1 to t2 relative to a measurement result in the time slot of t0 to t1, i.e., as a reduction rate.

**[0023]** For example, it is assumed that each of the reduction rates of the livestock animals A2 to An is greater than or equal to 50%. In other words, it is assumed that the step counts of the livestock animals A2 to An are half or less for the time slot of t1 to t2 relative to the time slot of t0 to t1. In this case, it can be considered that the livestock animals A2 to An are eating during the time slot of t1 to t2. It can also be considered that the livestock animal A1 belonging to the same herd is eating during the time slot of t1 to t2.

**[0024]** The estrus notifying apparatus 102 considers that the measurement value becomes less than the threshold value during the time slot of t1 to t2 due to eating even through the livestock animal A1 is in estrus, and determines that the livestock animal A1 is in estrus during the time slot of t1 to t2. The estrus notifying apparatus 102 outputs information indicating that the estrus of the livestock animal A1 started during the time slot of t1 to t2.

**[0025]** According to the estrus notifying method of the first embodiment described above, the detection accuracy of the livestock animal A can be improved and the workload required for comprehending the livestock animal A in estrus can be reduced.

(System Configuration Example of Estrus Notifying System 200)

**[0026]** A system configuration example of an estrus notifying system 200 will be described. FIG. 2 is an explanatory view of a system configuration example of the estrus notifying system 200. In FIG. 2, the estrus notifying system 200 includes the multiple communications devices 101, the estrus notifying apparatus 102, the multiple relay devices 211, and a client apparatus 230.

**[0027]** In the estrus notifying system 200, the communications devices 101 and the relay devices 211 are connected via a wireless communications network 210. Each of the communications devices 101 and the relay devices 211 has a given range around the communications device or the relay device, for example, a range of a 100-meter radius around the communications device or the relay device, as a communicable area enabling communication through the wireless communications network 210. If the communications device 101 and the relay device 211 are in a positional relationship enabling the communication, the communications device 101 and the relay device 211 are connected through the wireless communications network 210. For example, the wireless communications network 210 can be implemented by near field communication such as radio frequency identification (RFID).

**[0028]** The relay devices 211, the estrus notifying apparatus 102, and the client apparatus 230 are connected via a network 220. For example, the network 220 may be the Internet, a local area network (LAN), a wide area network (WAN), etc.

**[0029]** The communications devices 101 have measurement result information tables 201, etc., and are portable computers equipped to the respective livestock animals A raised in the farm F. Each of the communications devices 101 has a measurement function of measuring the step count of the livestock animal equipped with the communications device 101 and a communication function through the wireless communications network 210. For example, the communications devices 101 can be implemented by applying pedometers to which a communication function through the wireless communications network 210 is added. Storage contents of the

measurement result information tables 201 will be described later with reference to FIG. 7.

**[0030]** The relay devices 211 are disposed on the premises of the farm F and are computers having a communication function through the wireless communications network 210 and a communication function through the network 220. The multiple relay devices 211 are respectively disposed at different installation positions.

**[0031]** The estrus notifying apparatus 102 has a step count information DB 202, a herd management DB 203, a GPS communications device DB 204, etc., and is a computer having a communication function through the network 220. For example, the estrus notifying apparatus 102 can be implemented by applying a server included in a cloud computing system and a personal computer (PC) or a notebook PC used by a manager or a worker W of the farm F. Storage contents of the step count information DB 202, the herd management DB 203, and the GPS communications device DB 204 will be described later with reference to FIGs. 7 and 8.

**[0032]** The client apparatus 230 is a computer having a communication function through the network 220. The client apparatus 230 can be implemented by applying a PC or a notebook PC, a portable telephone, and a smartphone used by a worker W of the farm F.

(Hardware Configuration Example of Communications Device 101)

**[0033]** A hardware configuration example of the communications device 101 will be described. FIG. 3 is a block diagram of a hardware configuration example of the communications device 101. In FIG. 3, the communications device 101 has a central processing unit (CPU) 301, memory 302, an interface (I/F) 303, a sensor 304, and a timer 305. The constituent elements are connected to each other through a bus 300.

**[0034]** The CPU 301 is responsible for general control of the communications device 101. The memory 302 includes read only memory (ROM), random access memory (RAM), and flash ROM. The ROM and the flash ROM store various programs such as a boot program, for example. The RAM is used as a work area of the CPU 301.

**[0035]** The I/F 303 is connected through a communication line to the wireless communications network 210 and is connected via the wireless communications network 210 to another device (such as the relay device 211). The I/F 303 is responsible for an internal interface with the wireless communications network 210 and controls the input and output of data with respect to external devices.

**[0036]** The sensor 304 outputs information for detecting behavior of the communications device 101. For example, the sensor 304 is implemented by using a gyro sensor, a three-axis acceleration sensor, etc., and when acceleration occurs in the communications device 101, the sensor 304 outputs information corresponding to the acceleration. The sensor 304 has a function of counting steps with respect to the communications device 101.

**[0037]** The timer 305 has a time measuring function. For example, the timer 305 measures the actual time. The timer 305 may measure an elapsed time from a given time.

(Hardware Configuration Example of Relay Device 211)

**[0038]** A hardware configuration example of the relay device 211 will be described. FIG. 4 is a block diagram of a hardware configuration example of the relay device 211. In FIG. 4, the relay device 211 has a CPU 401, memory 402, an I/F 403, and an I/F 204. The constituent elements are connected to each other through a bus 400.

**[0039]** The CPU 401 is responsible for general control of the relay device 211. The memory 402 includes ROM, RAM, and flash ROM. The ROM and the flash ROM store various programs such as a boot program, for example. The RAM is used as a work area of the CPU 401.

**[0040]** The I/F 403 is connected through a communication line to the wireless communications network 210 and is connected via the wireless communications network 210 to other devices such as the communications device 101. Further, the I/F 404 is connected through a communication line to the network 220 and is connected via the network 220 to other devices such as the estrus notifying apparatus 102. The I/Fs 403 and 404 are responsible for an internal interface with the wireless communications network 210 and the network 220, and control the input and output of data with respect to external devices.

(Hardware Configuration Example of Estrus Notifying Apparatus 102, etc.)

**[0041]** A hardware configuration example of the estrus notifying apparatus 102 and the client device 230 will be described. In this example, the estrus notifying apparatus 102 and the client device 230 will simply be referred to as the "estrus notifying apparatus 102, etc."

**[0042]** FIG. 5 is a block diagram of a hardware configuration of the estrus notifying apparatus 102, etc. In FIG. 5, the estrus notifying apparatus 102, etc. have a CPU 501, a ROM 502, a RAM 503, a magnetic disk drive 504, a magnetic disk 505, an optical disk drive 506, an optical disk 507, a display 508 (103), an I/F 509, a keyboard 510, a mouse 511, a scanner 512, and a printer 513. The constituent units are connected via a bus 500 to each other.

**[0043]** The CPU 501 governs overall control of the estrus notifying apparatus 102, etc. The ROM 502 stores therein programs such as a boot program. The RAM 503 is used as a work area of the CPU 501. The magnetic disk drive 504, under the control of the CPU 501, controls the reading and writing of data with respect to the magnetic disk 505. The magnetic disk 505 stores therein data written under control of the magnetic disk drive 504.

**[0044]** The optical disk drive 506, under the control of

the CPU 501, controls the reading and writing of data with respect to the optical disk 507. The optical disk 507 stores therein data written under control of the optical disk drive 506, the data being read by a computer.

**[0045]** The display 508 (103) displays, for example, data such as text, images, functional information, etc., in addition to a cursor, icons, and/or tool boxes. A cathode ray tube (CRT), a thin-film-transistor (TFT) liquid crystal display, a plasma display, etc., may be employed as the display 508 (103).

**[0046]** The I/F 509 is connected to the network 220 through a communication line and is connected to other apparatuses (e.g., the relay devices 211 and the client apparatus 230) through the network 220. The I/F 509 administers an internal interface with the network 220 and controls the input and output of data with respect to external apparatuses. For example, a modem or a LAN adaptor may be employed as the I/F 509.

**[0047]** The keyboard 510 includes, for example, keys for inputting letters, numerals, and various instructions and performs the input of data. Alternatively, a touch-panel-type input pad or numeric keypad, etc. may be adopted. The mouse 511 is used to move the cursor, select a region, or move and change the size of windows. A track ball or a joy stick may be adopted provided each respectively has a function similar to a pointing device.

**[0048]** The scanner 512 optically reads an image and takes in the image data into the estrus notifying apparatus 102, etc. The scanner 512 may have an optical character reader (OCR) function as well. The printer 513 prints image data and text data. The printer 513 may be, for example, a laser printer or an ink jet printer.

**[0049]** Further, for example, among the components described above, the estrus notifying apparatus 102 may be configured to omit the optical disk drive 506, the optical disk 507, the display 508, the mouse 511, the scanner 512, and the printer 513. The client apparatus 230 may be configured to omit the optical disk drive 506, the optical disk 507, the mouse 511, the scanner 512, and the printer 513.

(Example of Information Stored in Communications Device 101)

**[0050]** An example of information stored in the communications device 101 will be described. As described above, the communications device 101 stores the measurement result information table 201. For example, the measurement result information table 201 is implemented by using the memory 302 of the communications device 101.

<Example of Storage Contents of Measurement Result Information Table 201>

**[0051]** FIG. 6 is an explanatory view of an example of storage contents of the measurement result information table 201. In FIG. 6, the measurement result information table 201 has fields for measurement dates/times and measurement values. By setting information in these fields, records of measurement result information 600-1 to 600-6 are stored for respective combinations of measurement dates/times and measurement values in the measurement result information table 201.

**[0052]** The measurement date/time indicates date and time of transmission timing of past measurement result information. In the case of the first embodiment, by way of example, the measurement dates/times indicate dates and times of transmission timings of the measurement result information of the last six times. The measurement value indicates a measurement value of the step count of the livestock animal A at the transmission timing of past measurement result information. In the case of the first embodiment, by way of example, the measurement values indicate measurement values of the step counts of the livestock animal A at the transmission timings of the measurement result information of the last six times.

**[0053]** For example, the communications device 101 stores, as a current measurement value, a value acquired by accumulating the step count of the livestock animal A until the current time from a given timing such as timing of setting the measurement value to "0". Each time the livestock animal A takes one step, acceleration is momentarily generated in the communications device 101. When this acceleration is detected by the sensor 304, the communications device 101 counts up the current measurement value by "+1".

**[0054]** When the transmission timing of the measurement result information arrives based on the time measurement result of the time 305, the communications device 101 stores the measurement result information correlated with the current measurement information at the measurement date/time corresponding to the transmission timing. The transmission timing is on the hour, for example.

**[0055]** In FIG. 6, the measurement result information 600-1 indicates that the measurement value at the time point of "500 on February 20, 2012" is "C6 (C6 is a positive integer)". When the measurement result information is stored, the communications device 101 transmits the records of the measurement result information stored in the measurement result information tables 201 via the relay device 211 to the estrus notifying apparatus 102.

**[0056]** Although the communications device 101 stores the measurement result information of the last six times in the described example, configuration is not limited hereto. Configuration may be such that the communications device 101 does not store past measurement result information. For example, in this case, when the transmission timing of the measurement result information arrives, the communications device 101 may transmit the current measurement value as the measurement result information and delete the measurement result information. Such a configuration can reduce a data amount stored by the communications device 101 in terms of the storage of the measurement result informa-

tion.

**[0057]** Although the communications device 101 transmits the records of the measurement result information stored in the measurement result information tables 201 in this example, configuration is not limited hereto. For example, the communications device 101 may transmit only the current measurement result information, or particularly, only the measurement result information 600-1 in the example of FIG. 6. Such a configuration can reduce a data amount stored by the communications device 101 in terms of the transmission of the measurement result information.

**[0058]** The communications device 101 may transmit the current measurement result information and the measurement result information failed in transmission at past transmission timing. For example, in this case, when receiving the measurement result information from the communications device 101, the relay device 211 transmits successful reception information indicative of reception of the measurement result information to the communications device 101. If the successful reception information is not received within a given period after transmission of the measurement result information, the communications device 101 determines that the transmission of the measurement result information has failed.

**[0059]** In this case, the communications device 101 correlates and stores information indicative of failure of transmission with the measurement result information determined as having failed in transmission. When the transmission timing of the measurement result information subsequently arrives, the communications device 101 transmits the current measurement result information and the measurement result information failed in transmission. Such a configuration can ensure transmission of the measurement result information to the relay device 211 while reducing a data amount transmitted by the communications device 101 in terms of the transmission of the measurement result information.

(Example of Information Stored by Estrus Notifying Apparatus 102)

**[0060]** An example of information stored by the estrus notifying apparatus 102 will be described. As described above, the estrus notifying apparatus 102 stores the step count information DB 202 and the herd management DB 203. The various DBs 202 and 203 are implemented by using a storage unit such as the ROM 502, the RAM 503, the magnetic disk 505, and the optical disk 507 of the estrus notifying apparatus 102.

<Example of Storage Contents of Step Count Information DB 202>

**[0061]** FIG. 7 is an explanatory view of an example of storage contents of the step count information DB 202. In FIG. 7, the step count information DB 202 is stored for each communications device ID and has a communications device ID for identifying the communications device 101. The step count information DB 202 has fields for dates, step counts for each time slot, and estrus predictor flags. By setting information in these fields, records of step-count information 700-1 to 700-3 are stored for respective combinations of dates, step count histories, and estrus predictor flags in the step count information DB 202.

**[0062]** The date indicates a date, for example, year/month/day, of measurement of the number of steps. The step count indicates the step count of the livestock animal A based on the measurement result information. The field of the step count includes a field for each time slot such as "0:00-1:00", "1:00-2:00", "2:00-3:00", ..., "22:00-23:00", and "23:00-24:00", for example. Each of the time slot fields stores information indicative of the step count of the livestock animal A during the time slot. For example, the estrus notifying apparatus 102 stores a value acquired by subtracting a measurement value at the starting time, from a measurement value at the ending time of each of the time slot fields as the step count of the livestock animal A in the time slot into each of the time slot fields.

**[0063]** For example, it is assumed that the estrus notifying apparatus 102 acquires the measurement result information including information indicating that the measurement value at "2:00 on February 20, 2012" is "C2" and that the immediately preceding measurement value at "1:00 on February 20, 2012" is "C1". In this case, the estrus notifying apparatus 102 stores "N302 (=C2-C1)" acquired by subtracting "C1" from "C2" in the step count field identified by a date of "February 20, 2012" and a time of "2:00".

**[0064]** The estrus predictor flag field stores each estrus predictor flag as "0" indicative of OFF or "1" indicative of ON, for example. For example, the estrus notifying apparatus 102 stores "1" in the estrus predictor flag field if the step count acquired as a measurement result is greater than or equal to a predetermined threshold value. The setting of the estrus predictor flag will be described later with reference to FIG. 18.

**[0065]** For example, the step count information 700-1 has "N301" stored in the field of "0:00-1:00" and "N302" stored in the field of "1:00-2:00" as well as "1" stored in the estrus predictor flag field since "N302" is greater than or equal to the threshold value, for example. The step count information is stored in the step count information DB 202 for a predetermined period such as three months, for example.

**[0066]** The step count field may be provided with a relay device ID field storing a relay device ID for identifying the transmission source relay device 211 when the measurement result information is received from the relay device 211 at each of the times. For example, when measurement result information is received at "2:00 on February 20, 2012", the relay device ID of the relay device 211 of the transmission source of the measurement result information may be stored in the relay device ID field.

This enables understanding of a communication area in which the livestock animals A are located in each time slot. The step count information DB 202 stores the information described above for each communications device ID.

<Example of Storage Contents of Herd Management DB 203>

**[0067]** FIG. 8 is an explanatory diagram of an example of storage contents of the herd management DB 203. In FIG. 8, the herd management DB 203 has a herd ID field and a communications device ID field. By setting information in these fields in advance, records of herd information 800-1 to 800-1 are stored for respective combinations of herd IDs and communications device IDs in the herd management DB 203.

**[0068]** The herd ID indicates information for identifying each herd. The communications device ID indicates information for identifying each of the communications devices 101. For example, in FIG. 8, the herd information 800-1 indicates that a herd ID "M1" includes the 90 communications devices 101 of communications device IDs "G101 to G189".

(Functional Configuration Example of Estrus Notifying Apparatus 102)

**[0069]** FIG. 9 is a block diagram of a functional configuration example of the estrus notifying apparatus 102. In FIG. 9, the estrus notifying apparatus 102 includes a first storage unit 901, an acquiring unit 902, a change detecting unit 903, a determining unit 904, an identifying unit 905, an output unit 906, and a second storage unit 907. The acquiring unit 902 to the output unit 906 are functions acting as a control unit and, for example, the functions are implemented by causing the CPU 501 to execute a program stored on the magnetic disk 505 depicted in FIG. 5, for example, or by the magnetic disk 505, the I/F 509, etc. Processing results of the functional units are stored in the RAM 503, for example.

**[0070]** The first storage unit 901 has a function of storing measurement results from the respective communications devices 101 attached to the multiple livestock animals A. For example, the first storage unit 901 stores a measurement result of the step count of each livestock animal in a livestock animal group for each time slot, acquired by the acquiring unit 902 described later. A time slot is a period having a temporal width. The first storage unit 901 corresponds to the step count information DB 202 depicted in FIG. 7, for example.

**[0071]** The acquiring unit 902 has a function of collecting respective measurement results of the multiple livestock animals A at certain intervals. The certain intervals may be predefined intervals and may correspond to timing of reception of the measurement result information. The timing of reception of the measurement result information is every hour.

**[0072]** The change detecting unit 903 has a function of detecting a change time slot in which a change rate of a measurement result relative to an immediately preceding time slot is greater than or equal to a predetermined value in a predetermined proportion or more of the multiple livestock animals A. In other words, the change detecting unit 903 detects a change time slot in which the livestock animals A having a change rate of measurement results relative to an immediately preceding time slot greater than or equal to a predetermined value account for a predetermined proportion or more of the multiple livestock animals A. The predetermined proportion may arbitrarily be defined as 70 or 80 percent, for example, and is 100 percent (all the animals) in this description for convenience of description.

