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(54) SENSOR, DISASTER PREVENTION SYSTEM, FIRE DETERMINATION METHOD, AND PROGRAM

(57) An object of the present disclosure is to improve the reliability in terms of fire determination. A sensor (1) includes a plurality of heat detecting elements (30) and a decision unit (91). The decision unit (91) determines, by collating a plurality of heat detection values obtained by the plurality of heat detecting elements (30) with a predetermined decision condition, whether or not a fire is present.

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Description

Technical Field

[0001] The present disclosure generally relates to a sensor, a disaster prevention system, a fire determination method, and a program, and more particularly relates to a sensor for sensing heat generated by a fire, for example, a disaster prevention system including the sensor, a fire determination method, and a program.

Background Art

[0002] JP 2002-352344 A discloses a fire sensor including, as a sensing means, a single bar-shaped thermistor with a thermistor chip serving as a heat sensing unit at its tip. The thermistor is mounted on the lower surface of a circuit board such that the thermistor faces downward when the fire sensor is installed. The fire sensor has openings provided through a bottom plate and peripheral walls of a protector, covers the outer periphery of the thermistor, and is configured to be ventilated from a detection space thereof toward the thermistor.

Summary of Invention

[0003] The fire sensor of JP 2002-352344 A has only one heat detecting spot, and therefore, there may be a variation in the reliability in terms of a fire determination according to the locational relationship between the fire source location and the location where the fire sensor is arranged.

[0004] It is therefore an object of the present disclosure to provide a sensor, a disaster prevention system, a fire determination method, and a program, all of which are configured or designed to improve the reliability in terms of the fire determination.

[0005] A sensor according to an aspect of the present disclosure includes a plurality of heat detecting elements and a decision unit. The decision unit determines, by collating a plurality of heat detection values obtained by the plurality of heat detecting elements with a predetermined decision condition, whether or not a fire is present.

[0006] A disaster prevention system according to another aspect of the present disclosure includes the one or more sensors and a reception terminal. The reception terminal communicates with the one or more sensors to receive notification about presence of a fire detected.

[0007] A fire determination method according to still another aspect of the present disclosure includes: acquiring a plurality of heat detection values obtained by a plurality of heat detecting elements of a sensor; and determining, by collating the plurality of heat detection values obtained with a predetermined decision condition, whether or not a fire is present.

[0008] A program according to still another aspect of the present disclosure is designed to cause one or more processors to perform the fire determination method described above.

Brief Description of Drawings

[0009]

FIG. 1A is a perspective view illustrating the appearance of a sensor included in a disaster prevention system according to an exemplary embodiment;
FIG. 1B is a plan view of the sensor as viewed from over the sensor with its back cover removed;
FIG. 2 is a cross-sectional view of the sensor;
FIG. 3A illustrates a block configuration for the sensor;
FIG. 3B illustrates a block configuration for a receiver included in the disaster prevention system;
FIG. 4 is a conceptual diagram illustrating an overall configuration for the disaster prevention system;
FIG. 5 is a flowchart showing how the sensor may operate when performing fire determination processing and estimation processing;
FIG. 6 is a conceptual diagram illustrating how the disaster prevention system performs localization processing; and
FIG. 7 is a flowchart showing how the disaster prevention system may operate when performing the localization processing.

Description of Embodiments

(1) Overview

[0010] The drawings to be referred to in the following description of embodiments are all schematic representations. That is to say, the ratio of the dimensions (including thicknesses) of respective constituent elements illustrated on the drawings does not always reflect their actual dimensional ratio.

[0011] A disaster prevention system 100 according to an exemplary embodiment (see FIG. 4) includes one or more sensors 1 (e.g., six in the example illustrated in FIG. 4) and a reception terminal to communicate with the one or more sensors 1 to receive notification about the presence of a fire detected. In this embodiment, the disaster prevention system 100 is supposed to be implemented as an automatic fire alarm system to be introduced into a facility 500 (see FIG. 6) such as an office building. Therefore, the "reception terminal" is supposed to be a receiver Y1 (see FIGS. 3B and 4) of the automatic fire alarm system.

[0012] The facility 500 does not have to be an office building. Alternatively, the facility 500 may also be any facility selected from, for example, theaters, movie theaters, public halls, amusement facilities, complex facilities, restaurants, department stores, schools, hotels, inns, hospitals, nursing homes for the elderly, kindergartens, libraries, museums, art museums, underground shopping malls, railway stations, airports, multi-family dwelling houses (condominiums; what are called "mansions" in Japan), and single-family dwelling houses.

[0013] The reception terminal does not have to be the receiver Y1 of the automatic fire alarm system. If the facility 500 is a single-family dwelling house, for example, the reception terminal may also be an intercom indoor unit or a home energy management system (HEMS) controller, for example. Alternatively, the reception terminal may also be a telecommunications device such as a smartphone, a tablet computer, or a personal computer. Still alternatively, the reception terminal may also be a server installed outside of the facility 500.

[0014] A sensor 1 according to an exemplary embodiment may be implemented as, for example, a fire sensor, which includes a heat detection unit 3 (see FIGS. 1B and 3A) for detecting heat generated by a fire, for example. In other words, the sensor 1 has at least the capability of detecting heat. The sensor 1 may also be a so-called "combination fire sensor" in which the sensor 1 further includes a smoke detection unit for detecting smoke. Optionally, the sensor 1 may further include a detection unit for detecting, for example, the presence of a flame, gas leakage, or carbon monoxide (CO) produced by imperfect combustion.

[0015] As shown in FIG. 1A, the sensor 1 is installed on an installation surface X11 of a structural component X1 (e.g., a ceiling in the example illustrated in FIG. 1A), which is a building component such as the ceiling (or a wall) of the facility 500, for example.

[0016] The sensor 1 according to this embodiment includes a plurality of heat detecting elements 30 and a decision unit 91 as shown in FIG. 3A. In this embodiment, the sensor 1 includes eight heat detecting elements 30, for example. The eight heat detecting elements 30 are mounted on a board 2. Each of the heat detecting elements 30 may be implemented as, for example, a chip thermistor for detecting the heat of a gas that has flowed in through openings 7 of a housing 5.

[0017] The decision unit 91 is configured to determine, by collating a plurality of heat detection values obtained by the plurality of heat detecting elements 30 with a predetermined decision condition, whether or not a fire is present. That is to say, the target to be collated with the predetermined decision condition is the detection value obtained by every heat detecting element 30. As used herein, the "predetermined decision condition" includes a condition about determination (or selection) of a "target value" to be compared with a fire determination threshold value from the plurality of detection values. For example, the predetermined decision condition includes calculating the average value (target value) of the plurality of detection values.

[0018] This configuration allows a comprehensive fire determination to be made based on the plurality of detection values obtained by the plurality of heat detecting elements 30. This reduces the chances of the reliability in terms of the fire determination varying according to the locational relationship between the fire source location and the location where the fire sensor is arranged. Consequently, this contributes to improving the reliability in terms of the fire determination.

[0019] Also, a fire determination method according to this embodiment includes an acquisition step and a decision step. The acquisition step includes acquiring a plurality of heat detection values respectively obtained by the plurality of heat detecting elements 30 of the sensor 1. The decision step includes determining, by collating the plurality of detection values thus acquired with a predetermined decision condition, whether or not a fire is present. In this embodiment, a fire determination method including this decision step is used on the sensor 1. This configuration also contributes to improving the reliability in terms of the fire determination. The fire determination method including the decision step may also be implemented as a program. The program according to this embodiment is designed to cause one or more processors to perform the fire determination method including the decision step.

[0020] A disaster prevention system 100 according to this embodiment includes: one or more sensors 1, each including a plurality of heat detecting elements 30; and an estimation unit E1 (see FIG. 3A). The estimation unit E1 estimates, based on results of heat detection provided by the plurality of heat detecting elements 30, a direction D1 of a fire source (see FIG. 6) in a monitoring region R1 (see FIG. 6). In this embodiment, the function of the estimation unit E1 is supposed to be provided for the control unit 9 of the sensor 1 as shown in FIG. 3A.

[0021] According to this configuration, not just determination information about whether or not a fire is present but also a result of estimation about the direction D1 of the fire source may be obtained as well. This facilitates providing more detailed (i.e., a larger amount of) fire information.

[0022] Another fire determination method according to this embodiment includes an acquisition step and an estimation step. The acquisition step includes acquiring results of heat detection provided by a plurality of heat detecting elements 30 of one or more sensors 1. The estimation step includes estimating, based on the results of detection acquired, a direction D1 of a fire source in a monitoring region R1. In this embodiment, a fire determination method including this estimation step may be used on the disaster prevention system 100, for example. This configuration also facilitates providing more detailed fire information. The fire determination method including the estimation step may also be implemented as a program. The program according to this embodiment is designed to cause one or more processors to perform the fire determination method including the estimation step.

(2) Details

(2.1) Overall system configuration

[0023] An overall configuration for the disaster prevention system 100 according to this embodiment will be described in detail.

[0024] The disaster prevention system 100 is supposed to be implemented as an "automatic fire alarm system" as described above. The disaster prevention system 100 is introduced into a facility 500 (see FIG. 6) such as an office building.

[0025] The disaster prevention system 100 includes a single receiver Y1 (reception terminal) and a plurality of (i.e., two or more) sensors 1. The plurality of sensors 1 are connected to the receiver Y1 via feed lines using a pair of (two-wired) signal lines L1. Although not described in detail herein, the disaster prevention system 100 includes a plurality of (e.g., three in the example illustrated in FIG. 4) signal lines L1. Each pair of signal lines L1 is installed on an associated monitoring region R1 (e.g., on each floor) and the plurality of sensors 1 installed on each monitoring region R1 communicates with the receiver Y1 via the signal lines L1.

[0026] The disaster prevention system 100 further includes a plurality of terminal devices 101. Each of the terminal devices 101 is arranged at the terminal of an associated signal line L1 (i.e., at the opposite end from the receiver Y1). Each terminal device 101 includes a terminal resistor, via which the pair of electric wires of the signal line L1 are electrically connected together. This allows the receiver Y1 to detect any disconnection of the signal line L1 by monitoring an electric current flowing between the pair of electric wires.

[0027] The plurality of sensors 1 monitor a monitoring region R1 in the facility 500. In the example illustrated in FIG. 6, only three sensors 1 installed in a room such as an assembly room, corresponding to a part of the monitoring region R1, are shown for the sake of convenience of description. Note that the number of the sensors 1 provided is not limited to any particular number.

[0028] The configuration of each sensor 1 will be described in detail later. In short, each sensor 1 includes a heat detection unit 3 for detecting heat and a communications unit 11 (communications interface) as shown in FIG. 3A. The communications unit 11 of each sensor 1 and the receiver Y1 are ready to communicate with each other via the signal lines L1.

[0029] Each sensor 1 has a notification capability. The notification capability is the capability of switching components connected to each signal line L1 from a non-short-circuited state into a short-circuited state. When detecting the presence of a fire, each sensor 1 uses the notification capability to transmit a signal as a notification of the presence of the fire (hereinafter referred to as a "fire warning") to the receiver Y1. In other words, the communications unit 11 of each sensor 1 transmits, via the signal lines L1, the fire warning as a notification of the presence of the fire. That is to say, the sensor 1 according to this embodiment is a contact type fire sensor for use in an automatic fire alarm that adopts a so-called "proprietary-type (P-type)" communication method. Nevertheless, the communication method does not have to be the P-type communication method. Alternatively, the sensor 1 may transmit the fire warning by a so-called "record type (R-type)" communication method. Optionally, the disaster prevention system 100 may further include one or more relays that relay communications between the receiver Y1 and the plurality of sensors 1.

[0030] In addition, each sensor 1 has not only the notification capability but also a communication capability as well. The communication capability is the capability of communicating bidirectionally with the receiver Y1 by using a transmission signal transmitted through the signal lines L1. On receiving, from the receiver Y1, a transmission signal including an address request that requests for an address (identifier) of the source device of the fire warning when a fire alarm is sounded (i.e., when the fire warning is transmitted), the communications unit 11 of each sensor 1 uses the communication capability to transmit a pre-assigned address to the receiver Y1.

[0031] The disaster prevention system 100 is basically configured to make any of the sensors 1 detect the presence of a fire and make the sensor 1 notify the receiver Y1 of the presence of the fire. Optionally, the disaster prevention system 100 may further include one or more transmitters as well. Each of the transmitters is a device including, for example, a push button switch and configured to notify the receiver Y1 of the presence of a fire by having a person who has detected the fire within the facility 500 manually operate (push) the push button switch. The transmitters, as well as the sensors 1, may be connected to the receiver Y1 via feed lines that use the signal lines L1.

[0032] Optionally, the disaster prevention system 100 may have the capability of being triggered (or activated) in synch with any other piece of equipment such as smoke prevention and exhaustion equipment or emergency announcement equipment. In that case, the disaster prevention system 100 may, at the outbreak of a fire, control a fire door of the smoke prevention and exhaustion equipment and alert people to the presence of the fire using an alarm sound or a verbal warning message emitted through the emergency announcement equipment.

(2.2) Sensor

(2.2.1) Overall configuration for sensor

[0033] Next, the configuration of a sensor 1 according to this embodiment will be described. The following description will be focused on only one of the plurality of sensors 1.

[0034] The sensor 1 is supposed to be installed on a ceiling surface (one surface of the structural component X1) of the facility 500 as in the example illustrated in FIG. 1A.

[0035] In the following description, the upward/downward directions and rightward/leftward directions will be defined with respect to the sensor 1 based on the upward, downward, rightward, and leftward arrows shown in FIG. 2. In this case, the thickness of the board 2 of the sensor 1 is aligned with the upward/downward direction, and the direction in which a pair of auxiliary ports 7C (vertical ports) are arranged side by side is aligned with the rightward/leftward direction. Note that these arrows are just shown there as an assistant to description and are insubstantial ones. It should also be noted that these directions do not define the directions in which the sensor 1 according to this embodiment should be used.

[0036] As shown in FIG. 3A, the sensor 1 includes a heat detection unit 3 including, in total, eight heat detecting elements 30, a control unit 9, a display unit 10, and the communications unit 11 described above. The sensor 1 further includes the board 2 and the housing 5 as shown in FIGS. 1A, 1B, and 2. In addition, the sensor 1 further includes a mounting member 12 (see FIG. 2) for mounting the sensor 1 onto the structural component X1. The sensor 1 is mounted removably, via the mounting member 12, onto a disklike mounting base fixed on the structural component X1.