**[0073]** The change rate relative to an immediately preceding time slot is a change rate between the step count for the previous time slot and the step count for the current time slot. The change rate may be represented by a reduction percentage indicative of a degree of reduction or an increase percentage indicative of a degree of increase, for example. A change rate greater than or equal to a predetermined value is, for example, a value of 50%. Therefore, for example, the change detecting unit 903 detects a time slot in which the step counts of the livestock animals A are reduced by 50% or more relative to the previous time or are increased by 50% or more relative to the previous time. The step counts of the livestock animals A may be reduced while eating, for example. The step counts of the livestock animals A may be increased during an urgent situation such as when a wild dog appears or thunder occurs. Therefore, the change time slot is a time slot during eating or during an urgent situation.

**[0074]** The determining unit 904 has a function of determining the presence/absence of estrus for each of the multiple livestock animals A based on multiple step count measurement results, excluding measurement results corresponding to the change time slot. For example, the determining unit 904 determines that estrus has started if a measurement result of the determination object livestock animal A in the current time slot is greater than or equal to a threshold value. The determining unit 904 determines the presence/absence of estrus, excluding the measurement results corresponding to a time slot in which the step counts of the livestock animals A are reduced by 50% or more as compared to the previous time and a time slot in which the numbers of the steps are increased by 50% or more as compared to the previous time. In other words, the determining unit 904 does not make a determination on estrus for a time slot considered as an eating time and a time slot considered as an urgent situation.

**[0075]** The output unit 906 has a function of outputting identification information of the livestock animal A determined as being in estrus by the determining unit 904. The identification information is a communications device ID, for example.

**[0076]** The identifying unit 905 has a function of identifying an estrus start time on the assumption that an indication of estrus has continued during the change time slot if the determining unit 904 determines that a livestock animal is in estrus. For example, if the previous time slot is a time slot considered as an eating time or an urgent situation, the identifying unit 905 identifies the previous time slot as the estrus start time if the determining unit 904 determines that a livestock animal is in estrus in the current time slot. In other words, although estrus started in the previous time slot, if the presence/absence of the estrus cannot be determined due to an eating or urgent state, the identifying unit 905 identifies the estrus start time of the livestock animal A on the assumption that the estrus started in the previous time slot. The estrus start time is a time of a starting point of each time slot and is, for example, 1:00 in the case of the time slot of 1:00-2:00.

**[0077]** The output unit 906 outputs the identification information of the livestock animal A determined as being in estrus and the estrus start time identified by the identifying unit 905.

**[0078]** The second storage unit 907 has a function of storing multiple livestock animals A1 to An forming a herd in a livestock animal group. The change detecting unit 903 refers to the second storage unit 907 to detect a change time slot in which a change rate of measurement results relative to an immediately preceding time slot is greater than or equal to a predetermined value in a predetermined proportion or more of multiple livestock animals belonging to the same herd. In other words, the change detecting unit 903 detects a change time slot in which the livestock animals A1 to A in the same herd having the change rate greater than or equal to the predetermined value account for a predetermined proportion or more.

**[0079]** For example, the change detecting unit 903 detects a change time slot in which 80 percent of the livestock animals A1 to An in the same herd can be considered to be eating or in an urgent situation. The livestock animals A1 to An in the same herd have a similar behavioral pattern and therefore, the detection accuracy of the change time slot considered as the eating time or urgent situation can be improved by detecting the change time slot for the livestock animals A1 to An in the same herd.

**[0080]** Specific description will be made of a case where the livestock animal A1 is determined as being in estrus when a measurement result of the livestock animal A1 in each time slot is greater than or equal to the threshold value for two consecutive times.

**[0081]** The first storage unit 901 stores measurement results of the step counts of respective livestock animals in a livestock animal group in first, second, and third consecutive time slots as time elapses. For example, the first storage unit 901 stores the measurement results in the consecutive time slots of 0:00-1:00 as a first time, 1:00-2:00 as a second time, and 2:00-3:00 as a third time for each livestock animal A.

**[0082]** The acquiring unit 902 acquires a measurement result of the step count of any livestock animal A in the livestock animal group for the third time slot. For example, the acquiring unit 902 acquires a measurement result of a communications device ID "G101" having a herd ID "M1" from 2:00-3:00 as a measurement result of the livestock animal A1 that is the determination object at this time.

**[0083]** If the measurement result of the step count of the livestock animal A1 during the third time slot acquired by the acquiring unit 902 is greater than or equal to the threshold value, the determining unit 904 determines whether the measurement result of the step count of the livestock animal A1 during the second time slot is greater than or equal to the threshold value. For example, if the measurement result at this time from 2:00-3:00 is greater than or equal to the threshold value, the determining unit 904 determines whether the measurement result at the previous time from 1:00-2:00 is greater than or equal to the threshold value.

**[0084]** If the determining unit 904 determines that the measurement result of the step count of the livestock animal A1 during the second time slot is less than the threshold value, the acquiring unit 902 acquires the measurement results of the step counts of the other livestock animals A2 to An different from the livestock animal A1 in the livestock animal group in the first and second time slots from the first storage unit 901. For example, the acquiring unit 902 acquires the measurement results of the step counts of the livestock animals A2 to An at the time before the previous time from 0:00-1:00, and at the previous time from 1:00-2:00.

**[0085]** The change detecting unit 903 calculates a degree of reduction of the step counts of the other livestock animals A2 to An from the first time slot to the second time slot, based on the measurement results of the step counts of the other livestock animals A2 to An in the first and second time slots acquired by the acquiring unit 902. The degree of reduction is a change rate for determining whether the step counts are reduced due to eating, in the entire herd including the livestock animal A and is particularly a value indicative of a level of reduction of the step count for the second time slot based on the step count for the first time slot. The degree of reduction can be represented by a difference or a proportion for each of the livestock animals A2 to An, for example. The degree of reduction may be an overall average of the livestock animals A2 to An or an overall rate of the livestock animals A2 to An acquired from respective differences or proportions calculated for the livestock animals A2 to An.

**[0086]** In this example, the degree of reduction is a proportion for each of the livestock animals A2 to An. For example, assuming that the measurement result is "100 steps" for the first time slot and "25 steps" for the second time slot, the second time slot is 25% of the first time slot. In this case, the degree of reduction can be represented as a reduction percentage of 75%. For example, if 80 percent or more of the livestock animals A2 to An has a

reduction percentage of 50%, it can be considered that the livestock animals were eating. In this example, it is considered that the livestock animals were eating if all the livestock animals A2 to An have a reduction percentage of 50%. The change detecting unit 903 may calculate an average value of the degrees of reduction of all the livestock animals A2 to An to use this average value as the degree of reduction.

**[0087]** If the degree of reduction calculated by the change detecting unit 903 is greater than or equal to a predetermined value, the determining unit 904 determines that the livestock animal A is in estrus. The identifying unit 905 identifies a time of the starting point of the second time slot as the estrus start time of the livestock animal A1. If the determining unit 904 determines that the livestock animal A is in estrus, the output unit 906 outputs the identification information of the livestock animal A and the estrus start time.

**[0088]** A degree of reduction greater than or equal to the predetermined value means that the reduction percentage is greater than or equal to 50%, for example. If the reduction percentage is greater than or equal to 50%, the determining unit 904 determines that the herd including the livestock animal A1 is eating during the second time slot. If the reduction percentage is less than 50%, the determining unit 904 considers that the herd including the livestock animal A1 is not eating during the second time slot and therefore, determines that the livestock animal A1 is not in estrus. In this case, the output unit 906 does not output the identification information of the livestock animal A1.

**[0089]** If the determining unit 904 determines that the measurement result of the step count of the livestock animal A1 during the second time slot is greater than or equal to the threshold value, i.e., if 1:00-2:00 is not eating time and the measurement results are continuously greater than or equal to the threshold value from 1:00-2:00 and 2:00-3:00, the output unit 906 outputs the identification information of the livestock animal A1. In this case, the identifying unit 905 identifies 1:00 as the estrus start time since the estrus of the livestock animal A1 starts between 1:00 and 2:00.

**[0090]** As a result, when a measurement result of the livestock animal A1 at this time is greater than or equal to the threshold value and a measurement result at the previous time is less than the threshold value, if it is considered that the livestock animal A1 was eating from the measurement results of the other livestock animals A2 to An at the previous time, the estrus of the livestock animal A1 can be considered as having started in the previous time slot. Therefore, a period of estrus of the livestock animal A1, or particularly, a staring period of the estrus can accurately be detected. To correctly detect the estrus start timing, for example, the time slots of the measurement results stored in the first storage unit 901 may be defined as time slots having a temporal width shorter than one hour, such as 45 minutes and 30 minutes.

**[0091]** A DB may be stored that correlates the communications device IDs of the livestock animals A with an address of the client device 230 of a worker and, if estrus of a livestock animal A is detected, the output unit 906 may output information indicative of the estrus of the livestock animal A to the corresponding address. As a result, the worker managing the livestock animal A can be notified of the estrus of the livestock animal A.

**[0092]** Description will be made of the case that the livestock animal A1 is determined as being in estrus when a measurement result of the livestock animal A1 in each time slot is greater than or equal to the threshold value for three consecutive times.

**[0093]** If the measurement result of the step count of the livestock animal A1 during the third time slot is greater than or equal to the threshold value, the determining unit 904 determines whether the measurement result of the step count of the livestock animal A1 during the second time slot is less than the threshold value while the measurement result of the step count of the livestock animal A1 during the first time slot is greater than or equal to the threshold value. In other words, if the measurement result at this time is greater than or equal to the threshold value, the determining unit 904 determines whether the measurement result at the previous time is less than the threshold value while the measurement result at the time before the previous time is greater than or equal to the threshold value.

**[0094]** If the measurement result of the step count of the livestock animal A1 for the second time slot is less than the threshold value while the measurement result of the step count of the livestock animal A1 for the first time slot is greater than or equal to the threshold value, the acquiring unit 902 acquires the measurement results of the step counts of the other livestock animals A2 to An in the first and second time slots from the first storage unit 901. In other words, if the measurement result of A1 at this time is greater than or equal to the threshold value and the measurement result at the previous time is less than the threshold value while the measurement result at the time before the previous time is greater than or equal to the threshold value, the acquiring unit 902 acquires the measurement results of the step counts of the other livestock animals A2 to An in the first and second time slots.

**[0095]** The change detecting unit 903 calculates a degree of reduction of the step counts of the other livestock animals A2 to An as described above. If the degree of reduction calculated by the change detecting unit 903 is greater than or equal to the predetermined value, the determining unit 904 determines that the livestock animal A1 is in estrus.

**[0096]** As a result, when the measurement results of the livestock animal A1 at this time and the time before the previous time are greater than or equal to the threshold value and the measurement result at the previous time is less than the threshold value, it can be considered that this is due to eating, i.e., that the measurement re-

sults are greater than or equal to the threshold value for three consecutive times. Therefore, it can be considered that the estrus started from the time before the previous time. As a result the starting period of estrus of the livestock animal A1 can correctly be detected.

**[0097]** Description will be made of the case of giving consideration to the fact that the step count of the livestock animal A increases in an urgent state such as when another animal like a wild dog appears. First, description will be made of the case that the livestock animal A1 is determined as being in estrus when a measurement result of the livestock animal A1 becomes greater than or equal to the threshold value only once.

**[0098]** If the measurement result of the step count of the livestock animal A1 for the third time slot is greater than or equal to the threshold value, the acquiring unit 902 acquires the measurement results of the step counts of the other livestock animals A2 to An in the second and third time slots from the first storage unit 901. The change detecting unit 903 calculates a degree of increase of the step counts of the other livestock animals A2 to An from the second time slot to the third time slot based on the measurement results of the step counts of the other livestock animals A2 to An in the second and third time slots acquired by the acquiring unit 902.

**[0099]** The degree of increase is a change rate for determining whether the step counts are increased due to an urgent state in the entire herd including the livestock animal A and is particularly a value indicative of a level of increase of the step count for the third time slot based on the step count for the second time slot. The degree of increase can be represented by a difference or a proportion for each of the livestock animals A2 to An, for example. The degree of increase may be an overall average of the livestock animals A2 to An or an overall rate of the livestock animals A2 to An acquired from respective differences or proportions calculated for the livestock animals A2 to An.

**[0100]** In this example, the degree of increase is a proportion for each of the livestock animals A2 to An. For example, assuming that the measurement result is "100 steps" for the second time slot and "150 steps" for the third time slot, the second time slot is 150% of the first time slot. In this case, the degree of reduction can be represented as an increase percentage of 50%. For example, if 80 percent or more of the livestock animals A2 to An has an increase percentage of 50%, it can be considered that the livestock animals were in an urgent state. In this example, it is considered that the livestock animals were in an urgent state if all the livestock animals A2 to An have an increase percentage of 50%. The change detecting unit 903 may calculate an average value of the degrees of increase/reduction of all the livestock animals A2 to An to use this average value as the degree of reduction.

**[0101]** If the degree of increase calculated by the change detecting unit 903 is less than a predetermined value, the determining unit 904 determines that the livestock animal A is in estrus. The degree of reduction less than a predetermined value means that the increase percentage is less than 50%, for example. If the increase percentage is less than 50%, the determining unit 904 considers that the herd including the livestock animal A1 is not in an urgent state during the third time slot and therefore, determines that the livestock animal A1 is simply not in estrus. If the increase percentage is greater than or equal to 50%, the determining unit 904 considers that the herd including the livestock animal A1 is in an urgent state and therefore determines that the livestock animal A1 is not in estrus.

**[0102]** As a result, even when a measurement result of the livestock animal A1 at this time is greater than or equal to the threshold value, if it is considered that the livestock animal A1 is in an urgent state from the measurement results of the other livestock animals A2 to An at this time, the livestock animal A1 can be considered as not in estrus. Therefore, a false report can be prevented.

**[0103]** Description will be made of the case that the livestock animal A1 is determined as being in estrus when a measurement result of the livestock animal A1 in each time slot is greater than or equal to the threshold value for three consecutive times with consideration given to whether the livestock animal A1 is in an urgent state. The same description applies to the case that the livestock animal A1 is determined as being in estrus when a measurement result of the livestock animal A1 in each time slot is greater than or equal to the threshold value for two consecutive times with consideration given to whether the livestock animal A1 is in an urgent state.

**[0104]** If the measurement result of the step count of the livestock animal A1 for the third time slot acquired by the acquiring unit 902 is greater than or equal to the threshold value, the determining unit 904 determines whether the measurement result of the step count of the livestock animal A1 for the first and second time slots is greater than or equal to the threshold value. In other words, the determining unit 904 determines whether the measurement result of the livestock animal A1 is greater than or equal to the threshold value for three consecutive times.

**[0105]** If the determining unit 904 determines that the measurement result of the step count of the livestock animal A1 for the first and second time slots is greater than or equal to the threshold value, i.e., that the measurement result is greater than or equal to the threshold value for three consecutive times, the acquiring unit 902 acquires the measurement results of the step counts of the other livestock animals A2 to An in the second and third time slots from the first storage unit 901.

**[0106]** The change detecting unit 903 calculates a degree of increase of the step counts of the other livestock animals A2 to An from the second time slot to the third time slot. If the degree of increase calculated by the change detecting unit 903 is less than the predetermined value, the determining unit 904 determines that the live-

stock animal A1 is in estrus. If the livestock animal A1 is not in an urgent state, the output unit 906 outputs the identification information of the livestock animal A1 on the assumption that the estrus of the livestock animal A1 started at the first time.

**[0107]** If the degree of increase calculated by the change detecting unit 903 is greater than or equal to the predetermined value, it can be considered that the livestock animal A1 was in an urgent state. If the degree of increase becomes greater than or equal to the predetermined value next time, the determining unit 904 determines that the livestock animal A1 is in estrus. The identifying unit 905 identifies the estrus start time on the assumption that the estrus of the livestock animal A1 started at the first time. The output unit 906 outputs the identification information of the livestock animal A and the estrus start time.

**[0108]** As a result, even if the measurement result of the livestock animal A1 is greater than or equal to the threshold value for three consecutive times, the measurement result at the third time can be considered as an urgent state. Therefore, even if the measurement result of the livestock animal A1 is greater than or equal to the threshold value for three consecutive times, it can be considered that the livestock animal A1 is not in estrus in the case of the urgent state, and a false report can be prevented.

**[0109]** If the measurement result of the livestock animal A1 at the fourth time is greater than or equal to the threshold value, it can be considered that the livestock animal A1 is in estrus and the identification information of the livestock animal A1 can be output on the assumption that the estrus have started during the first time slot corresponding to the first time. As a result, a staring period of the estrus can accurately be detected while a false report is prevented.

**[0110]** The acquisition of the measurement results of the step counts of the other livestock animals A2 to An by the acquiring unit 902 will be described. The second storage unit 907 has a function of storing the multiple livestock animals A1 to An forming a herd in a livestock animal group. For example, the second storage unit 907 stores the herd management DB 203 depicted in FIG. 8. The change detecting unit 903 has a function of referring to the second storage unit 907 to extract the other livestock animals A2 to An forming a herd with the livestock animal A1. The acquiring unit 902 acquires the measurement results of the step counts of the other livestock animals A2 to An extracted by the change detecting unit 903. The acquiring unit 902 can acquire the measurement results of the step counts of the other livestock animals A2 to An in this way.

**[0111]** The herds may not be stored in advance in the second storage unit 907 as the herd information 800-1 and, for example, multiple livestock animals A located in each communication area of the relay device 211 can be set as a herd. For example, if two communication areas are closely present and one herd is located across two communication areas, a herd may not be set.

**[0112]** In this case, herds may be set when livestock animals are located in communication areas separated from each other such that one herd is not located across two communication areas. For a livestock animal A set as a first animal present in a communication area without setting of a herd, a new herd may be set if a herd of the other livestock animals A is not set in the same area while no other communication area is located closer such that a herd is present across the communication areas.

(Example of Screen Displayed on Client Device 230)

**[0113]** An example of a screen displayed on the client device 230 will be described.

**[0114]** FIG. 10 is an explanatory diagram of an example of a screen displayed on the client device 230. In FIG. 10, the display 508 displays notification information 1001 and a current time 1002. The notification information 1001 is displayed as a communications device ID that is information identifying the livestock animal A in estrus and an estrus starting time slot "13:00-14:00".