[0037] When the mounting member 12 is mechanically connected to the mounting base on the structural component X1, electrical connection between a connection terminal inside the sensor 1 and a contact portion of the mounting base is also established. Thus, connecting the mounting member 12 to the mounting base allows the control unit 9 and communications unit 11 mounted on the board 2 to be electrically connected to electric cables (including a power cable and the signal line L1) on the back of the structural component X1 via the connection terminal and the contact portion.

[0038] When detecting a fire, the sensor 1 transmits a fire warning, providing information about the presence of the fire detected, to the reception terminal Y1, and receives a signal from the reception terminal Y1, via the communications unit 11. The sensor 1 is powered by the receiver Y1, a relay, or a commercial power supply. Alternatively, the sensor 1 may also be powered by a battery provided inside the housing 5.

(2.2.2) Housing

[0039] The housing 5 houses the board 2, the heat detection unit 3, the control unit 9, the display unit 10, the communications unit 11, and other circuit modules therein. That is to say, the housing 5 houses the plurality of heat detecting elements 30.

[0040] The housing 5 is made of a synthetic resin and may be made of flame-retardant ABS resin, for example. The housing 5 is formed in the shape of a circular cylinder, which is generally compressed in the upward/downward direction. As shown in FIG. 2, the housing 5 includes: a circular cylindrical front cover 51, of which one surface (e.g., an upper surface in the example illustrated in FIG. 2) is open; and a disklike back cover 52. The housing 5 has a facing surface 55 (see FIG. 2) to face the structural component X1 when the housing 5 is mounted on the structural component X1. In this embodiment, the upper surface of the back cover 52 corresponds to the facing surface 55. The housing 5 is formed by attaching the back cover 52 into the front cover 51 such that the back cover 52 is inserted through the opened surface of the front cover 51.

[0041] In addition, as shown in FIGS. 1A and 2, the housing 5 also has openings 7 for letting a gas (hot air) flow into the housing 5. The openings 7 include a plurality of side inlets 7A (lateral ports), a single inlet port 7B (vertical port), and a pair of auxiliary ports 7C (vertical ports). In this embodiment, the openings 7 are provided through the front cover 51.

[0042] As shown in FIGS. 1A and 2, the front cover 51 includes: a compressed circular cylindrical body 510, of which the upper and lower ends are opened; a disklike base portion 511 provided under the circular cylindrical body 510; and a plurality of beams 512 that connect the circular cylindrical body 510 to the base portion 511.

[0043] The circular cylindrical body 510, the base portion 511, and the plurality of beams 512 are formed integrally with each other. The plurality of beams 512 are arranged at nearly regular intervals along the circumference of the peripheral edge portion of the base portion 511 and protrude from the peripheral edge portion toward the opened lower edge portion of the circular cylindrical body 510. The plurality of beams 512 are provided to keep a predetermined distance between the circular cylindrical body 510 and the base portion 511. The plurality of side inlets 7A are provided through the peripheral wall of the front cover 51 with such a configuration and arranged at nearly regular intervals along the circumference of the peripheral wall.

[0044] Each of these side inlets 7A is a generally rectangular through hole, which radially penetrates through the peripheral wall of the front cover 51 and serves as a hole connecting the flow channel inside the housing 5 to the external space. Each side inlet 7A is located between a pair of adjacent beams 512. The inlet port 7B is a circular through hole, which penetrates through the base portion 511 in the thickness direction and serves as a hole connecting the flow channel inside the housing 5 to the external space. The inlet port 7B is provided through an outer surface 53, opposite from the facing surface 55, of the housing 5 (i.e., the lower surface of the base portion 511). The inlet port 7B is arranged at the center of the outer surface 53 when viewed from in front of the outer surface 53, for example. The pair of auxiliary ports 7C are arranged in the vicinity of the right and left edges of the outer surface 53 as shown in FIG. 2. Each of the auxiliary ports 7C is a generally rectangular through hole, which penetrates through the base portion 511 in the thickness direction and serves, just like each side inlet 7A and the inlet port 7B, as a hole connecting the flow channel inside the housing 5 to the external space.

[0045] The front cover 51 also has, on the upper surface facing the board 2, a plurality of ribs for positioning the board 2. The front cover 51 further includes a plurality of control plates 522 (see FIG. 1B) for controlling the flow of a gas inside the housing 5. Specifically, a pair of control plates 522 are provided so that each control plate 522 expands inward from behind an associated beam 512. The plurality of control plates 522 control (or guide) the flow of a gas that has flowed in through the side inlets 7A to allow the gas to flow more smoothly toward the heat detecting elements 30.

(2.2.3) Board

[0046] The board 2 is implemented as a printed wiring board. On the board 2, mounted are, for example, the heat detection unit 3, the control unit 9, the display unit 10, the communications unit 11, and other circuit modules.

[0047] As shown in FIG. 1B, the board 2 is formed in a generally circular shape as a whole in a plan view. As shown in FIG. 2, the board 2 has a first surface 21 (e.g., lower surface in this example) facing the inlet port 7B and a second surface 22 (e.g., upper surface in this example) located opposite from the first surface 21. In this embodiment, all of the eight heat detecting elements 30 of the heat detection unit 3 are surface-mounted on the second surface 22 of the single board 2. That is to say, the sensor 1 includes the single board 2 and the plurality of heat detecting elements 30 are mounted on the single board 2. This may reduce an increase in the number of parts required compared to a situation where the plurality of heat detecting elements 30 are mounted to be distributed among a plurality of boards, for example. In addition, this may also reduce a dispersion in the arrangement of the plurality of heat detecting elements 30.

[0048] A plurality of electronic components that form the control unit 9, the communications unit 11, and other circuit modules are also mounted on the second surface 22 of the board 2, for example. Note that the plurality of electronic components that form the control unit 9, the communications unit 11, and other circuit modules do not have to be mounted on only the single board 2. Alternatively, an additional mount board may be provided around the board 2 and some or all of those electronic components may be mounted on the additional mount board.

[0049] Next, the structure of the board 2 will be described in detail. As shown in FIG. 1B, the board 2 includes a body 200 and six extended portions 201. The body 200 has a generally circular shape. The six extended portions 201 are arranged at approximately regular intervals along the circumferential edge of the body 200. Each extended portion 201 is extended away from the center of the body 200. That is to say, the board 2 may have, for example, a hexagonal symmetrical shape, which makes the board 2 symmetrical when the board 2 is rotated 60 degrees around its center.

[0050] As shown in FIGS. 1B and 2, the body 200 has, in the central area thereof, a port 25 that penetrates through the body 200 in the thickness direction. The port 25 has a generally circular opening. The port 25 is arranged to be substantially laid on top of the inlet port 7B when viewed from in front of the inlet port 7B.

[0051] The body 200 has a pair of projections 26, which are provided at an opening edge of the port 25 to protrude toward each other in the rightward/leftward direction as shown in FIG. 2. The respective tips of the pair of projections 26 are exposed through the inlet port 7B when viewed from in front of the inlet port 7B. A single heat detecting element 30 (chip thermistor) is mounted on the upper surface near the tip of each projection 26.

[0052] In addition, on the upper surface near the tip of each of the six extended portions 201, a single heat detecting element 30 (chip thermistor) is mounted.