**[0115]** The current time 1002 indicates 16:00 and a temporal difference from the start time of the estrus is up to three hours. In particular, if the estrus started at 13:00, the temporal difference is maximized to three hours and, if the estrus started at 14:00, the temporal difference is minimized to two hours. Such a display screen can make a notification of a start timing of estrus if estrus of the livestock animal A started while suppressing a temporal difference from the start time of the estrus. Therefore, probability of impregnation can be improved and sex-choice birth can effectively be achieved. Although the notification information 1001 is displayed as the estrus starting time slot "13:00-14:00", this is not a limitation and, for example, "estrus starting time: 13:30" may be displayed as a midpoint of the temporal width.

(Example of Estrus Determination)

**[0116]** An example of estrus determination will be described with reference to FIGs. 11 to 14. FIG. 11 is an explanatory diagram of an example (part one) of the estrus determination. In FIG. 11, an explanatory diagram 1100 has a horizontal axis indicative of time and a vertical axis indicative of the step count acquired as a measurement result to represent a relationship between a time slot and the step count of a determination object livestock animal A1 belonging to a certain herd. A predetermined threshold value is set for the step count. A time of acquisition of information of the step count for each time slot by the estrus notifying apparatus 102 is an ending time of the time slot and, for example, a time of acquisition of information of the step count for the time slot from 4:00-5:00 is 5:00. It is basically determined that the determination objet livestock animal A1 is in estrus if the step count for each time slot is greater than or equal to the threshold value for three consecutive times.

**[0117]** In an example depicted in the explanatory diagram 1100, when the step count is reduced due to eating, if the step counts in the time slots before and after the eating are greater than or equal to the threshold value, it is determined that the livestock animal A1 is in estrus. The explanatory diagram 1100 represents a relationship between a time slot and the step count of the livestock animal A1 belonging to a certain herd and the step count from 4:00-5:00 is greater than or equal to the threshold value. The step count from 5:00-6:00 is less than the threshold value. The step count from 6:00-7:00 is greater than or equal to the threshold value.

**[0118]** It is assumed that the step count from 6:00-7:00 is the current measurement result. Since the step count from 4:00-5:00 is greater than or equal to the threshold value, the measurement result from 5:00-6:00 may represent that the step count is reduced due to eating. Therefore, the estrus notifying apparatus 102 calculates a degree of reduction of the step count from 5:00-6:00 for the other livestock animals A2 to An in the same herd. The degree of reduction of the step count from 5:00-6:00 is a value indicative of a level of reduction of the step count from 5:00-6:00 based on the step count from 4:00-5:00. If the degree of reduction is greater than or equal to the predetermined value, i.e., if the step counts of the other livestock animals A2 to An are reduced, the estrus notifying apparatus 102 determines that the livestock animals are eating in the time slot from 5:00-6:00.

**[0119]** The estrus notifying apparatus 102 determines that the step count from 5:00-6:00 during eating indicates the estrus of the determination object livestock animal A1 since the step counts in the time slots before and after the eating are greater than or equal to the threshold value. The estrus notifying apparatus 102 outputs at 7:00 the information indicating that the estrus of the livestock animal A started between 4:00 and 5:00. If the degree of reduction is less than the predetermined value, i.e., if the step counts of the other livestock animals A2 to An are not reduced, the estrus notifying apparatus 102 determines that the livestock animal A1 is not in estrus.

**[0120]** The case of determination of estrus without considering the eating will additionally be described. It is assumed that since the step count from 5:00-6:00 is less than the threshold value, the continuity of the time slots having the step counts greater than or equal to the threshold value is reset, for example. In other words, it is assumed that whether the step count is greater than or equal to the threshold value for three consecutive time slots is subsequently determined by using a time slot from 6:00-7:00 as a starting point in terms of continuity. In this case, the information indicative of the estrus of the livestock animal A1 starting between 6:00 and 7:00 is output at 9:00 after two time slots. Therefore, the start time of estrus is detected as a time delayed by two hours and the time of notification is delayed by one hour.

**[0121]** In the determination example depicted in the explanatory diagram 1100, if the step count are greater than or equal to the threshold value in the time slots before and after the eating, it is determined that the estrus of the livestock animal A1 started during the time slot in which the step count became greater than or equal to the threshold value for the first time. As a result, the start timing of estrus can correctly be detected and can be reported at an earlier time with a temporal difference from the estrus start timing suppressed. Therefore, probability of impregnation can be improved and sex-choice birth can effectively be achieved.

**[0122]** In terms of further improvement in correctness, the livestock animal A1 may be determined as being in estrus if the step count is greater than or equal to the threshold value in the time slot from 7:00-8:00 next to the time slot from 6:00-7:00. In other words, the livestock animal A1 may be determined as being in estrus if the step count is greater than or equal to the threshold value for three consecutive times except eating.

**[0123]** Although it is determined that the determination object livestock animal A1 is in estrus if the step count for each time slot is greater than or equal to the threshold value for three consecutive times in this example, it may be determined that the determination object livestock animal A1 is in estrus if the step count for each time slot is greater than or equal to the threshold value for two consecutive times. In this case, when the current number of steps is greater than or equal to the threshold value, if it is determined that the livestock animal was eating in the previous time slot, the livestock animal A1 may be determined as being in estrus.

**[0124]** FIG. 12 is an explanatory diagram of an example (part two) of the estrus determination. In FIG. 12, an explanatory diagram 1200 represents another example of determining that the livestock animal A1 is in estrus if the step count is reduced due to eating while the step counts in the time slots before and after the eating are greater than or equal to the threshold value. In the explanatory diagram 1200, the step counts from 4:00-5:00, from 5:00-6:00, and from 7:00-8:00 are greater than or equal to the threshold value. The step count from 6:00-7:00 is less than the threshold value.

**[0125]** It is assumed that the step count from 7:00-8:00 is the current measurement result. Since the step count acquired three times before from 4:00-5:00 and the step count acquired two times before from 5:00-6:00 are greater than or equal to the threshold value, the measurement result at the previous time from 6:00-7:00 may represent that the step count is reduced due to eating although the livestock animal A1 is already in estrus between 6:00 and 7:00. Therefore, the estrus notifying apparatus 102 calculates a degree of reduction of the step count from 6:00-7:00 for the other livestock animals A2 to An in the same herd. If the degree of reduction is greater than or equal to the predetermined value, i.e., if the step counts of the other livestock animals A2 to An are reduced, the estrus notifying apparatus 102 determines that the livestock animals were eating in the time slot from 6:00-7:00.

**[0126]** The estrus notifying apparatus 102 determines

that the determination object livestock animal A1 is in estrus since the step counts in the time slots before and after the eating are greater than or equal to the threshold value. The estrus notifying apparatus 102 outputs at 8:00 the information indicating that the estrus of the livestock animal A started between 4:00 and 5:00. If the degree of reduction is less than the predetermined value from 6:00-7:00, i.e., if the step counts of the other livestock animals A2 to An are not reduced, the estrus notifying apparatus 102 determines that the livestock animal A1 is not in estrus.

**[0127]** The case of determination of estrus without considering the eating will additionally be described. It is assumed that since the step count from 6:00-7:00 is less than the threshold value, the continuity of the time slots having the step counts greater than or equal to the threshold value is reset, for example. In other words, it is assumed that the time slot from 7:00-8:00 is used as a starting point in terms of continuity to determine that the step count is greater than or equal to the threshold value for three consecutive time slots including the subsequent time slots, i.e., the time slots from 8:00-9:00 and from 9:00-10:00. In this case, the information indicative of the estrus of the livestock animal A1 starting between 7:00 and 8:00 is output at 10:00. Therefore, the start time of estrus is detected as a time delayed by three hours and the time of notification is delayed by two hour.

**[0128]** FIG. 13 is an explanatory diagram of an example (part three) of the estrus determination. In FIG. 13, an explanatory diagram 1300 represents an example of determining that the livestock animal A1 is in estrus if the step count is greater than or equal to the threshold value for two consecutive times while the step count is reduced due to eating in the time slot before the step count becomes greater than or equal to the threshold value. In the explanatory diagram 1300, the step counts from 5:00-6:00 and from 6:00-7:00 are greater than or equal to the threshold value.

**[0129]** It is assumed that the step count from 6:00-7:00 is the current measurement result. Since the step count at the previous time from 5:00-6:00 is greater than or equal to the threshold value, the measurement result at the time before the previous time from 4:00-5:00 may represent that the step count is reduced due to eating although the livestock animal A1 is already in estrus between 4:00-5:00. Therefore, the estrus notifying apparatus 102 calculates a degree of reduction of the step count from 4:00-5:00 for the other livestock animals A2 to An in the same herd. If the degree of reduction is greater than or equal to the predetermined value, i.e., if the step counts of the other livestock animals A2 to An are reduced, the estrus notifying apparatus 102 determines that the livestock animals were eating in the time slot from 4:00-5:00.

**[0130]** The estrus notifying apparatus 102 determines that the livestock animal A1 is in estrus even though the step count is greater than or equal to the threshold value for two consecutive times rather than three consecutive times, since the step counts is reduced due to eating in the time slot before the step count becomes greater than or equal to the threshold value.

**[0131]** FIG. 14 is an explanatory diagram of an example (part four) of the estrus determination. In FIG. 14, an explanatory diagram 1400 represents an example of refraining from determining a livestock animal as being in estrus during an urgent situation even if the step count is greater than or equal to the threshold value for three consecutive times. In the explanatory diagram 1400, the step counts from 4:00-5:00, from 5:00-6:00, and from 6:00-7:00 are greater than or equal to the threshold value. Therefore, the step count of the livestock animals A1 for each time slot is greater than or equal to the threshold value for three consecutive times.

**[0132]** In the explanatory diagram 1400, with regard to the step count from 6:00-7:00 greater than or equal to the threshold value, consideration is given to whether the livestock animal is in an urgent state due to appearance of another animal such as a wild dog. For example, the estrus notifying apparatus 102 calculates a degree of increase of the step count from 6:00-7:00 for the other livestock animals A2 to An in the same herd. If the degree of increase is greater than or equal to the predetermined value, i.e., if the step counts of the other livestock animals A2 to An are increased, the estrus notifying apparatus 102 determines that the livestock animals are in an urgent state from 6:00-7:00.

**[0133]** If the step count for the next time slot from 7:00-8:00 is less than the threshold value, the estrus notifying apparatus 102 determines that the livestock animal A1 is not in estrus. On the other hand, if the step count for the next time slot from 7:00-8:00 is greater than or equal to the threshold value, the estrus notifying apparatus 102 determines that the livestock animal A1 is in estrus. For example, the estrus notifying apparatus 102 does not count the time slot from 6:00-7:00 in an urgent state in terms of the consecutive number of times and considers that the step count is greater than or equal to the threshold value for three consecutive times in three time slots from 4:00-5:00, from 5:00-6:00, and from 7:00-8:00, determining that the livestock animal A1 is in estrus.

**[0134]** A degree of increase in a time slot after 7:00-8:00 may also be calculated for the other livestock animals A2 to An to determine estrus in consideration of the degree of increase. In particular, if the step count is greater than or equal to the threshold value in a time slot after 7:00-8:00 and the degree of increase is greater than or equal to the predetermined value, the determination of estrus may be shifted to a subsequent time in each case.

**[0135]** If it is determined that the livestock animal A1 is in estrus, the estrus notifying apparatus 102 outputs at 8:00 the information indicating that the estrus of the livestock animal A1 started between 4:00 and 5:00. If the degree of increase in the time slot from 6:00-7:00 is less than the predetermined value, i.e., if the step counts of

the other livestock animals A2 to An are not increased, the estrus notifying apparatus 102 determines that the livestock animal A1 is not in an urgent state from 6:00-7:00 and determines that the livestock animal A1 is in estrus. For example, the estrus notifying apparatus 102 outputs at 7:00 the information indicating that the estrus of the livestock animal A1 started between 4:00 and 5:00.

**[0136]** In the determination example depicted in the explanatory diagram 1400, false detection can be prevented when estrus of the livestock animal A1 is detected. Therefore, unnecessary work of a worker going to a pasture area due to false detection can be reduced. In the explanatory diagram 1400, when the step count of the livestock animal A1 is greater than or equal to the threshold value for three consecutive times, only the degree of increase at the third time is taken into consideration, or particularly, the degree of increase is taken into consideration only when it is determined whether the livestock animal is in estrus. This is because a frequency of the urgent state is smaller than eating and the degree of increase is intended to be taken into consideration at least when determination of estrus is made. A degree of increase may be taken into consideration also at the first and second times.

(Communication Process Procedure of Relay Device 211)

**[0137]** A communication process procedure of the relay device 211 will be described. FIG. 15 is a flowchart of an example of the communication process procedure of the relay device 211. In the flowchart of FIG. 15, the relay device 211 determines whether measurement result information and a communications device ID have been received from the communications device 101 (step S1501). The measurement result information and the communications device ID are transmitted from the communications device 101 at intervals of one hour, for example.

**[0138]** The relay device 211 waits until measurement result information and a communications device ID have been received (step S1501: NO). When measurement result information and a communications device ID have been received (step S1501: YES), the relay device 211 transmits the received measurement result information and the communications device ID to the estrus notifying apparatus 102 (step S1502) and terminates a series of operations of this flowchart.

**[0139]** As described above, if the measurement result information and the communications device ID are received, the relay device 211 can transmit these records of information to the estrus notifying apparatus 102.

(Estrus Notifying Process Procedure of Estrus Notifying Apparatus 102)

**[0140]** An estrus notifying process procedure of the estrus notifying apparatus 102 will be described. FIG. 16 is a flowchart (part one) of an example of the estrus notifying process procedure of the estrus notifying apparatus 102. In the flowchart of FIG. 16, the estrus notifying apparatus 102 first determines whether measurement result information and a communications device ID of a communications device 101 have been received from the relay device 211 (step S1601). The estrus notifying apparatus 102 waits until the measurement result information and the communications device ID have been received (step S1601: NO). The measurement result information and the communications device ID are transmitted from the relay device 211 at intervals of one hour, for example.

**[0141]** When the measurement result information and the communications device ID have been received (step S1601: YES), the estrus notifying apparatus 102 stores the measurement result information and the communications device ID into the step count information DB 202 (see FIG. 7) (step S1602). The estrus notifying apparatus 102 sets "1" as "i" indicative of a value of "1 to I" of the herd IDs "M1" to "M1" (step S1603). The estrus notifying apparatus 102 selects herd information 800-i of a herd ID "Mi" (step S1604). The herd information 800-i includes a herd ID and communications device IDs. The estrus notifying apparatus 102 selects a communications device ID from the herd information 800-i of the herd ID "Mi" (step S1605).

**[0142]** The estrus notifying apparatus 102 acquires from the step count information DB 202, the measurement result information that is the step count information 700 corresponding to the communications device ID (see FIG. 7) (step S1606). The estrus notifying apparatus 102 executes an estrus determining process (step S1607). Details of the estrus determining process will be described later with reference to FIGs. 17 and 18. The estrus notifying apparatus 102 determines whether an unselected communications device ID is present (step S1608). If an unselected communications device ID exists (step S1608: YES), the estrus notifying apparatus 102 transitions to the operation at step S1605. If an unselected communications device ID does not exist (step S1608: NO), the estrus notifying apparatus 102 adds "1" to "i" (step S1609).

**[0143]** The estrus notifying apparatus 102 determines if "i" is greater than "I" (step S1610). If "i" is equal to or less than "I" (step S1610: NO), the estrus notifying apparatus 102 transitions to the operation at step S1604. If "i" is greater than "I" (step S1610: YES), the estrus notifying apparatus 102 terminates a series of operations of this flowchart. As a result, the estrus notifying apparatus 102 can define the communications device IDs as the object of the estrus determination.

**[0144]** The estrus determining process procedure depicted at step S1607 of FIG. 16 will be described with reference to FIG. 17. FIG. 17 is a flowchart (part one) of an example of the estrus determining process procedure of the estrus notifying apparatus 102. In the flowchart of FIG. 17, the estrus notifying apparatus 102 refers to the

step count information DB 202 to determine whether the estrus predictor flag is "1" indicative of ON (step S1701). The estrus predictor flag is a flag set to "1" when an indication of estrus is present and is set to "1" at step S1713 and step S1804 of FIG. 18 as described later in detail.

**[0145]** If the estrus predictor flag is "0" (step S1701: NO), the estrus notifying apparatus 102 determines if the current measurement value is greater than or equal to the threshold value (step S1702). If the current measurement value is less than the threshold value (step S1702: NO), the estrus notifying apparatus 102 terminates a series of operations of this flowchart. If the current measurement value is greater than or equal to the threshold value (step S1702: YES), the estrus notifying apparatus 102 determines if the measurement value is greater than or equal to the threshold value for two consecutive times (step S1703).

**[0146]** If the measurement value is not greater than or equal to the threshold value for two consecutive times (step S1703: NO), i.e., if the measurement value becomes greater than or equal to the threshold value for the first time, the estrus notifying apparatus 102 transitions to the operation at step S1801 of FIG. 18. If the measurement value is greater than or equal to the threshold value for two consecutive times (step S1703: YES), the estrus notifying apparatus 102 determines whether the measurement value is greater than or equal to the threshold value for three consecutive times (step S1704). If the measurement value is not greater than or equal to the threshold value for three consecutive times (step S1704: NO), i.e., if the measurement value is greater than or equal to the threshold value for two consecutive times, the estrus notifying apparatus 102 transitions to the operation at step S1801 of FIG. 18.

**[0147]** If the measurement value is greater than or equal to the threshold value for three consecutive times (step S1704: YES), the estrus notifying apparatus 102 acquires from the step count information DB 202, the measurement results of the other livestock animals A in the same herd (see FIG. 7) to calculate a degree of increase of the other livestock animals A in the same herd (step S1705). The degree of increase is a value indicative of an increase in the step counts of the livestock animals A in the entire herd during an urgent situation and is particularly a value indicative of a level of increase in the step counts of the other livestock animals A from the previous time slot to the current time slot. The estrus notifying apparatus 102 determines whether the calculated degree of increase is less than a predetermined value $\beta$ (step S1706).