[0053] In the following description, out of the total of eight heat detecting elements 30, the six heat detecting elements 30 provided on the six extended portions 201 will be hereinafter referred to as "main heat detecting elements 30A" and the pair of heat detecting elements 30 provided on the pair of projections 26 will be hereinafter referred to as "auxiliary heat detecting elements 30B." In addition, those six main heat detecting elements 30A will be hereinafter referred to as "first through sixth heat detecting elements 301-306." Of the pair of auxiliary heat detecting elements 30B, the heat detecting element 30 on the right will be hereinafter referred to as a "seventh heat detecting element 307" and the heat detecting element 30 on the left will be hereinafter referred to as an "eighth heat detecting element 308." The pair of auxiliary heat detecting elements 30B are mounted on the second surface 22 of the board 2 so as to be arranged along the peripheral edge of the inlet port 7B when viewed from in front of the inlet port 7B.

[0054] In addition, the board 2 further has through holes 31, which are provided in the vicinity of the respective heat detecting elements 30 to penetrate through the board 2 in the thickness direction. Specifically, the through hole 31 provided in the vicinity of each main heat detecting element 30 has a generally rectangular opening and is arranged opposite from (i.e., inside of) an associated side inlet 7A with respect to the main heat detecting element 30A. On the other hand, the through hole 31 provided in the vicinity of each auxiliary heat detecting element 30B has a generally triangular opening and is arranged opposite from (i.e., outside of) an associated port 25 with respect to the auxiliary heat detecting element 30B.

[0055] Providing these through holes 31 beside the respective heat detecting elements 30 allows the area occupied by the board 2 to be reduced around the heat detecting elements 30. Thus, the through holes 31 reduces the chances of the heat generated by a plurality of electronic components that form the control unit 9, the communications unit 11, and other circuit modules being propagated through the board 2 to affect the heat detecting elements 30. In addition, the through holes 31 also reduce the chances of the heat generated by the heat detecting elements 30 being transmitted through the board 2 to cause a decrease in the temperature of the heat detecting elements 30. That is to say, the through holes 31 contribute to improving the thermal insulation properties. The opening area of each through hole 31 is suitably larger than the surface area of an associated heat detecting element 30 (e.g., its surface area when viewed from over the board 2).

[0056] The display unit 10 includes a plurality of light sources such as light-emitting diodes (LEDs). The plurality of light sources are mounted on the board 2. The plurality of light sources includes two light sources corresponding to indicating lamps. The light emitted from each of the indicating lamps is transmitted through a guide portion of a light guide lens, for example, to emerge from two window holes 533 (see FIG. 1A) provided through the outer surface 53 of the front cover 51.

(2.2.4) Heat detection unit and control unit

[0057] As described above, the heat detection unit 3 includes the eight heat detecting elements 30 which are mounted on the second surface 22 of the board 2. However, the number of the heat detecting elements 30 provided is not limited to any particular number as long as two or more heat detecting elements 30 are provided. In addition, the respective heat detecting elements 30 according to this embodiment are implemented as chip thermistors for detecting the heat of a gas that has flowed in through the openings 7 and are surface-mounted on the board 2. In this embodiment, the heat detecting elements 30 are supposed to be negative temperature coefficient (NTC) thermistors. However, this is only an example and should not be construed as limiting. Alternatively, the heat detecting elements 30 may also be implemented as positive temperature coefficient (PTC) thermistors.

[0058] The six main heat detecting elements 30A (a plurality of heat detecting elements 30) are arranged in a peripheral area 50 surrounding the center 5A (see FIG. 1B) of the housing 5 when viewed in a direction intersecting with the installation surface X11 on which the sensor 1 is installed (i.e., when viewed in the upward/downward direction in this example). In FIG. 1B, the peripheral area 50 is indicated by dotted hatching surrounded with one-dot chains to help the reader recognize the peripheral area 50 more easily. However, this should not be construed as strictly limiting the range of the peripheral area 50 to the illustrated one. The six main heat detecting elements 30A are arranged at approximately regular intervals in the peripheral area 50.

[0059] In addition, the six main heat detecting elements 30A are arranged to face, one to one, the plurality of side inlets 7A out of the openings 7. Furthermore, two extended portions 201, on which the second heat detecting element 302 and the fifth heat detecting element 305 are respectively mounted out of the six main heat detecting elements 30A, are arranged to respectively face the two auxiliary ports 7C of the openings 7.

[0060] As shown in FIG. 1B, the first heat detecting element 301, which is one of the six main heat detecting elements 30A, is arranged on a virtual line segment Q1 that connects a mark M1 (to be described later) to the center 5A of the housing 5 when viewed from over the second surface 22 of the board 2. Meanwhile, the second through sixth heat detecting elements 302-306 are arranged to form angles of 60, 120, 180, 240, 300 degrees, respectively, with respect to the line segment Q1 when viewed from over the second surface 22 of the board 2.

[0061] The auxiliary heat detecting elements 30B are mounted on the board 2 to either roughly fall within, or slightly deviate from, the projection area of the inlet port 7B when viewed from in front of the inlet port 7B out of the openings 7.

[0062] The heat detection unit 3 is electrically connected to the control unit 9 through, for example, patterned wiring formed on the board 2. Each heat detecting element 30 outputs an electrical signal (detection signal) to the control unit 9. In other words, the control unit 9 monitors the resistance values, which are variable depending on an increase in temperature, of the respective heat detecting elements 30 through the electrical signals provided by the respective heat detecting elements 30.

[0063] The heat detection unit 3 may include not only the heat detecting elements 30 but also an amplifier circuit for amplifying the electrical signals provided by the heat detecting elements 30, a converter circuit for performing analog-to-digital conversion on the electrical signals, and other circuits. Alternatively, the electrical signals may be amplified and converted on the control unit 9 end.

[0064] The control unit 9 may be implemented as a computer system including one or more processors (microprocessors) and one or more memories. That is to say, the one or more processors perform the functions of the control unit 9 by executing one or more programs stored in the one or more memories. In this embodiment, the program is stored in advance in the memory of the control unit 9. However, this is only an example and should not be construed as limiting. The program may also be downloaded via a telecommunications line such as the Internet or distributed after having been stored in a non-transitory storage medium such as a memory card.

[0065] As shown in FIG. 3A, the control unit 9 includes a decision unit 91, a diagnosis unit 92, and an estimation unit E1. In other words, the control unit 9 has a function of the decision unit 91, a function of the diagnosis unit 92, and a function of the estimation unit E1. The estimation unit E1 will be described in detail later in the next section.

[0066] The decision unit 91 is configured to receive a detection signal from the heat detection unit 3 to determine whether or not a fire is present (i.e., to perform fire determination processing). In particular, the decision unit 91 determines, by collating a plurality of heat detection values obtained by the plurality of heat detecting elements 30 with a predetermined decision condition, whether or not a fire is present in the monitoring region

R1 (i.e., performs a decision step). Specifically, the decision unit 91 monitors the detection signals from the eight heat detecting elements 30 of the heat detection unit 3 and collates the signal levels of these detection signals (i.e., a plurality of detection values) with a predetermined decision condition, thereby determining whether or not a fire is present. As used herein, the "detection values" may be any of the output voltage (values) of the heat detecting elements 30, the resistance values, calculated based on the voltage values, of the heat detecting elements 30, or temperature values corresponding to the resistance values. In the following description, the "detection values" are supposed to be temperature values, for example.

[0067] The "predetermined decision condition" will be described in detail. The predetermined decision condition includes at least one of the following first through sixth decision conditions.