**[0148]** If the degree of increase is greater than or equal to the predetermined value $\beta$ (step S1706: NO), i.e., in the case of an urgent state increasing the step counts of the other livestock animals A, the estrus notifying apparatus 102 sets the estrus predictor flag to "1" (step S1713) and terminates a series of operations of this flowchart. For example, the estrus predictor flag is set to "1" in the determination for the time slot from 6:00-7:00 depicted in FIG. 14. If the degree of increase is less than the predetermined value $\beta$ (step S1706: YES), i.e., if the step counts of the other livestock animals A are not increased, the estrus notifying apparatus 102 determines that the estrus started three time slots before (step S1707). The determination of the start of estrus leading to step S1707 corresponds to the estrus determination depicted in FIG. 14.

**[0149]** The estrus notifying apparatus 102 transmits the communications device ID and information of the estrus starting time slot to the client device 230 (step S1708) and terminates a series of operations of this flowchart. At step S1701, if the estrus predictor flag is "1" at step S1701 (step S1701: YES), the estrus notifying apparatus 102 determines whether the current measurement value is greater than or equal to the threshold value (step S1709). If the current measurement value is less than the threshold value (step S1709: NO), the estrus notifying apparatus 102 sets the estrus predictor flag to "0" (step S1711) and terminates a series of operations of this flowchart.

**[0150]** If the current measurement value is greater than or equal to the threshold value (step S1709: YES), the estrus notifying apparatus 102 determines a time slot in which the estrus started (step S1710). For example, if the timing of setting the estrus flag to "1" is step S1713, it is determined that the estrus started four time slots before and, if the timing is step S1804 of FIG. 18, it is determined that the estrus started two time slots before.

**[0151]** The determination of the estrus having started four time slots before corresponds to the estrus determination depicted in FIG. 14. The determination of the estrus having started two time slots before corresponds to the estrus determination depicted in FIG. 13. When the estrus flag is set to "1", the timing of the setting may also be stored or a different flag may be set in each case. The estrus notifying apparatus 102 sets the estrus predictor flag to "0" (step S1712) and transitions to step S1708.

**[0152]** FIG. 18 is a flowchart (part two) of an example of the estrus determining process procedure of the estrus notifying apparatus 102. In the flowchart of FIG. 18, the estrus notifying apparatus 102 acquires from the step count information DB 202, the measurement results of the other livestock animals A in the same herd (see FIG. 7) to calculate a degree of reduction of the other livestock animals A in the same herd (step S1801). The degree of reduction is a value indicative of a reduction in the step counts of the livestock animals A in the entire herd due to eating and is particularly a value indicative of a level of reduction in the step counts from the time slot before the previous time slot to the previous time slot. The estrus notifying apparatus 102 determines if the calculated degree of reduction is greater than or equal to a predetermined value $\alpha$ (step S1802). Therefore, at step S1802, the estrus notifying apparatus 102 determines whether, in the previous time slot, the livestock animals are eating.

**[0153]** If the degree of reduction is less than the predetermined value $\alpha$ (step S1802: NO), i.e., if the livestock

animals are not eating in the previous time slot, the estrus notifying apparatus 102 terminates a series of operations of this flowchart. If the degree of reduction is greater than or equal to the predetermined value $\alpha$ (step S1802: YES), the estrus notifying apparatus 102 determines if the step count is greater than or equal to the threshold value in the time slot before the previous time slot (step S1803).

**[0154]** If the step count is not greater than or equal to the threshold value in the time slot before the previous time slot (step S1803: NO), the estrus notifying apparatus 102 sets the estrus predictor flag to "1" (step S1804) and terminates a series of operations of this flowchart. For example, the estrus flag is set to "1" in the determination for the time slot from 5:00-6:00 depicted in FIG. 13. If the step count is greater than or equal to the threshold value in the time slot before the previous time slot (step S1803: YES), the estrus notifying apparatus 102 determines if the step count is greater than or equal to the threshold value in the time slot before the two previous time slots (step S1805).

**[0155]** If the step count is not greater than or equal to the threshold value in the time slot before the two previous time slots (step S1805: NO), the estrus notifying apparatus 102 determines that the estrus started two time slots before (step S1806) and transitions to the operation at step S1708 of FIG. 17. The determination of the start of estrus leading to step S1806 corresponds to the estrus determination depicted in FIG. 11.

**[0156]** If the step count is greater than or equal to the threshold value in the time slot before the two previous time slots (step S1803: YES), the estrus notifying apparatus 102 determines that the estrus started three time slots before (step S1807) and transitions to the operation at step S1708 of FIG. 17. The determination of the start of estrus leading to step S1807 corresponds to the estrus determination depicted in FIG. 12.

**[0157]** The estrus determining process depicted in FIGs. 17 and 18 enables the detection of the estrus of the livestock animal A with consideration given to eating and can improve the detection accuracy of the livestock animal A. For example, the estrus determining process can prevent the probability of impregnation from decreasing due to determining that the estrus start timing is after eating. Therefore, the probability of impregnation can be improved and sex-choice birth can effectively be achieved.

**[0158]** The estrus determining process depicted in FIGs. 17 and 18 enables the detection of the estrus of the livestock animal A with consideration given to whether the livestock animal A is in an urgent state. As a result, false detection can be prevented when the estrus of the livestock animal A is detected. Therefore, unnecessary work of a worker going to the pasture area due to false detection can be reduced.

(Estrus Notifying Process Procedure of Client Device 230)

**[0159]** An estrus notifying process procedure of the client device 230 will be described. FIG. 19 is a flowchart of an example of the estrus notifying process procedure of the client device 230. In the flowchart of FIG. 19, the client device 230 determines whether the communications device ID and the information of the time slot have been received from the estrus notifying apparatus 102 (step S1901).

**[0160]** The client device 230 waits until the communications device ID and the information of the estrus starting time slot have been received (step S1901: NO). When the communications device ID and the information of the estrus starting time slot have been received (step S1901: YES), the client device 230 outputs the communications device ID and the information of the estrus starting time slot (step S1902) and terminates a series of operations of this flowchart. As a result, if the livestock animal A is in estrus, a worker managing the livestock animal A can be notified of the estrus of the livestock animal A.

**[0161]** As described above, when the step count of the livestock animal A at this time is greater than or equal to the threshold value and the number of the steps at the previous time is less than the threshold value, if the step counts of the other livestock animals A are reduced by a predetermined amount from the time before the previous time to the previous time, the estrus notifying apparatus 102 according to the first embodiment determines that the livestock animal A is in estrus. As a result, the estrus of the livestock animal A can be determined in consideration of a reduction in the step count during eating and the detection accuracy of the livestock animal A in estrus can be improved.

**[0162]** For example, the probability of impregnation can be prevented from decreasing due to determining that the estrus start timing is after eating. Therefore, the probability of impregnation can be improved and sex-choice birth can effectively be achieved. As a result, the workload required for comprehending the livestock animal A in estrus can be reduced.

**[0163]** The estrus notifying apparatus 102 according to the first embodiment can determine that the livestock animal A is in estrus if the number of the steps is greater than or equal to the threshold value in the time slots before and after the time slot determined as the eating time. Therefore, the detection accuracy of the livestock animal A can be improved further.

**[0164]** The estrus notifying apparatus 102 according to the first embodiment can determine that the livestock animal A is in estrus with consideration given to whether the livestock animal A is in an urgent state even if the number of the steps is greater than or equal to the threshold value. As a result, false detection can be prevented when estrus of the livestock animal A is detected. Therefore, unnecessary work of a worker going to a pasture area due to false detection can be reduced.

**[0165]** If the step count for each time slot is greater than or equal to the threshold value for three consecutive times, the estrus notifying apparatus 102 according to the first embodiment can determine that the livestock animal A is in estrus with consideration given to whether the livestock animals A are in an urgent state during the third time slot. As a result, false detection can be prevented when estrus of the livestock animal A is detected.

(Second Embodiment)

**[0166]** An estrus notifying apparatus according to a second embodiment will be described. In the first embodiment, estrus is determined with consideration given to eating and an urgent state if the step counts measured in respective time slots are continuously greater than or equal to the threshold value. In the second embodiment, estrus is determined with consideration given only to an urgent state if the step count is greater than or equal to the threshold value in a single time slot rather than if the step counts measured in respective time slots are continuously greater than or equal to the threshold value. The portions identical to those described in the first embodiment are denoted by the same reference numerals used in the first embodiment and will not be again described.

(Functional Configuration Example of Estrus Notifying apparatus 2000)

**[0167]** FIG. 20 is a block diagram of a functional configuration of an estrus notifying apparatus 2000 according to the second embodiment. In FIG. 20, the estrus notifying apparatus 2000 includes a first storage unit 2001, an acquiring unit 2002, a change detecting unit 2003, a determining unit 2004, an identifying unit 2005, and an output unit 2006. The acquiring unit 2002 to the output unit 2006 are functions acting as a control unit and, for example, the functions are implemented by causing the CPU 501 to execute a program stored in the magnetic disk 505 depicted in FIG. 5, for example, or by the magnetic disk 505, the I/F 509, etc. Processing results of the functional units are stored in the RAM 503, for example.

**[0168]** The first storage unit 2001 stores measurement results of the step counts of respective livestock animals in a livestock animal group in first and second consecutive time slots as time elapses. For example, the first storage unit 2001 stores measurement results in consecutive time slots from 0:00-1:00 as a first time and from 1:00-2:00 as a second time for each of the livestock animals A. The first storage unit 2001 corresponds to the step count information DB 202 depicted in FIG. 7, for example.

**[0169]** The acquiring unit 2002 acquires a measurement result of the step count of any of the livestock animals A in the livestock animal group for the second time slot from the first storage unit 2001. For example, the acquiring unit 2002 acquires a measurement result from 1:00-2:00 of the communications device ID "G101" of the herd ID "M1" as the measurement result of the livestock animal A1 that is the determination object at the this time, for example.

**[0170]** If the determining unit 2004 determines that the measurement result of the step count of the livestock animal A1 for the second time slot is greater than or equal to the threshold value, the acquiring unit 2002 acquires the measurement results of the step counts of the other livestock animals A2 to An different from the livestock animal A1 in the livestock animal group in the first and second time slots from the first storage unit 2001. For example, the acquiring unit 2002 acquires the measurement results of the step counts of the livestock animals A2 to An at the previous time from 0:00-1:00, and at the this time from 1:00-2:00.

**[0171]** The change detecting unit 2003 calculates a degree of increase of the step counts of the other livestock animals A2 to An from the first time slot to the second time slot based on the measurement results of the step counts of the other livestock animals A2 to An in the first and second time slots acquired by the acquiring unit 2002. The degree of increase is a change rate for determining whether the step counts are increased due to an urgent state in the entire herd including the livestock animal A and is particularly a value indicative of a level of increase of the step count for the second time slot based on the step count for the first time slot.

**[0172]** If the degree of increase calculated by the change detecting unit 2003 is less than a predetermined value, i.e., if it can be considered that the livestock animals are not in an urgent state, the determining unit 2004 determines that the livestock animal A1 is in estrus. The identifying unit 2005 identifies the second time slot as the time slot in which the estrus of the livestock animal A1 started. The output unit 2006 outputs the identification information of the livestock animal A1 as well as information indicating that the estrus of the livestock animal A1 started during the second time slot.

(Estrus Determining Process Procedure of Estrus Notifying Apparatus 2000)

**[0173]** An estrus determining process procedure of the estrus notifying apparatus 2000 will be described. FIG. 21 is a flowchart of an example of the estrus determining process procedure of the estrus notifying apparatus 2000. In the flowchart of FIG. 21, the estrus notifying apparatus 2000 first determines if the current measurement value is greater than or equal to the threshold value (step S2101). If the current measurement value is less than the threshold value (step S2101: NO), the estrus notifying apparatus 2000 terminates a series of operations of this flowchart.

**[0174]** If the current measurement value is greater than or equal to the threshold value (step S2101: YES), the estrus notifying apparatus 2000 acquires from the step

count information DB 202, the measurement results of the other livestock animals A in the same herd (see FIG. 7) to calculate a degree of increase of the other livestock animals A in the same herd (step S2102). The degree of increase is a value indicative of an increase in the step counts of the livestock animals A in the entire herd during an urgent situation and is particularly a value indicative of a level of increase in the step counts of the other livestock animals A from the previous time slot to the current time slot. The estrus notifying apparatus 2000 determines whether the calculated degree of increase is less than the predetermined value β (step S2103).

**[0175]** If the degree of increase is greater than or equal to the predetermined value β (step S2103: NO), i.e., in the case of an urgent state increasing the step counts of the other livestock animals A, the estrus notifying apparatus 2000 considers that the livestock animal A is not in estrus and terminates a series of operations of this flowchart. If the degree of increase is less than the predetermined value β (step S2103: YES), i.e., if the step counts of the other livestock animals A are not increased, the estrus notifying apparatus 2000 determines that the estrus started in the current time slot (step S2104). The estrus notifying apparatus 2000 transmits the communications device ID and information of the estrus starting time slot to the client device 230 (step S2105) and terminates a series of operations of this flowchart.

**[0176]** As described above, the estrus notifying apparatus 2000 according to the second embodiment can refrain from determining a livestock animal as being in estrus even though the livestock animal is not in estrus when the livestock animal temporarily moves around or when the step count is increased due to appearance of a wild dog, etc. In other words, false detection can be prevented when estrus of the livestock animal A is detected. Therefore, unnecessary work of a worker going to a pasture area due to false detection can be reduced.

**[0177]** In the second embodiment, a livestock animal may be determined as being in estrus if the step count for each time slot is greater than or equal to the threshold value for three consecutive times as is the case with the first embodiment. If consideration is given to whether the livestock animals are in an urgent state, for example, a degree of increase may be used only at the time of third determination as is the case with the first embodiment.

**[0178]** The estrus notifying method described in the present embodiment may be implemented by executing a prepared program on a computer such as a personal computer and a workstation. The estrus notifying program is stored on a computer-readable recording medium such as a hard disk, a flexible disk, a CD-ROM, an MO, and a DVD, read out from the computer-readable medium, and executed by the computer. The estrus notifying program may be distributed through a network such as the Internet.

EXPLANATIONS OF LETTERS OR NUMERALS

**[0179]**

| | |
|---|---|
| 101 | communications device |
| 102 | estrus notifying apparatus |
| 211 | relay device |
| 202 | step count information DB |
| 203 | disease information DB |
| 230 | client apparatus |
| 901 | first storage unit |
| 902 | acquiring unit |
| 903 | change detecting unit |
| 904 | determining unit |
| 905 | identifying unit |
| 906 | output unit |
| 907 | second storage unit |
| 2000 | estrus notifying apparatus |
| 2001 | first storage unit |
| 2002 | acquiring unit |
| 2003 | change detecting unit |
| 2004 | determining unit |
| 2005 | identifying unit |
| 2006 | output unit |

## Claims

1. An estrus notifying method executed by a computer that determines estrus based on a step count measurement result from a step count measurement unit attached to each livestock animal among a plurality of livestock animals, the estrus notifying method comprising:

   collecting the step count measurement result of each livestock animal at certain intervals;
   detecting a change time slot in which a change rate of the step count measurement result relative to an immediately preceding time slot is greater than or equal to a predetermined value among a predetermined proportion or more of the plurality of livestock animals;
   determining for each livestock animal and based on the step count measurement results excluding the step count measurement result corresponding to the change time slot, whether the livestock animal is in estrus; and
   outputting identification information of the livestock animal determined as being in the estrus.

2. The estrus notifying method according to claim 1, further comprising
   identifying an estrus start time of the livestock animal determined as being in estrus, the estrus start time being identified on an assumption that an indication of estrus continued through the change time slot and if the livestock animal is determined as being in es-

trus, wherein
the outputting includes outputting identification information of the livestock animal determined as being in the estrus and the identified estrus start time.

**3.** The estrus notifying method according to claim 1, wherein
the detecting includes referring to a storage unit storing information of a herd of the plurality of livestock animals, to detect a change time slot in which a change rate of the step count measurement result relative to an immediately preceding time slot is greater than or equal to a predetermined value in a predetermined proportion or more of the plurality of livestock animals belonging to the same herd.

**4.** An estrus notifying apparatus that determines estrus based on a step count measurement result from a step count measurement unit attached to each livestock animal among a plurality of livestock animals, the estrus notifying apparatus comprising:

an acquiring unit that collects the step count measurement result of each livestock animal at certain intervals;
a change detecting unit that detects a change time slot in which a change rate of the step count measurement result relative to an immediately preceding time slot is greater than or equal to a predetermined value among a predetermined proportion or more of the plurality of livestock animals;
a determining unit that determines for each livestock animal and based on the step count measurement results excluding the step count measurement result corresponding to the change time slot, whether the livestock animal is in estrus; and
an output unit that outputs identification information of the livestock animal determined as being in the estrus.

**5.** The estrus notifying apparatus according to claim 4, further comprising
an identifying unit that identifies an estrus start time of the livestock animal determined as being in estrus, the estrus start time being identified on an assumption that an indication of estrus continued through the change time slot and if the livestock animal is determined as being in estrus, wherein
the output unit outputs identification information of the livestock animal determined as being in the estrus and the identified estrus start time.

**6.** The estrus notifying apparatus according to claim 4, wherein
the change detecting unit refers to a storage unit storing information of a herd of the plurality of livestock animals, to detect a change time slot in which a change rate of the step count measurement result relative to an immediately preceding time slot is greater than or equal to a predetermined value in a predetermined proportion or more of the plurality of livestock animals belonging to the same herd.

**7.** An estrus notifying program executed by a computer that determines estrus based on a step count measurement result from a step count measurement unit attached to each livestock animal among a plurality of livestock animals, the estrus notifying program causing the computer to execute a process comprising:

collecting the step count measurement result of each livestock animal at certain intervals;
detecting a change time slot in which a change rate of the step count measurement result relative to an immediately preceding time slot is greater than or equal to a predetermined value among a predetermined proportion or more of the plurality of livestock animals;
determining for each livestock animal and based on the step count measurement results excluding the step count measurement result corresponding to the change time slot, whether the livestock animal is in estrus; and
outputting identification information of the livestock animal determined as being in the estrus.