[0068] The first decision condition is "to select the maximum value from the plurality of detection values." If the predetermined decision condition includes the first decision condition, then the decision unit 91 determines, based on at least the maximum value, whether or not a fire is present. For example, the decision unit 91 selects the highest temperature value (maximum value) out of eight temperature values (detection values) acquired at the same timing (in that case, the predetermined decision condition includes the fifth decision condition to be described later) by the eight heat detecting elements 30 and compares the temperature value with a temperature threshold value for fire determination. The control unit 9 stores (information about) the temperature threshold value in advance in the memory. When finding the highest temperature value greater than the temperature threshold value, the decision unit 91 decides that the fire should be present. Applying this first decision condition facilitates, compared to making a decision based on the lowest temperature value (minimum value) by comparing the lowest temperature value with the same temperature threshold value, for example, shortening the time it takes for the decision unit 91 to decide that a fire should be present (i.e., increase the responsivity of the disaster prevention system 100 in terms of fire determination).

[0069] The second decision condition is "to select the minimum value from the plurality of detection values." If the predetermined decision condition includes the second decision condition, then the decision unit 91 determines, based on at least the minimum value, whether or not a fire is present. For example, the decision unit 91 selects the lowest temperature value (minimum value) out of the eight temperature values (detection values) acquired at the same timing by the eight heat detecting elements 30 and compares the temperature value with a temperature threshold value for fire determination. When finding the lowest temperature value greater than the temperature threshold value, the decision unit 91 decides that the fire should be present. Applying this second decision condition reduces, compared to making a decision based on the highest temperature value (maximum value) by comparing the highest temperature value with the same temperature threshold value, for example, the chances of the decision unit 91 deciding, by mistake, that a fire should be present (i.e., reduces the chances of providing incorrect information or false alarm).

[0070] The third decision condition is "to determine the number of heat detecting elements 30 which have obtained detection values that are greater than a threshold value about fire determination, among the plurality of heat detecting elements 30 that have obtained the plurality of detection values." If the predetermined decision condition includes the third decision condition, then the decision unit 91 determines, based on at least the number of the heat detecting elements 30, whether or not a fire is present. For example, the decision unit 91 compares every one of the eight temperature values (detection values), obtained by the eight heat detecting elements 30 at the same certain timing, with a temperature threshold value for fire determination. The control unit 9 stores (information about) the number threshold value for fire determination in advance in the memory. The decision unit 91 obtains the number of the temperature values (detection values) that are greater than the temperature threshold value for fire determination (i.e., the number of the heat detecting elements 30) and compares the number with the number threshold value. When finding the number of the heat detecting elements 30 equal to or greater than the number threshold value (e.g., four), the decision unit 91 decides that the fire should be present. Applying this third decision condition reduces the chances of the decision unit 91 deciding, by mistake, that a fire should be present (i.e., reduces the chances of providing incorrect information or false alarm).

[0071] The fourth decision condition is "to calculate the average value of the plurality of detection values." If the predetermined decision condition includes the fourth decision condition, then the decision unit 91 determines, based on at least the average value, whether or not a fire is present. For example, the decision unit 91 calculates an average temperature value (average value) based on eight temperature values (detection values) acquired at the same certain timing by the eight heat detecting elements 30 and compares the average temperature value with a temperature threshold value for fire determination. When finding the average temperature value greater than the temperature threshold value, the decision unit 91 decides that the fire should be present. Applying this fourth decision condition further improves the reliability in terms of the fire determination.

[0072] The fifth condition is "to use a plurality of detection values acquired at the same timing from a plurality of heat detecting elements 30." The decision unit 91 makes a comparative decision about any one of the first through fourth decision conditions based on the eight temperature values (detection values) acquired at approximately the same timing by the eight heat detecting elements 30, for example. The decision unit 91 makes the comparative decision by repeatedly obtaining the same set of eight temperature values (detection values) at the same time in a predetermined sampling period while monitoring for a fire. Applying this fifth decision condition increases the responsivity of the disaster prevention system 100 in terms of the fire determination.

[0073] Nevertheless, the predetermined decision condition does not have to include the fifth decision condition. Alternatively, the decision unit 91 may hold, for a certain period of time, the peak of the temperature value acquired from each heat detecting element 30, for example. The decision unit 91 may obtain the peak value (detection value) of the temperature value of each heat detecting element 30 and may make the comparative decision about any one of the first to fourth decision conditions based on the eight peak values of the eight heat detecting elements 30.

[0074] The sixth decision condition is "to find an error value among the plurality of detection values and use all of the detection values but the error value." In this embodiment, the decision unit 91 makes the fire determination basically by collating all of the eight temperature values (detection values) obtained by the eight heat detecting elements 30 with a predetermined decision condition. However, if any abnormality such as a malfunction or disconnection (which may also include dirtiness or deterioration with time) happens to any of the eight heat detecting elements 30, then the temperature value provided by that heat detecting element 30 may be an abnormal value. For example, only the temperature value of one heat detecting element 30 may be much smaller or much larger than the temperature value of any other heat detecting element 30 or may also be almost unchanged (substantially constant). If a comparative decision is made about any one of the first through fourth decision conditions based on all of the eight temperature values including such an abnormal value, then it will take a lot of time for the threshold value to be exceeded, thus possibly either causing a significant delay before the fire is detected or causing an error. Thus, the decision unit 91 regards an abnormal temperature value as an error value, removes the error value from the eight temperature values, and then makes a comparative decision about any one of the first to fourth decision conditions. Applying this sixth decision condition further reduces the chances of the error value causing a significant delay before the detection or resulting in an erroneous decision when a comprehensive fire determination is made based on the plurality of detection values obtained by the plurality of heat detecting elements 30.

[0075] As described above, when deciding, by collating the plurality of detection values with the predetermined decision condition, that a fire should be present, the control unit 9 transmits a signal as an alert to the presence of the fire (a fire warning) to the receiver Y1 via the communications unit 11. In addition, on deciding that a fire should be present, the control unit 9 also outputs a control signal to flicker or light the light source of the display unit 10 (i.e., the indicating lamp) to a lighting circuit.

[0076] Optionally, the user or the installer may appropriately decide, on the spot, depending on the installation environment of the sensor 1, which of the first to sixth decision conditions should be applied to the sensor 1. For example, setting information indicating that first decision condition should be adopted may be transmitted from the receiver Y1 to the sensor 1 in accordance with a command entered into the receiver Y1. In that case, in accordance with the setting information received from the receiver Y1, the sensor 1 selects and enters the first decision condition. Alternatively, the sensor 1 may accept the decision condition selected in response to an operation performed on a dip switch, for example, provided for the housing 5.

[0077] Meanwhile, if the predetermined decision condition includes two or more decision conditions selected from the first through fourth decision conditions described above, then the temperature threshold values for fire determination for use in the respective decision conditions may be the same value to be used in common but may also be set on an individual basis as mutually different values. For example, if the predetermined decision condition includes the first decision condition (maximum value) and the fourth decision condition (average value), then the temperature threshold value for use in the first decision condition and the temperature threshold value for use in the fourth decision condition may be individually stored as different values in the memory. Note that if the predetermined decision condition includes two or more decision conditions selected from the first through fourth decision conditions and all of the two or more decision conditions are satisfied to indicate that a fire should be present, then the control unit 9 transmits a fire warning.

[0078] The diagnosis unit 92 is configured to make a diagnosis, based on a plurality of detection values, about whether or not any internal event has happened to the sensor 1 itself. As used herein, the "internal event" refers to any of various types of abnormality, including deterioration with time, dirtiness, malfunction, and disconnection, which may happen to the sensor 1 itself. Such an internal event that has happened may affect the fire determination made by the decision unit 91. Thus, the diagnosis unit 92 performs diagnosis processing on a regular basis (e.g., once a day) while monitoring for a fire. The diagnosis processing may be started in accordance with the user's operating command entered through either the operating unit of the sensor 1 or the receiver Y1. When performing the diagnosis processing, the diagnosis unit 92 determines, based on the eight temperature values (detection values) provided by the eight heat detecting elements 30, whether or not any internal event has happened. For example, the diagnosis unit 92 may perform the diagnosis processing to determine, based on the respective temperature values (detection values) or a relative dispersion thereof, whether or not there is any heat detecting element 30 operating improperly among the eight heat detecting elements 30. Optionally, the control unit 9 may store, in a memory in advance, information about respective current-voltage characteristic patterns of the heat detecting elements 30 depending on the respective types of abnormalities and may check, during the diagnosis processing, the respective current-voltage characteristics of the heat detecting elements 30 and compare the information about their current-voltage characteristics with the pattern information stored in the memory to determine the type of the abnormality.

[0079] When the diagnosis unit 92 makes a diagnosis, as a result of the diagnosis processing, that an internal event has happened, the control unit 9 transmits information to that effect to the receiver Y1 via the communications unit 11. In response, the receiver Y1 notifies the user, via the display unit Y12, for example, that an internal event has happened to the sensor 1. In addition, the control unit 9 also notifies the user, by changing the lighting state (of the indicating lamp of) the display unit 10, that an internal event has happened to the sensor 1.

[0080] As can be seen, the sensor 1 makes a diagnosis, based on the eight temperature values (detection values), about whether or not any internal event (such as deterioration with time, dirtiness, malfunction, or disconnection) that may affect the fire determination has happened, thus further improving the reliability in terms of the fire determination.

[0081] Note that when spotting, as a result of the diagnosis processing, any heat detecting element 30 that should be operating improperly, the control unit 9 suitably removes the detection value provided by that heat detecting element 30 as an error value according to the sixth decision condition described above while performing the fire determination processing actually.

(2.2.5) Direction of fire source

[0082] The estimation unit E1 is configured to estimate, based on the results of detection about heat obtained by the plurality of heat detecting elements 30, the direction D1 of the fire source in the monitoring region R1 (in the estimation step). In this embodiment, the control unit 9 of the sensor 1 performs the function of the estimation unit E1 as described above. In other words, the estimation unit E1 is provided for the sensor 1. The estimation unit E1 estimates, based on the result of detection, the direction D1 of the fire source with respect to its own device.

[0083] When the decision unit 91 decides that a fire should be present, the estimation unit E1 performs the estimation processing of estimating the direction D1 of the fire source. The control unit 9 generates estimation information based on the result of estimation. The control unit 9 may transmit the estimation information to the receiver Y1 either at the same timing as, or at a different timing from, the fire warning.

[0084] In this example, the estimation unit E1 estimates the direction D1 of the fire source based on the respective detection values, obtained by the six main heat detecting elements 30A arranged in the peripheral area 50 among the eight heat detecting elements 30, while performing the estimation processing. Optionally, the estimation unit E1 may also use the detection values obtained by the other two auxiliary heat detecting elements 30B as additional information.

[0085] In this embodiment, as shown in FIGS. 1A and 1B, the housing 5 has a mark M1 on the outer surface 56 thereof. The mark M1 indicates one direction with respect to the center 5A of the housing 5 when the housing 5 is viewed in a direction intersecting with the installation surface X11 on which the sensor 1 is installed (e.g., the upward/downward direction in this example). There is correlation between the respective arrangement locations of the plurality of heat detecting elements 30 and the location of the mark M1 with respect to the center 5A of the housing 5. In the example illustrated in FIGS. 1A and 1B, the mark M1 "N" which is the capital letter of the north, is provided on the outer side face (outer surface 56) of the circular cylindrical body 510 of the front cover 51. The mark M1 is arranged to face the first heat detecting element 301, which is one of the six main heat detecting elements 30A as described above. The sensor 1 is installed on the installation surface X11 with the mark M1 facing a particular direction (e.g., the north direction in this example). The estimation unit E1 estimates, based on the results of detection and the correlation, the direction D1 of the fire source with respect to the sensor 1. As used herein, the "results of detection" refer to the six temperature values (detection values) provided by the six main heat detecting elements 30A.

[0086] The estimation unit E1 analyzes the order of the six temperature values (detection values) in terms of their relative levels to make a comprehensive decision about which main heat detecting element 30A has a dominating high (or low) temperature value. Then, the estimation unit E1 estimates the direction in which the main heat detecting element 30A with such a dominating temperature value is arranged to be the direction D1 of the fire source.

[0087] In particular, in this embodiment, the control unit 9 stores the following correlation information in a memory in advance on the supposition that the sensor 1 is arranged with the mark M1 facing the north direction. The correlation information includes information that the first, second, and third heat detecting elements 301, 302, and 303 are associated with the north, west-northwest, west-southwest directions, respectively. In addition, the correlation information further includes information that the fourth, fifth, and sixth heat detecting elements 304, 305, and 306 are associated with the south, east-southeast, and east-northeast directions, respectively. The estimation unit E1 estimates, based on the correlation information, the direction D1 of the fire source in a form associated with north, south, east, and west directions.

[0088] Specifically, if the temperature value provided by the fourth heat detecting element 304 is most dominating value, for example, then the estimation unit E1 estimates the "south" direction pointing from the center 5A of the housing 5 toward the arrangement location of the fourth heat detecting elements 304 when the board 2 is viewed from over the board 2 to be the direction D1 of the fire source. Note that the number of the main heat detecting element 30A that provides a temperature value as the most dominating value is not always equal to one. For example, if the two temperature values provided by the second heat detecting element 302 and the third heat detecting element 303 are the most dominating values, for example, then the estimation unit E1 estimates the "west" direction pointing from the center 5A toward a midpoint of a line segment that connects the second heat detecting element 302 and the third heat detecting element 303 together to be the direction D1 of the fire source.

[0089] As can be seen, the estimation unit E1 estimates, based on the results of detection and the locational relationship between the six main heat detecting elements 30A, the direction D1 of the fire source on the supposition that the mark M1 faces the north direction and further generates estimation information in a form associated with the north, south, east, and west directions. The estimation information thus generated is transmitted to the receiver Y1. The receiver Y1 acquires, based on the estimation information received, the direction D1 of the fire source that has been estimated by the sensor 1, which is the source of the estimation information, with respect to the sensor 1 itself (i.e., with respect to its own device).

[0090] In this embodiment, there is correlation between the respective arrangement locations of the plurality of heat detecting elements 30 with respect to the center 5A of the housing 5 and the location of the mark M1 as described above. Thus, there is no need for the sensor 1 to collect and store information (in a memory, for example) about which directions the respective heat detecting elements 30 are associated with when installed in an actual installation environment. Consequently, this contributes to simplifying the configuration of the sensor 1. In addition, installing the sensor 1 with the mark M1 facing a particular direction allows the arrangement locations of the plurality of heat detecting elements 30 to be linked more easily with actual directions with respect to the sensor 1.

[0091] Optionally, the capability of estimating the direction D1 of the fire source in a form associated with the north, south, east, and west directions may also be provided outside of the sensor 1 (e.g., for the receiver Y1). The estimation unit E1 may generate estimation information, simply including information that allows the receiver Y1 to determine what main heat detecting element 30A has the dominating temperature value (e.g., identification information that makes the six main heat detecting elements 30A individually identifiable), and transmit the estimation information to the receiver Y1.