FIG.1

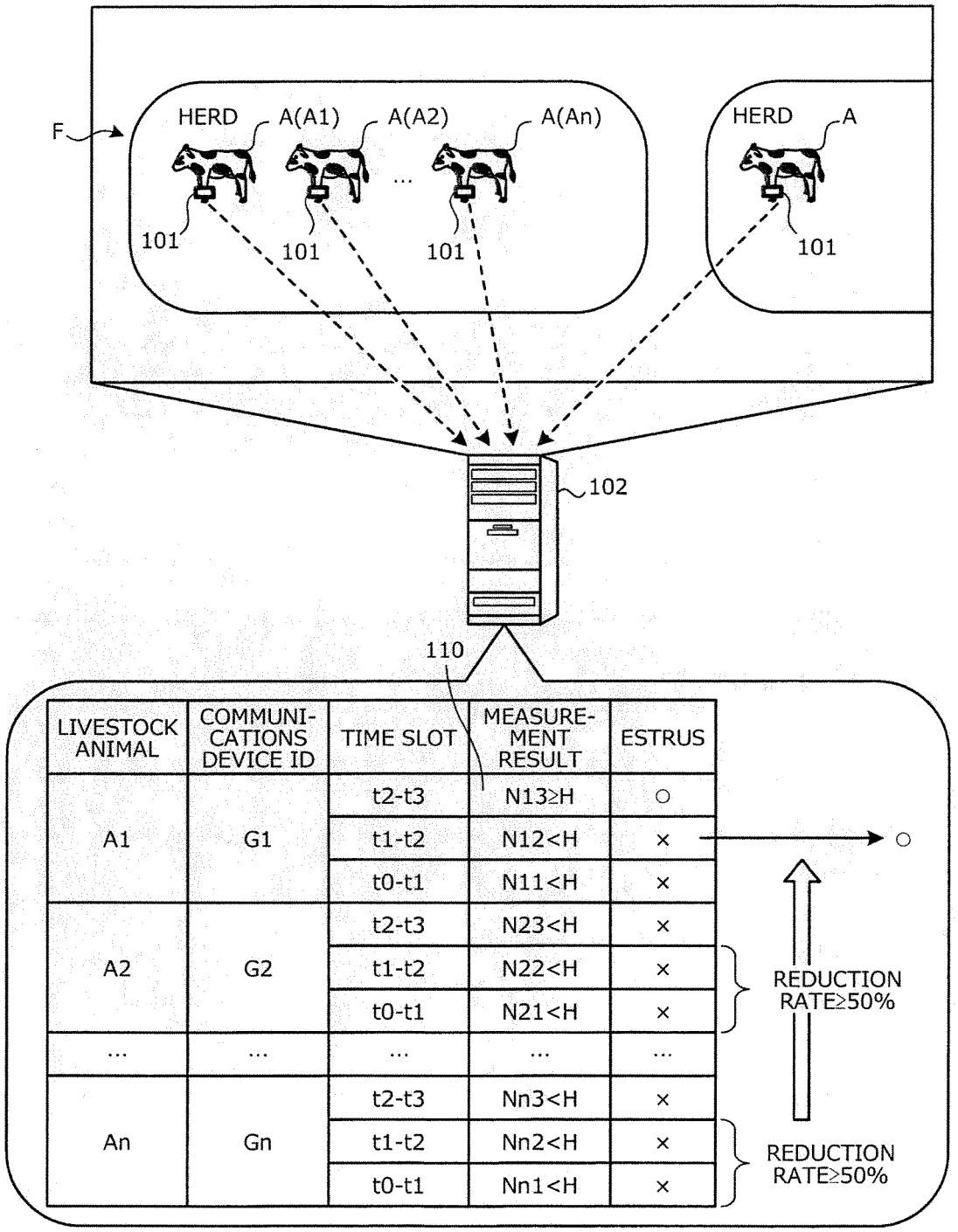

F
HERD
A(A1)
A(A2)
A(An)
HERD
A
101
101
101
101
102
110
LIVESTOCK ANIMAL
COMMUNI-CATIONS DEVICE ID
TIME SLOT
MEASURE-MENT RESULT
ESTRUS
A1
G1
t2-t3
N13≥H
○
t1-t2
N12<H
×
t0-t1
N11<H
×
A2
G2
t2-t3
N23<H
×
t1-t2
N22<H
×
t0-t1
N21<H
×
...
...
...
...
...
An
Gn
t2-t3
Nn3<H
×
t1-t2
Nn2<H
×
t0-t1
Nn1<H
×
○
REDUCTION RATE≥50%
REDUCTION RATE≥50%

FIG.2

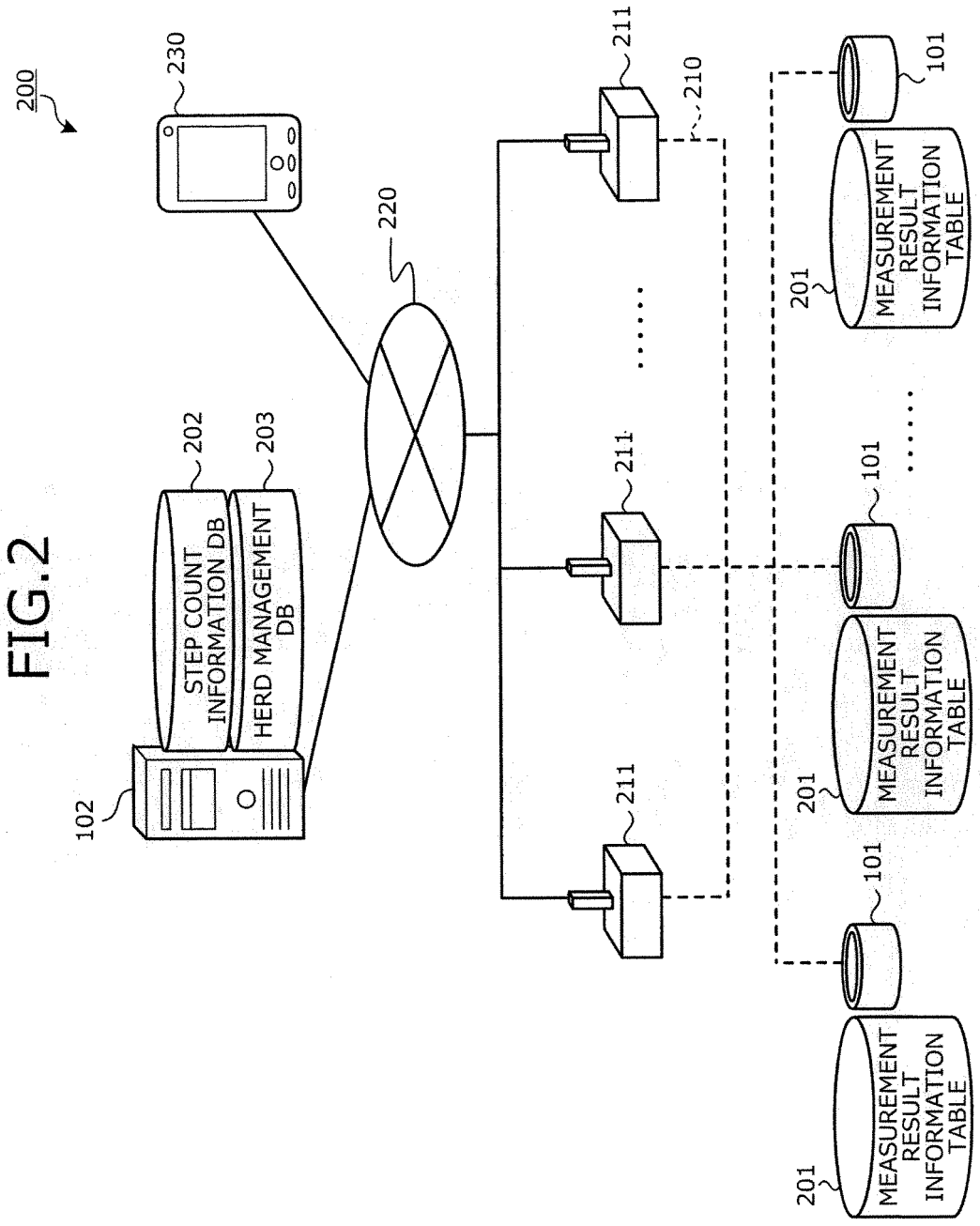

200
230
220
211
210
101
201
MEASUREMENT RESULT INFORMATION TABLE
202
STEP COUNT INFORMATION DB
203
HERD MANAGEMENT DB
102

FIG.3

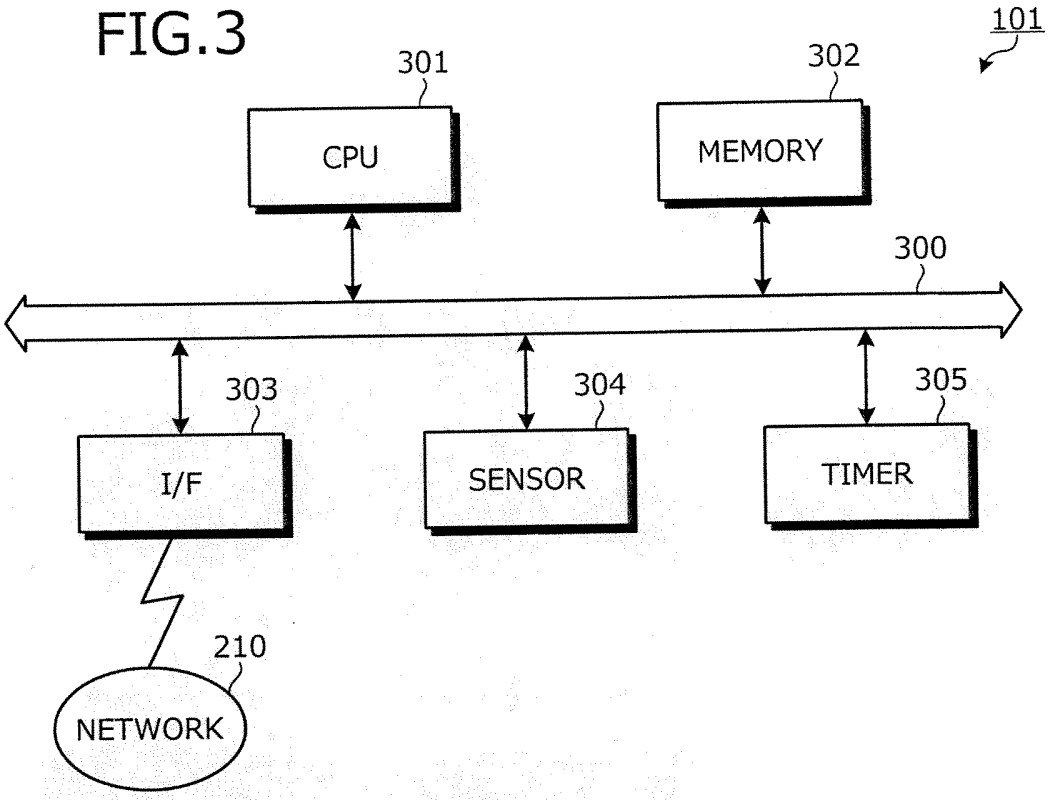

101
301
CPU
302
MEMORY
300
303
I/F
304
SENSOR
305
TIMER
210
NETWORK

FIG.4

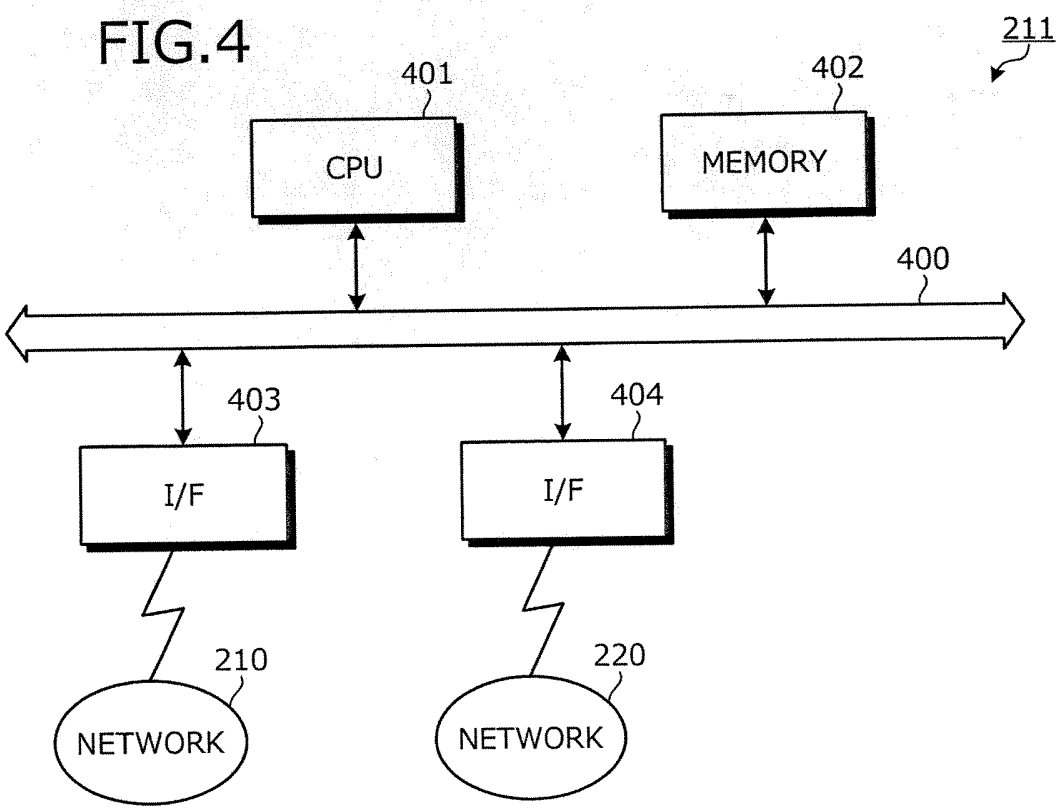

211
401
CPU
402
MEMORY
400
403
I/F
404
I/F
210
NETWORK
220
NETWORK

FIG.5

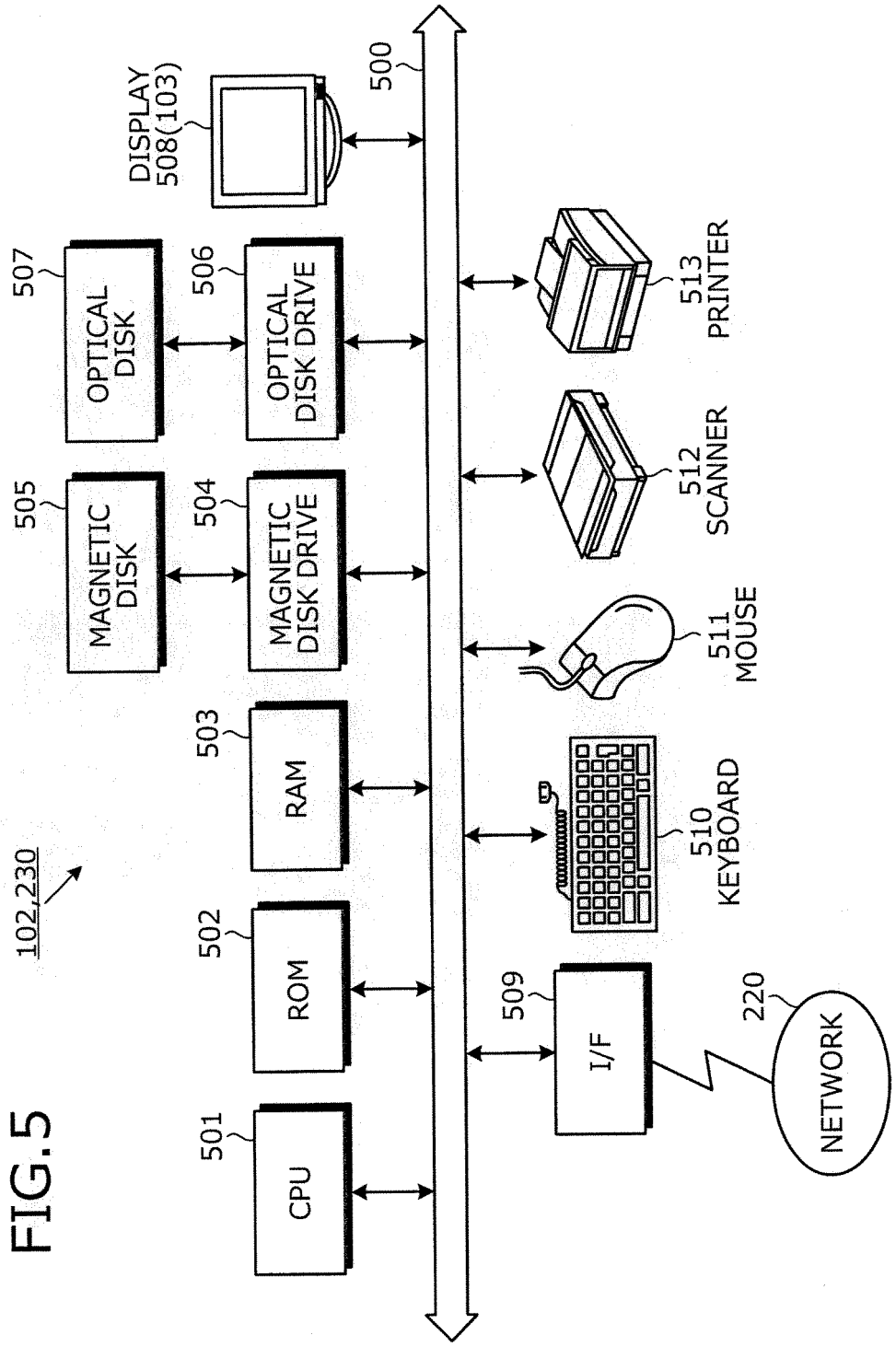

102,230
CPU
501
ROM
502
RAM
503
MAGNETIC DISK DRIVE
504
MAGNETIC DISK
505
OPTICAL DISK DRIVE
506
OPTICAL DISK
507
DISPLAY 508(103)
500
I/F
509
KEYBOARD
510
MOUSE
511
SCANNER
512
PRINTER
513
NETWORK
220

FIG.6

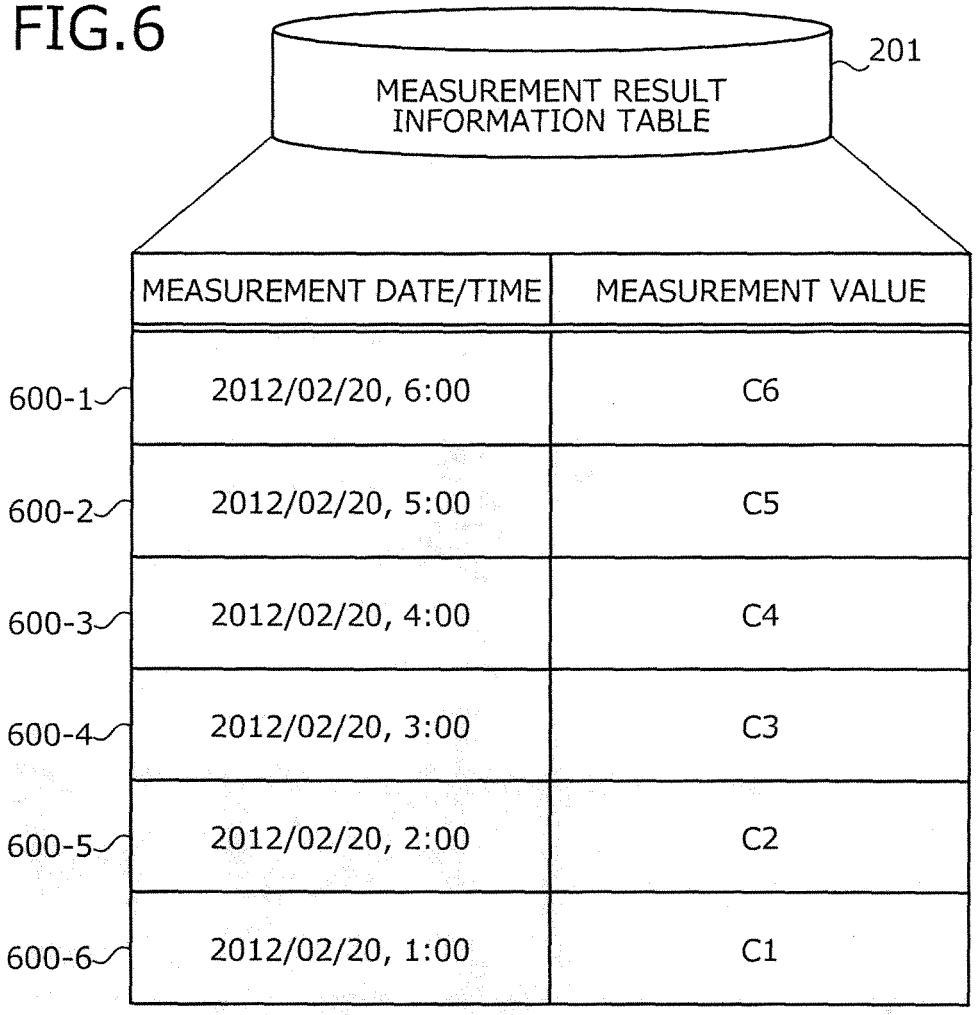

MEASUREMENT RESULT INFORMATION TABLE
201
MEASUREMENT DATE/TIME
MEASUREMENT VALUE
600-1
2012/02/20, 6:00
C6
600-2
2012/02/20, 5:00
C5
600-3
2012/02/20, 4:00
C4
600-4
2012/02/20, 3:00
C3
600-5
2012/02/20, 2:00
C2
600-6
2012/02/20, 1:00
C1

FIG. 7

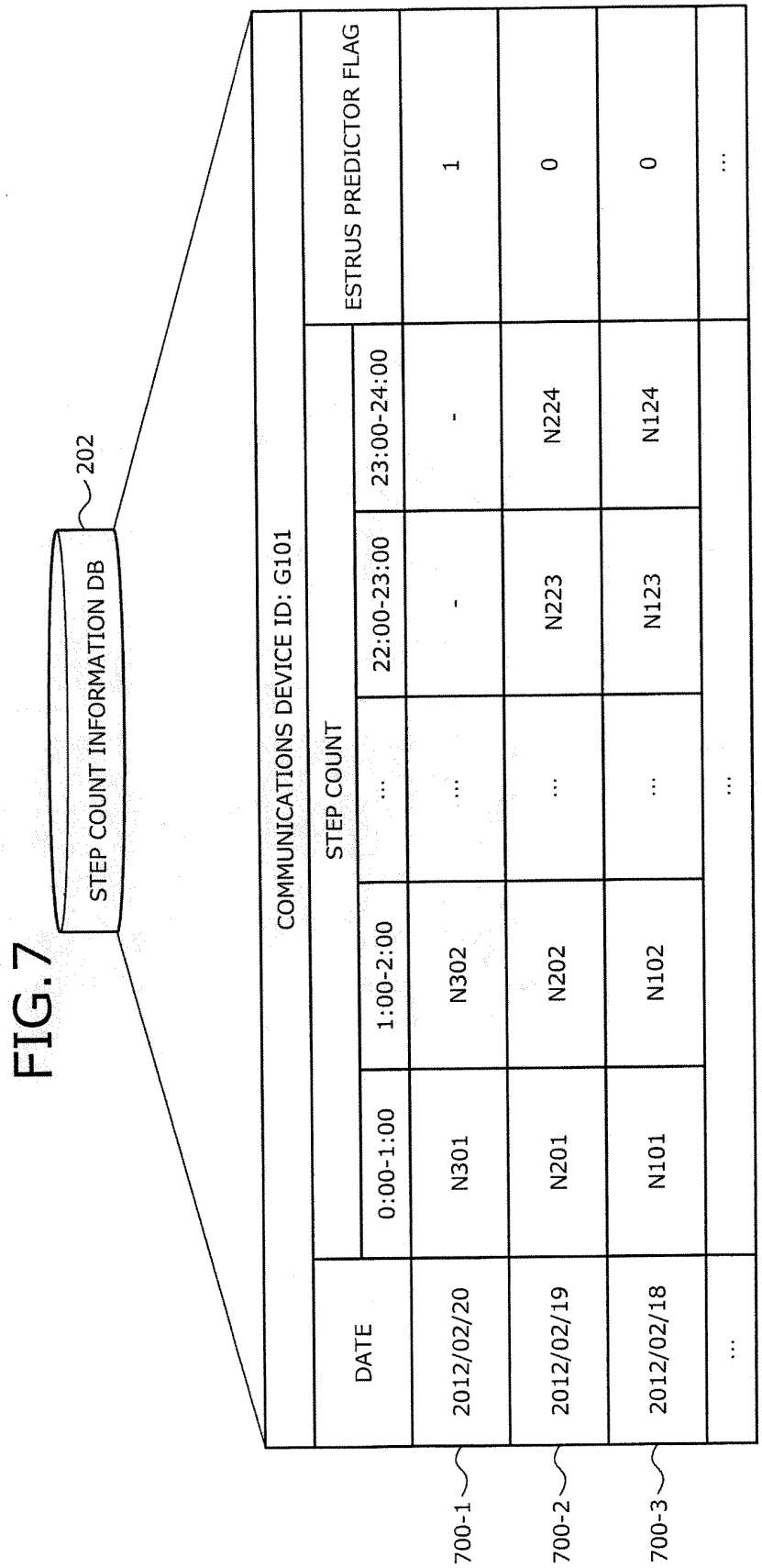

202
STEP COUNT INFORMATION DB
COMMUNICATIONS DEVICE ID: G101
DATE
STEP COUNT
0:00-1:00
1:00-2:00
...
22:00-23:00
23:00-24:00
ESTRUS PREDICTOR FLAG
2012/02/20
N301
N302
...
-
-
1
2012/02/19
N201
N202
...
N223
N224
0
2012/02/18
N101
N102
...
N123
N124
0
...
...
...
700-1
700-2
700-3

FIG.8

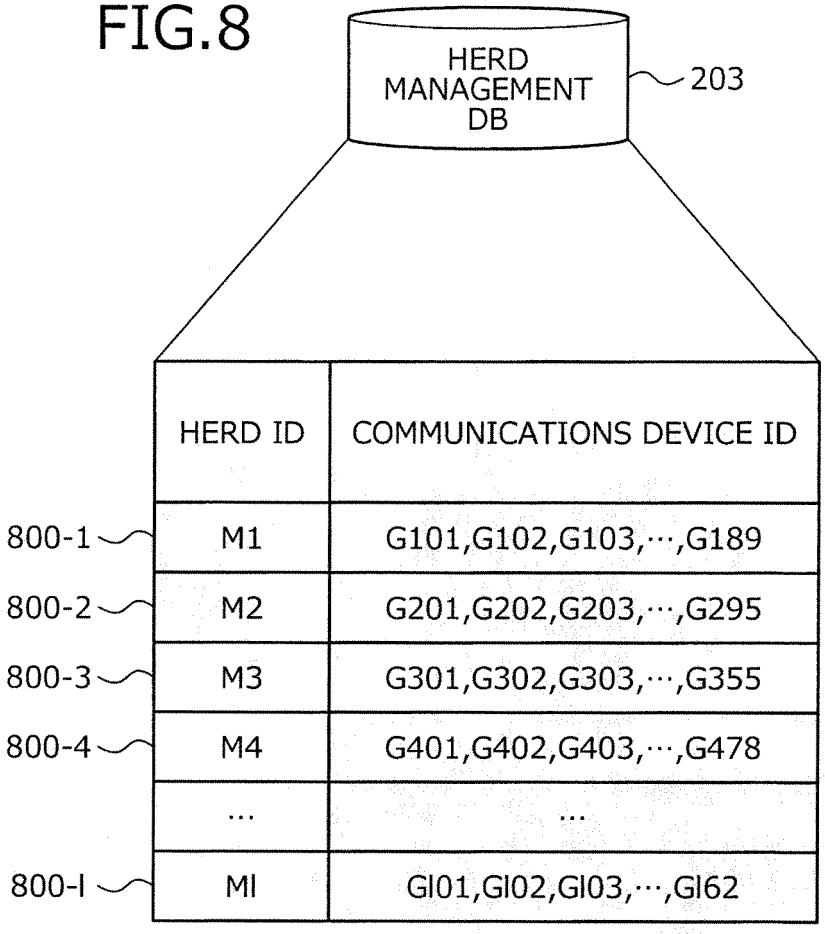

HERD MANAGEMENT DB
203
HERD ID
COMMUNICATIONS DEVICE ID
800-1
M1
G101,G102,G103,⋯,G189
800-2
M2
G201,G202,G203,⋯,G295
800-3
M3
G301,G302,G303,⋯,G355
800-4
M4
G401,G402,G403,⋯,G478
⋯
⋯
800-I
MI
GI01,GI02,GI03,⋯,GI62

FIG.9

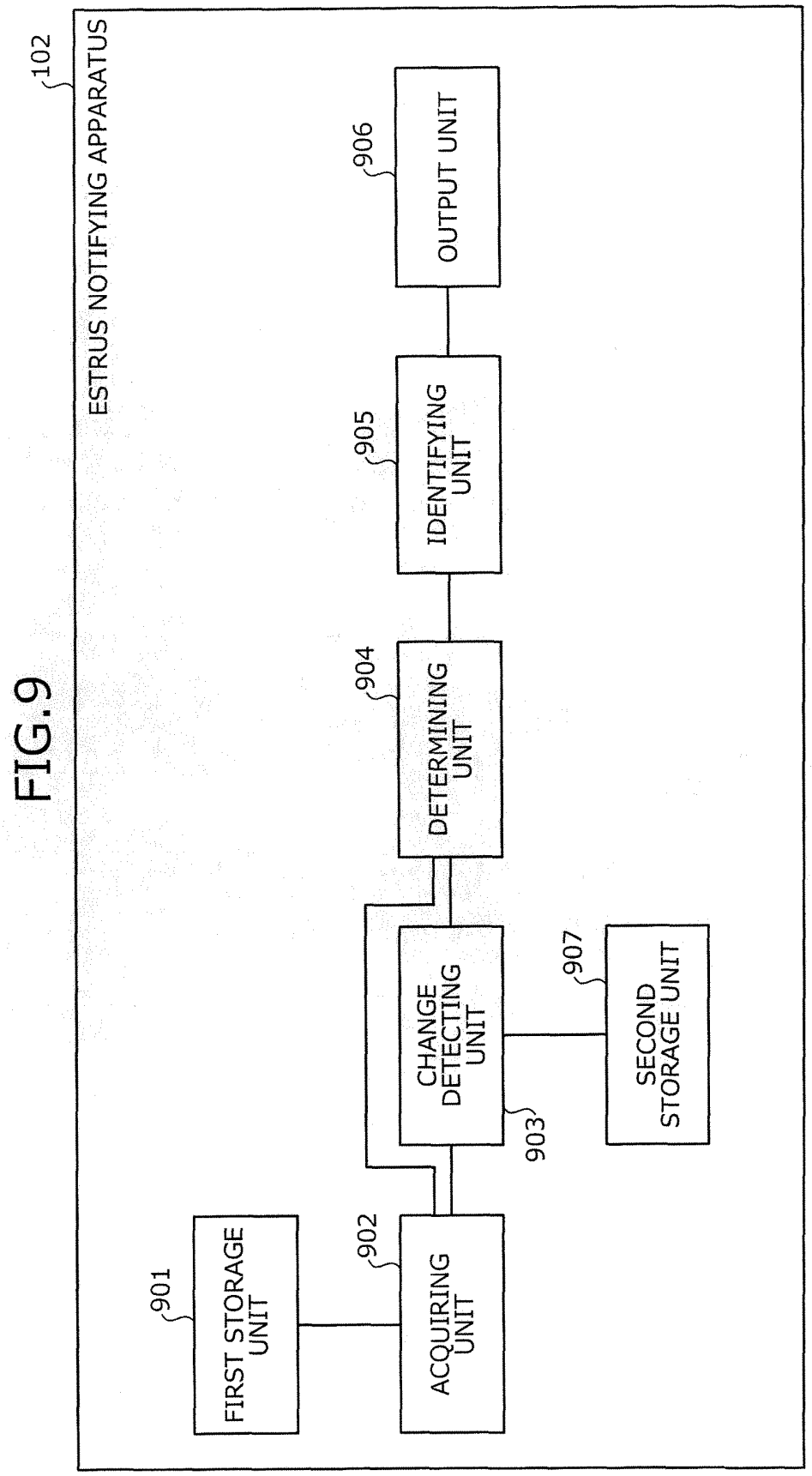

102
ESTRUS NOTIFYING APPARATUS
901
FIRST STORAGE UNIT
902
ACQUIRING UNIT
903
CHANGE DETECTING UNIT
904
DETERMINING UNIT
905
IDENTIFYING UNIT
906
OUTPUT UNIT
907
SECOND STORAGE UNIT

FIG.10

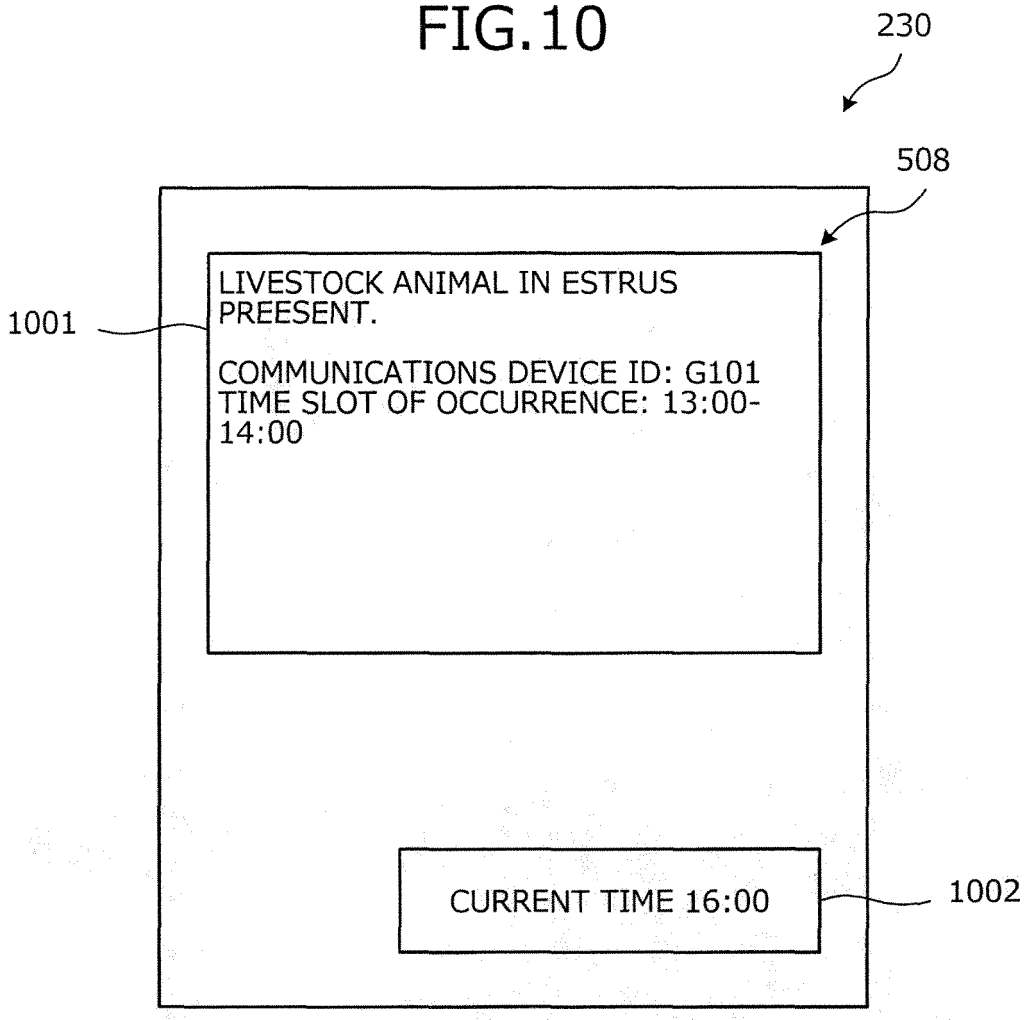

230
508
1001
LIVESTOCK ANIMAL IN ESTRUS PREESENT.
COMMUNICATIONS DEVICE ID: G101
TIME SLOT OF OCCURRENCE: 13:00-14:00
CURRENT TIME 16:00
1002