[0092] The direction D1 of the fire source is associated with the "north, south, east, and west directions." However, this is only an example and should not be construed as limiting. Alternatively, the estimation unit E1 may also generate estimation information, for example, in an implementation in which the direction D1 of the fire source is associated with an angle falling within the range from 0 through 360 degrees with respect to the location of the first heat detecting element 301 as a reference location (defining an angle of 0 degrees).

[0093] In addition, the disaster prevention system 100 according to this embodiment further includes an output unit G1 for outputting the result of estimation made by the estimation unit E1 (see FIGS. 3A and 3B). The output unit G1 includes: a local output unit G2 for outputting the result of estimation on the sensor 1 end; and a central output unit G3 for outputting the result of estimation on the receiver Y1 end.

[0094] The local output unit G2 corresponds to the display unit 10 of each sensor 1. The control unit 9 notifies a person (user) who is present around the sensor 1 of the direction D1 of the fire source by lighting (or flickering), based on the result of estimation, only an associated one of the plurality of light sources of the display unit 10. That is to say, the output unit G1 includes the local output units G2 provided for one or more sensors 1. Optionally, not only the local output unit G2 of the sensor 1 located at the fire source which has detected the fire but also the local output units G2 of the sensors 1, other than the sensor 1 located at the fire source, may be provided with the results of estimation by the sensor 1 at the fire source or the receiver Y1 and notify the user of the direction D1 of the fire source.

[0095] For example, the plurality of light sources of the display unit 10 includes not only the two light sources of the indicating lamps that emit light through the window holes 533 but also six light sources (direction indicators 10A; see FIG. 1B) corresponding one to one to the six main heat detecting elements 30A. In FIG. 1B, the locations of the direction indicators 10A are simply indicated by the dots for the sake of convenience of description.

[0096] Each of the six direction indicators 10A is arranged on the first surface 21 (lower surface) of the body 200 of the board 2 to be located in the vicinity of its associated main heat detecting element 30A, and lets the light emerge out of the housing 5 through a side inlet 7A facing the associated main heat detecting element 30A. The control unit 9 lights (or flickers) only the direction indicator 10A corresponding to the main heat detecting element 30A having the dominating temperature value and estimated by the estimation unit E1. This allows the user to visually recognize the direction D1 of the fire source just by looking at the sensor 1 and detecting in which direction the light emitted from the direction indicator 10A emerges through the side inlet 7A. This facilitates the user using the result of estimation made by the estimation unit E1 at the installation location where the sensor 1 is installed. For example, the user may go quickly in the direction D1 of the fire source as indicated by the direction indicator 10A to see if the alarm is false or not. In addition, this also allows the user to evacuate more easily so as to avoid the direction D1 of the fire source.

[0097] Optionally, each indicating lamp may also perform the function of the direction indicators 10A. Also, the six ports, through which the light emitted from the six direction indicators 10A is allowed to emerge, may be arranged at regular intervals along the peripheral edge of the base portion 511.

[0098] The central output unit G3 corresponds to the display unit Y12 of the receiver Y1 (see FIG. 3B). The display unit Y12 may be implemented as, for example, a liquid crystal display or an organic electroluminescent (EL) display. The receiver Y1 displays, as character sting data on the screen, information allowing determining the installation location of the sensor 1 as the source of the estimation information transmitted and information about the direction D1 of the fire source estimated by the sensor 1. This allows the user to visually recognize the direction D1 of the fire source estimated by the sensor 1 just by looking at the display unit Y12 of the receiver Y1.

[Exemplary operation]

[0099] Next, it will be briefly described with reference to the flowchart of FIG. 5 how each sensor 1 according to this embodiment may operate while performing the fire determination processing and the estimation processing. In this example, the predetermined decision condition is supposed to include the fourth decision condition (average value).

[0100] The sensor 1 performs the fire determination processing while operating. That is to say, the sensor 1 acquires, from time to time, the detection values from the eight heat detecting elements 30 while operating (in the acquisition step) to monitor these detection values (in ST1).

[0101] The sensor 1 calculates, in a predetermined sampling period, an average temperature value based on the eight temperature values (detection values) obtained by the eight heat detecting elements 30 and compares the average temperature value with the temperature threshold value for fire determination (in ST2: decision step). When finding the average temperature value greater than the temperature threshold value (if the answer is YES in ST2), the sensor 1 decides that a fire should be present and transmits a fire warning to the receiver Y1 (in ST3). The sensor 1 continues monitoring as long as the average temperature value is equal to or less than the temperature threshold value (if the answer is NO in ST2).

[0102] On deciding that a fire should be present, the sensor 1 further starts performing the estimation processing of estimating the direction D1 of a fire source (in ST4: estimation step).

[0103] In performing the estimation processing, the sensor 1 estimates the direction D1 of the fire source, generates estimation information in a mode associated with any one of the north, south, east, and west directions, and transmits the information to the receiver Y1 (in ST5). In addition, the sensor 1 lights (or flickers) only a corresponding direction indicator 10A of the display unit 10, thereby notifying surrounding users of the estimated direction D1 of the fire source (in ST6).

[0104] Meanwhile, on receiving the fire warning, the receiver Y1 controls the fire door of the smoke prevention and exhaustion equipment and calls an alert for the fire via either an alarm sound or a verbal warning message emitted through the emergency announcement equipment. In addition, the receiver Y1 also notifies the surrounding users of the estimated direction D1 of the fire source via the display unit Y12.

[0105] Note that the flowchart shown in FIG. 5 shows only an exemplary operation of the sensor 1. Thus, the processing steps shown in FIG. 5 may also be performed in a different order as appropriate, an additional processing step may be performed, or some of the processing steps may be omitted as appropriate as well.

[Advantages]

[0106] According to the exemplary embodiment described above, the decision unit 91 collates the plurality of heat detection values detected by the plurality of heat detecting elements 30, respectively, with a predetermined decision condition, thereby determining whether or not a fire is present in the monitoring region R1. This allows a fire determination to be made comprehensively based on the plurality of detection values obtained by the plurality of heat detecting elements 30. This reduces the chances of causing a dispersion in the reliability in terms of the fire determination depending on the locational relationship between the location of the fire source and the location where the sensor 1 is arranged. Consequently, this contributes to improving the reliability in terms of the fire determination.

[0107] In addition, according to this embodiment, the estimation unit E1 estimates the direction D1 of the fire source in the monitoring region R1 based on the results of heat detection obtained by the plurality of heat detecting elements 30. Consequently, not just determination information about whether or not a fire is present but also a result of estimation about the direction D1 of the fire source are obtained as well. This facilitates providing more detailed (i.e., a larger amount of) fire information.

[0108] In addition, the plurality of heat detecting elements 30 (i.e., the six main heat detecting elements 30A) are arranged in the peripheral area 50. This further improves the reliability in terms of the fire determination made by the decision unit 91, compared to a situation where the plurality of heat detecting elements 30 are arranged concentratedly in the central area of the housing 5. Furthermore, this further improves the reliability of the direction D1 of the fire source estimated by the estimation unit E1.