FIG.11

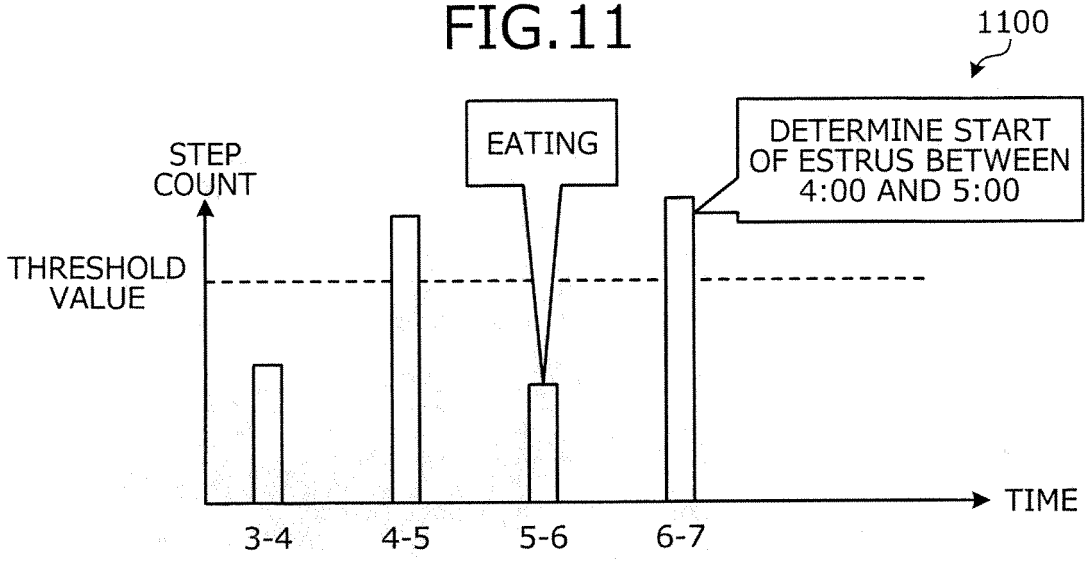

1100
EATING
DETERMINE START OF ESTRUS BETWEEN 4:00 AND 5:00
STEP COUNT
THRESHOLD VALUE
TIME
3-4
4-5
5-6
6-7

FIG.12

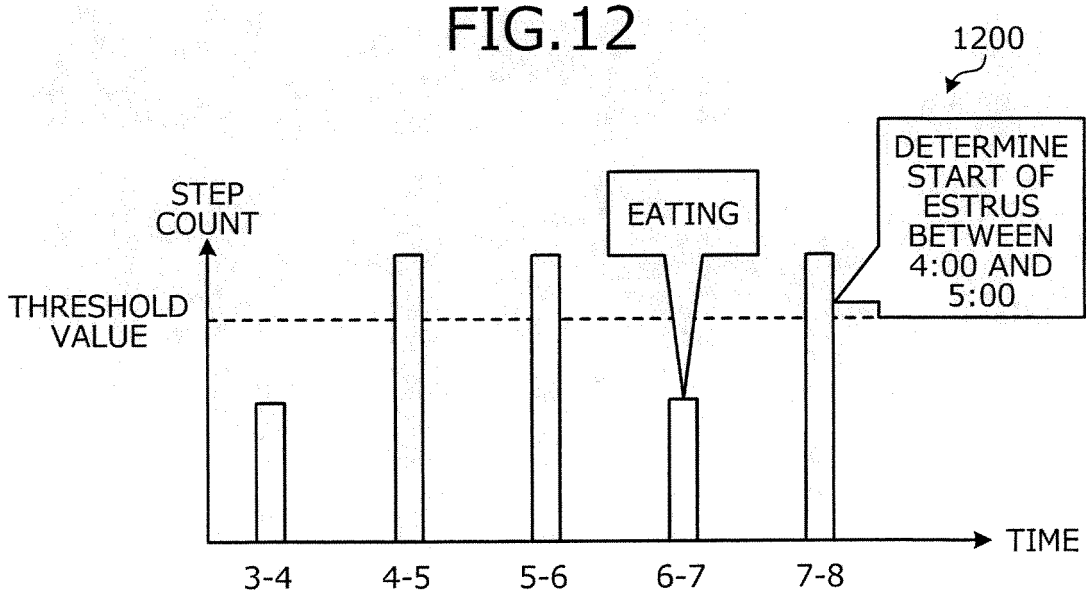

1200
DETERMINE START OF ESTRUS BETWEEN 4:00 AND 5:00
EATING
STEP COUNT
THRESHOLD VALUE
TIME
3-4
4-5
5-6
6-7
7-8

FIG.13

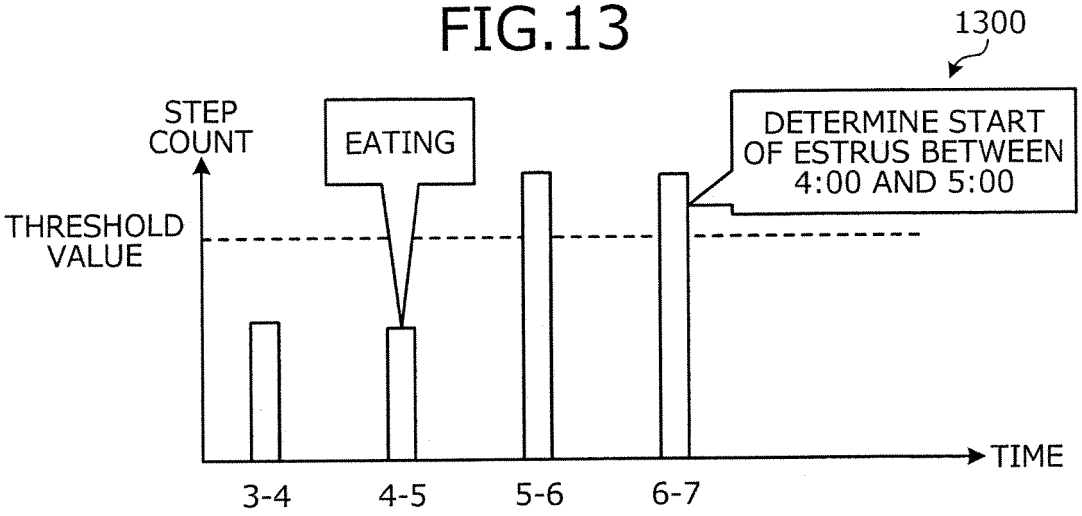

1300
STEP COUNT
EATING
DETERMINE START OF ESTRUS BETWEEN 4:00 AND 5:00
THRESHOLD VALUE
TIME
3-4
4-5
5-6
6-7

FIG.14

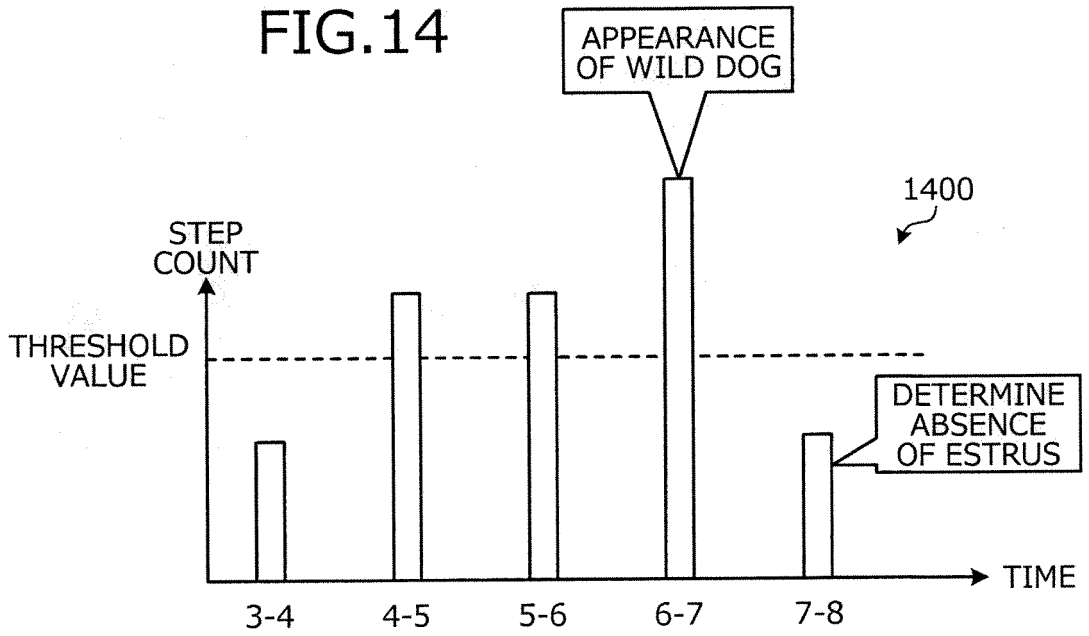

APPEARANCE OF WILD DOG
1400
STEP COUNT
THRESHOLD VALUE
DETERMINE ABSENCE OF ESTRUS
TIME
3-4
4-5
5-6
6-7
7-8

FIG.15

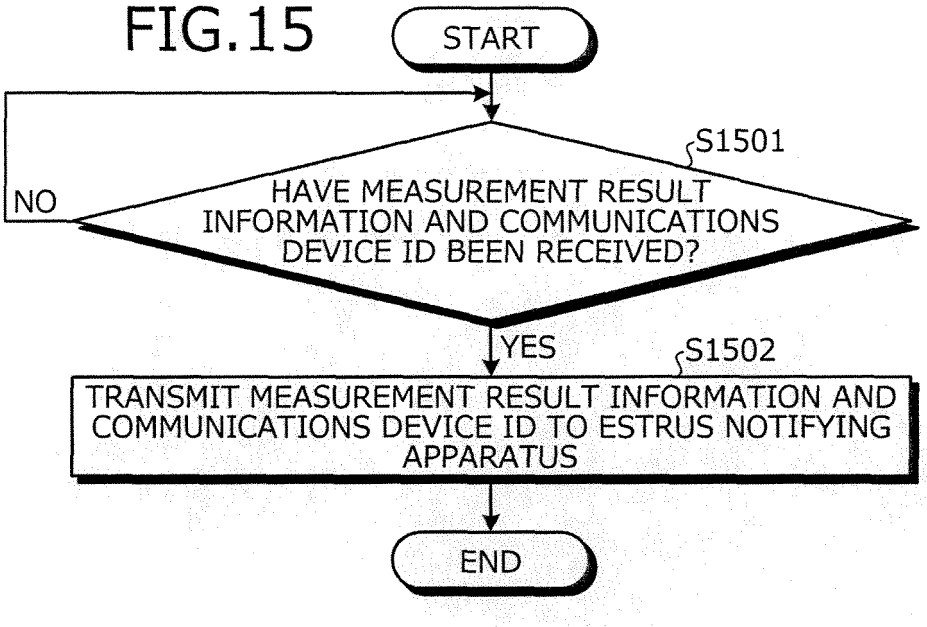

START
S1501
HAVE MEASUREMENT RESULT INFORMATION AND COMMUNICATIONS DEVICE ID BEEN RECEIVED?
NO
YES
S1502
TRANSMIT MEASUREMENT RESULT INFORMATION AND COMMUNICATIONS DEVICE ID TO ESTRUS NOTIFYING APPARATUS
END

FIG.16

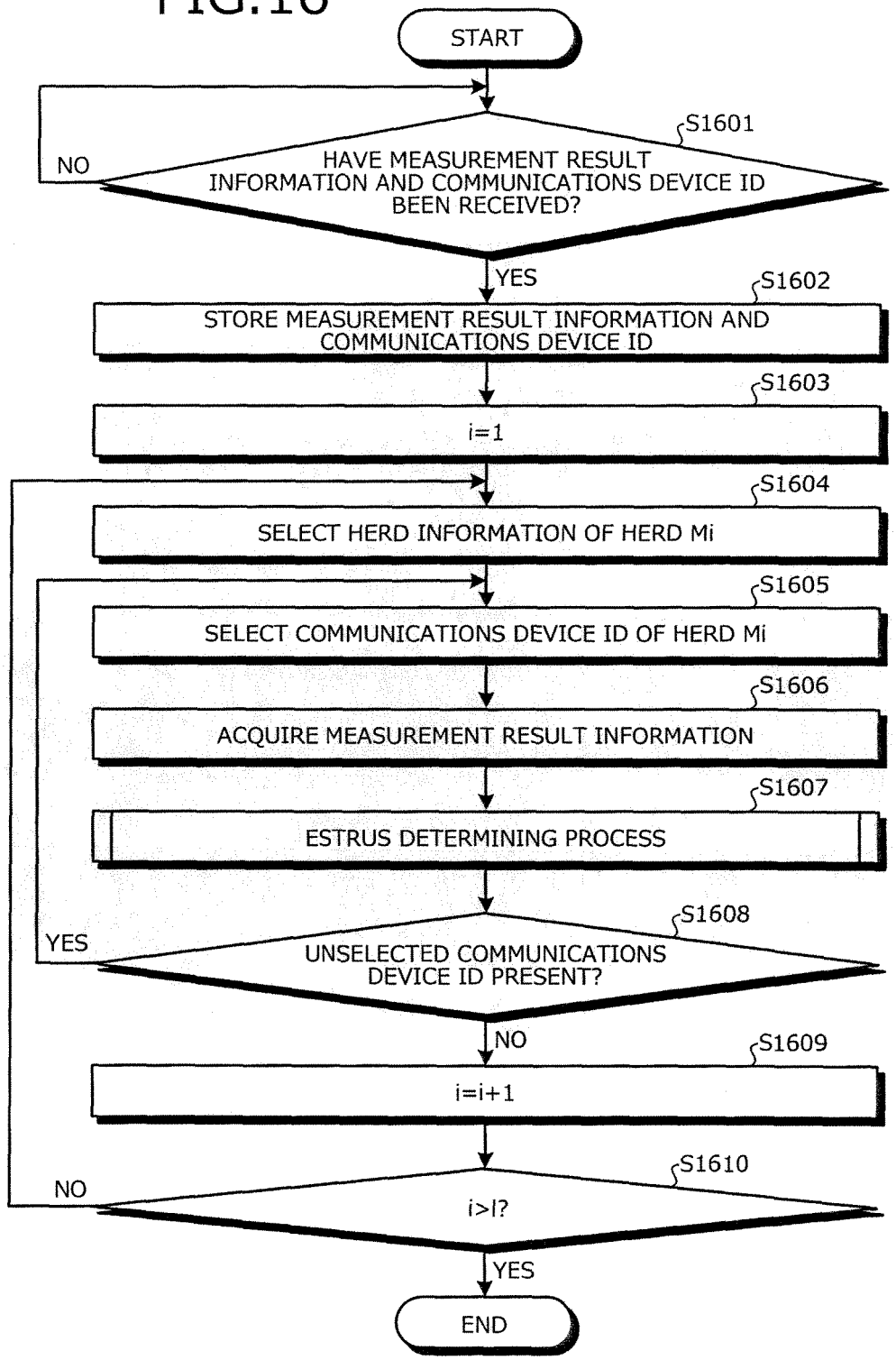

START
S1601
HAVE MEASUREMENT RESULT INFORMATION AND COMMUNICATIONS DEVICE ID BEEN RECEIVED?
NO
YES
S1602
STORE MEASUREMENT RESULT INFORMATION AND COMMUNICATIONS DEVICE ID
S1603
i=1
S1604
SELECT HERD INFORMATION OF HERD Mi
S1605
SELECT COMMUNICATIONS DEVICE ID OF HERD Mi
S1606
ACQUIRE MEASUREMENT RESULT INFORMATION
S1607
ESTRUS DETERMINING PROCESS
S1608
UNSELECTED COMMUNICATIONS DEVICE ID PRESENT?
YES
NO
S1609
i=i+1
S1610
i>I?
NO
YES
END

FIG.17

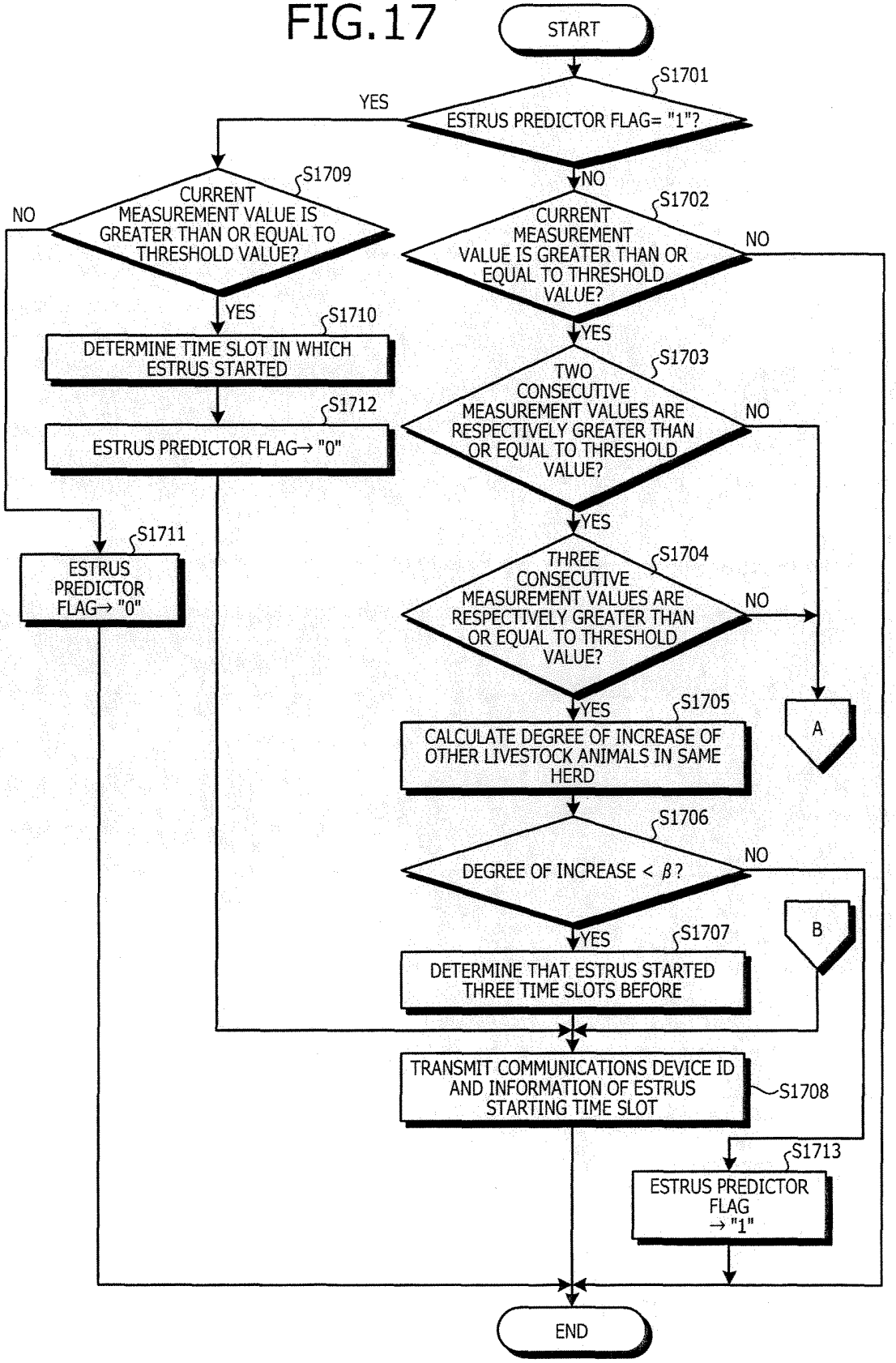

START
S1701
ESTRUS PREDICTOR FLAG= "1"?
YES
NO
S1709
CURRENT MEASUREMENT VALUE IS GREATER THAN OR EQUAL TO THRESHOLD VALUE?
NO
YES
S1710
DETERMINE TIME SLOT IN WHICH ESTRUS STARTED
S1712
ESTRUS PREDICTOR FLAG→ "0"
S1711
ESTRUS PREDICTOR FLAG→ "0"
S1702
CURRENT MEASUREMENT VALUE IS GREATER THAN OR EQUAL TO THRESHOLD VALUE?
NO
YES
S1703
TWO CONSECUTIVE MEASUREMENT VALUES ARE RESPECTIVELY GREATER THAN OR EQUAL TO THRESHOLD VALUE?
NO
YES
S1704
THREE CONSECUTIVE MEASUREMENT VALUES ARE RESPECTIVELY GREATER THAN OR EQUAL TO THRESHOLD VALUE?
NO
YES
S1705
CALCULATE DEGREE OF INCREASE OF OTHER LIVESTOCK ANIMALS IN SAME HERD
A
S1706
DEGREE OF INCREASE < β?
NO
YES
S1707
DETERMINE THAT ESTRUS STARTED THREE TIME SLOTS BEFORE
B
TRANSMIT COMMUNICATIONS DEVICE ID AND INFORMATION OF ESTRUS STARTING TIME SLOT
S1708
S1713
ESTRUS PREDICTOR FLAG → "1"
END

FIG.18

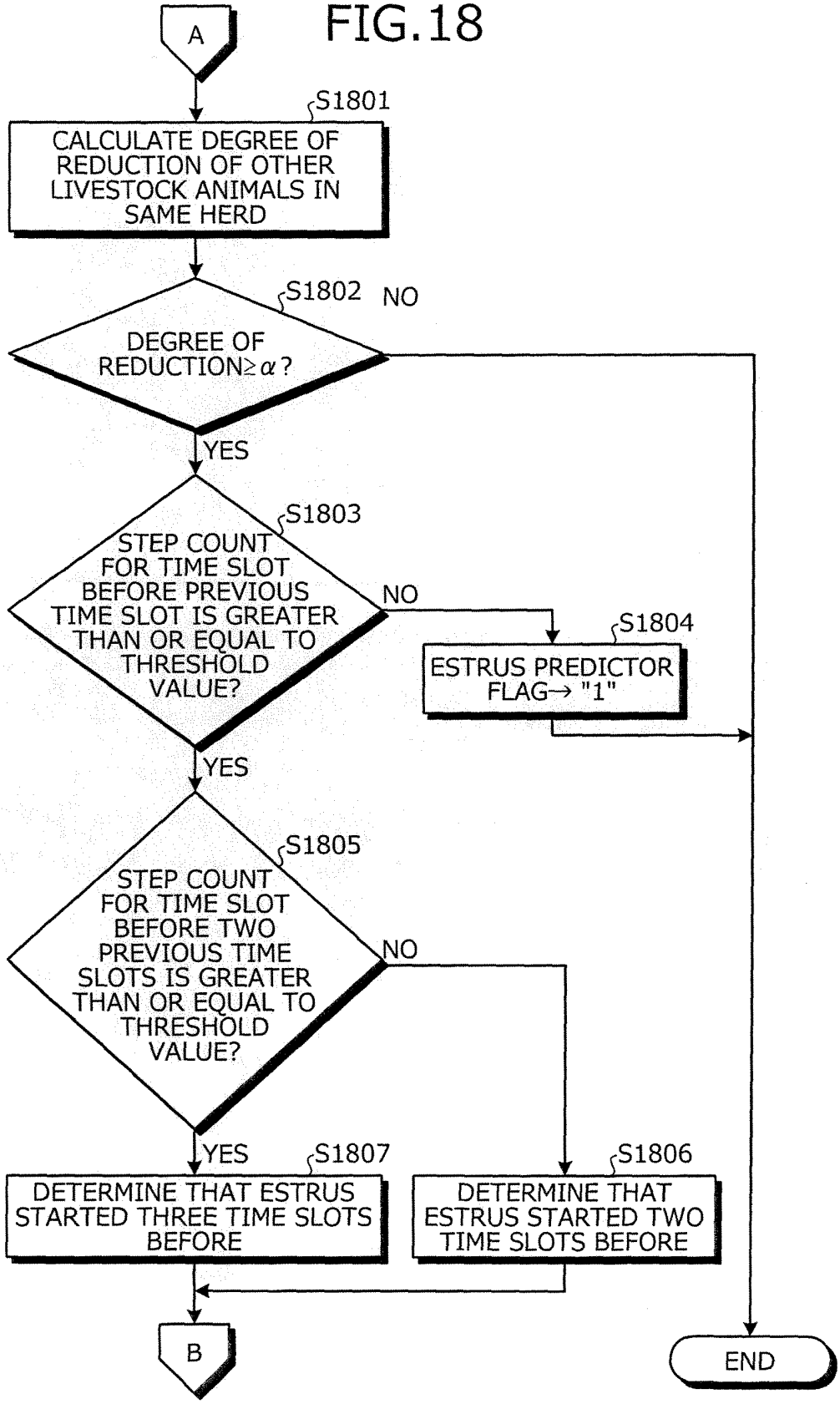

A
S1801
CALCULATE DEGREE OF REDUCTION OF OTHER LIVESTOCK ANIMALS IN SAME HERD
S1802
NO
DEGREE OF REDUCTION≥α?
YES
S1803
STEP COUNT FOR TIME SLOT BEFORE PREVIOUS TIME SLOT IS GREATER THAN OR EQUAL TO THRESHOLD VALUE?
NO
S1804
ESTRUS PREDICTOR FLAG→ "1"
YES
S1805
STEP COUNT FOR TIME SLOT BEFORE TWO PREVIOUS TIME SLOTS IS GREATER THAN OR EQUAL TO THRESHOLD VALUE?
NO
YES
S1807
DETERMINE THAT ESTRUS STARTED THREE TIME SLOTS BEFORE
S1806
DETERMINE THAT ESTRUS STARTED TWO TIME SLOTS BEFORE
B
END

FIG.19

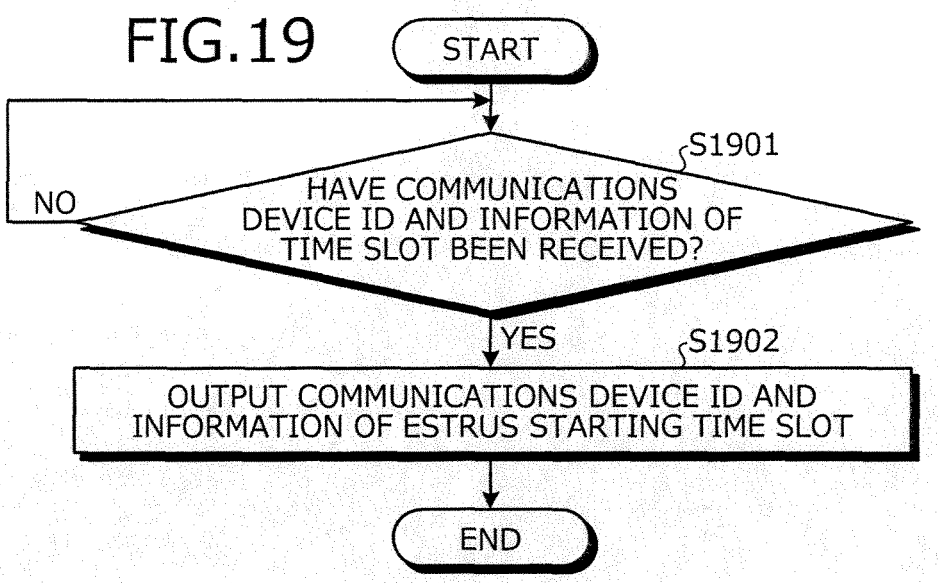

START
S1901
HAVE COMMUNICATIONS DEVICE ID AND INFORMATION OF TIME SLOT BEEN RECEIVED?
NO
YES
S1902
OUTPUT COMMUNICATIONS DEVICE ID AND INFORMATION OF ESTRUS STARTING TIME SLOT
END

FIG.20

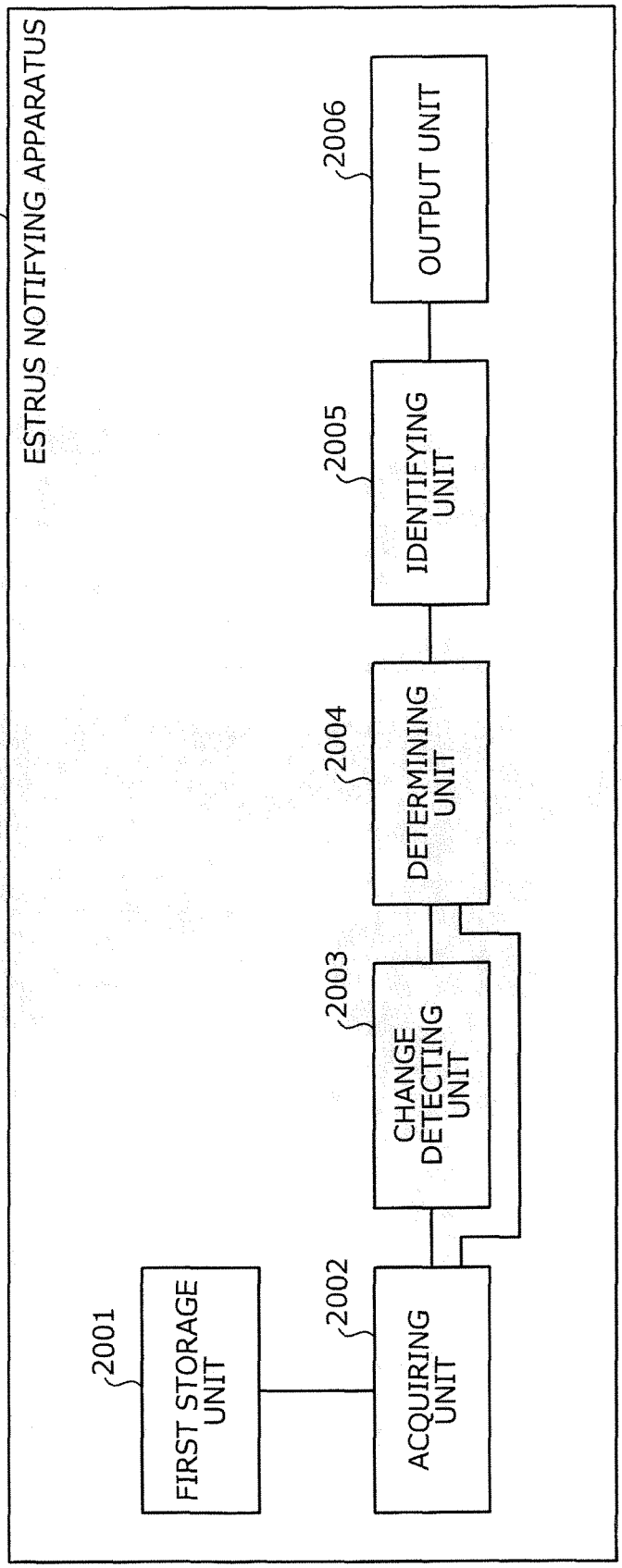
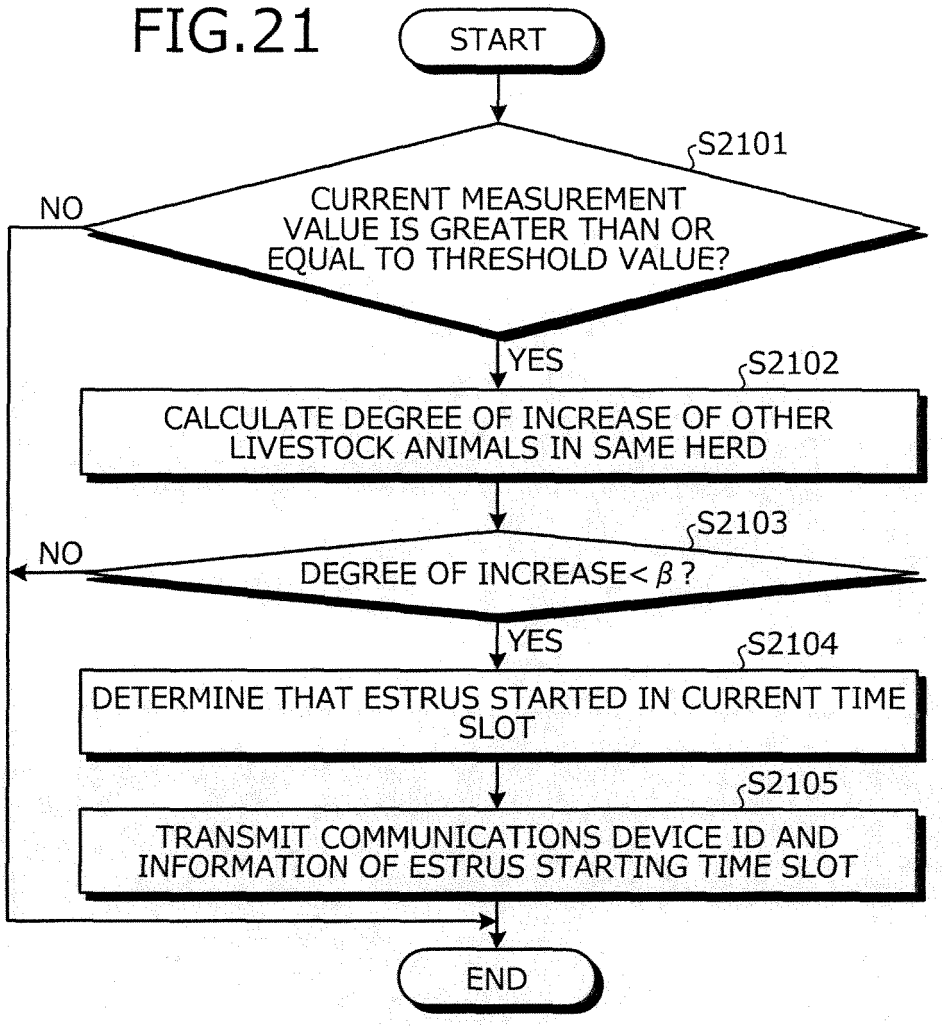

2000
ESTRUS NOTIFYING APPARATUS
2001
FIRST STORAGE UNIT
2002
ACQUIRING UNIT
2003
CHANGE DETECTING UNIT
2004
DETERMINING UNIT
2005
IDENTIFYING UNIT
2006
OUTPUT UNIT

FIG.21


START
S2101
CURRENT MEASUREMENT VALUE IS GREATER THAN OR EQUAL TO THRESHOLD VALUE?
NO
YES
S2102
CALCULATE DEGREE OF INCREASE OF OTHER LIVESTOCK ANIMALS IN SAME HERD
S2103
DEGREE OF INCREASE< β ?
NO
YES
S2104
DETERMINE THAT ESTRUS STARTED IN CURRENT TIME SLOT
S2105
TRANSMIT COMMUNICATIONS DEVICE ID AND INFORMATION OF ESTRUS STARTING TIME SLOT
END

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2012/058720

A. CLASSIFICATION OF SUBJECT MATTER
*A01K29/00*(2006.01)i, *A01K67/00*(2006.01)i, *A61D1/08*(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)
A01K29/00, A01K67/00, A61D1/08, G06Q50/02

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 1996-2012
Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
JSTPlus/JST7580(JDreamII)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | JP 11-128210 A (Matsushita Electric Works, Ltd.), 18 May 1999 (18.05.1999), entire text; all drawings (Family: none) | 1-7 |
| A | JP 2008-148569 A (Oki Electric Industry Co., Ltd.), 03 July 2008 (03.07.2008), entire text; all drawings & US 2008/0147458 A1 | 1-7 |
| A | JP 2008-92878 A (Comtec Co., Ltd.), 24 April 2008 (24.04.2008), entire text; all drawings (Family: none) | 1-7 |

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

* Special categories of cited documents:
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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
"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
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 18 June, 2012 (18.06.12) | 26 June, 2012 (26.06.12) |
| Name and mailing address of the ISA/ Japanese Patent Office<br>Facsimile No. | Authorized officer<br>Telephone No. |

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## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


- JP 2002139775 A **[0003]**
- JP 2007167024 A **[0003]**