[0109] Furthermore, according to the exemplary embodiment described above, the estimation unit E1 is provided for the sensor 1 and estimates, based on the result of detection, the direction D1 of the fire source with respect to its own device (sensor 1). This allows the result of estimation about the direction D1 of the fire source to be obtained by the sensor 1 by itself. This improves the responsivity of the disaster prevention system 100 (i.e., allows the result of estimation to be obtained more quickly), compared to providing the estimation unit E1 outside of the sensor 1.

(2.2.6) Fire localization

[0110] Next, the capability of further determining the fire source location based on the estimation information provided by the plurality of sensors 1 will be described. The disaster prevention system 100 according to this embodiment further includes a localization unit E2 (see FIG. 3B) for determining the fire source location P1 (see FIG. 6). The localization unit E2 determines the fire source location P1 by integrating together the results of estimation about the direction D1 of the fire source with respect to the respective sensors 1 based on the respective results of detection obtained by two or more sensors 1. In this embodiment, the capability of the localization unit E2 is provided for the processing unit Y11 of the receiver Y1 as in the example illustrated in FIG. 3B.

[0111] The processing unit Y11 may be implemented as a computer system including one or more processors (microprocessors) and one or more memories. That is to say, the one or more processors perform the respective functions of the processing unit Y11 by executing one or more programs stored in the one or more memories. In this embodiment, the program is stored in advance in the memory of the processing unit Y11. However, this is only an example and should not be construed as limiting. The program may also be downloaded via a telecommunications line such as the Internet or distributed after having been stored in a non-transitory storage medium such as a memory card. The processing unit Y11 includes the localization unit E2 as described above. The processing unit Y11 controls the display unit Y12 and a communications interface for communicating with the respective sensors 1.

[0112] On receiving the estimation information from the plurality of sensors 1 that have detected a fire, the localization unit E2 performs localization processing of determining the fire source location P1. The localization unit E2 generates localization information based on a result of the localization. The localization unit E2 displays the localization information on the screen of the display unit Y12.

[0113] Next, the localization processing will be described specifically with respect to FIG. 6. FIG. 6 illustrates a floor plan of a part of a floor within the facility 500. In the example illustrated in FIG. 6, three sensors 1 (1A-1C) are installed on the ceiling (as an exemplary structural component X1) of an assembly room, for example, corresponding to a part of the monitoring region R1. In FIG. 6, each sensor 1 is schematically indicated by a circle. In this example, the three sensors 1 are arranged at respective vertices of an equilateral triangle for the sake of convenience of description. However, this positional relationship should not be construed as limiting. Also, in this example, a fire is supposed to be present at a location defining the center of gravity of the equilateral triangle, at the respective vertices of which the sensors 1 are arranged by way of illustrative example (see the fire source location P1 shown in FIG. 6).

[0114] As indicated by the bearing mark in FIG. 6, the upward direction on the drawing indicates the north direction. Each of the three sensors 1 is installed on the ceiling such that its mark M1 faces the north.

[0115] In this case, the receiver Y1 is supposed to have received the estimation information from each of the three sensors 1 shown in FIG. 6.

[0116] The estimation information received from the sensor 1A includes information indicating that the direction D1 of the fire source is the southeast direction with respect to the sensor 1A (its own device). The information may also be replaced with the identification information of a main heat detecting element 30A indicating the dominating temperature value as described above. The estimation information received from the sensor 1B includes information indicating that the direction D1 of the fire source is the southwest direction with respect to the sensor 1B (its own device). The estimation information received from the sensor 1C includes information indicating that the direction D1 of the fire source is the north direction with respect to the sensor 1C (its own device).

[0117] In this case, the processing unit Y11 stores and manages, in a memory of its own device in advance, the coordinate information about the locations where the three sensors 1 are arranged. In addition, the processing unit Y11 also stores and manages, in the memory of its own device, map information about the respective floors within the facility 500 (such as the floor plan shown in FIG. 6, for example). The receiver Y1 may acquire the coordinate information of the sensor 1 and the map information inside the facility 500 from, for example, a server installed outside of the facility 500.

[0118] The localization unit E2 combines together the estimation information provided by the sensor 1A (indicating that the direction D1 of the fire source should be the southeast direction), the estimation information provided by the sensor 1B (indicating that the direction D1 of the fire source should be the southwest direction), and the estimation information provided by the sensor 1C (indicating that the direction D1 of the fire source should be the north direction). Specifically, the localization unit E2 obtains the coordinate information of an intersection where the three directions D1 of the fire source, estimated by the sensors 1A-1C, respectively, intersect with each other on an X-Y plane.

[0119] The coordinate information does not have to be information about the coordinates of a single point but may also be information about a certain coordinate range. In particular, the respective directions D1 of the fire source, estimated by the plurality of sensors 1, do not always intersect with each other at a single intersection but may intersect with each other at multiple intersections. In the latter case, the localization unit E2 obtains coordinate information about a coordinate range covering those multiple intersections.

[0120] On obtaining the coordinate information about the intersection, the localization unit E2 generates localization information based on the information thus obtained and provides the user with the localization information as information about the fire source location P1 estimated. The coordinate information about the intersection is provided for the user after having been converted into a form which is easily understandable for the user. For example, as shown in FIG. 6, the processing unit Y11 displays the coordinate information on the display unit Y12 in such a form that makes the fire source location P1 estimated easily recognizable on the floor plan (map information). Alternatively, the processing unit Y11 may estimate, based on the coordinate information about the intersection, that the fire source should be located around the center of the assembly room and may display, on the display unit Y12, character string data such as "fire source is located around center of assembly room."

[0121] As can be seen, the localization unit E2 determines the fire source location P1 by integrating together the respective directions D1 of fire source estimated by two or more sensors 1. This allows even more detailed fire information to be provided.

[Exemplary operation]

[0122] Next, it will be described briefly with reference to the flowchart of FIG. 7 how the disaster prevention system 100 according to this embodiment may operate when performing the localization processing.

[0123] On deciding that a fire should be present, the sensor 1 transmits a fire warning to the receiver Y1 and further performs estimation processing to transmit estimation information to the receiver Y1.

[0124] On receiving the fire warning from one or more sensors 1 (in ST11), the receiver Y1 immediately controls a fire door of the smoke prevention and exhaustion equipment and alerts people to the presence of the fire using an alarm sound or verbal warning message emitted through the emergency announcement equipment (in ST12). On the other hand, the receiver Y1 does not start performing the localization processing until the receiver Y1 receives the estimation information from two or more sensors 1 (in ST13). That is to say, when finding the number of the sensors 1, from which the receiver Y1 has received the estimation information, equal to or greater than two (if the answer is YES in S13), the receiver Y1 starts performing the localization processing (in ST14). On the other hand, when finding the number less than two (if the answer is NO in Step S13), the receiver Y1 waits.

[0125] When performing the localization processing, the receiver Y1 integrates together the estimation information provided by two or more sensors 1 (in ST15) to obtain coordinate information about an intersection where the respective directions D1 of the fire source intersect with each other (in ST16). The receiver Y1 generates localization information based on the information thus obtained and provides the user with the information as information about the fire source location P1 estimated (in ST17).

[0126] Optionally, every time the receiver Y1 receives additional estimation information from another sensor 1 from then on, the receiver Y1 may also integrate the additional estimation information with the other pieces of information to perform the localization processing again and thereby update information about the fire source location P1 into the latest information.

[0127] Note that the flowchart shown in FIG. 7 shows only an exemplary operation of the disaster prevention system 100. Thus, the processing steps shown in FIG. 7 may also be performed in a different order as appropriate, an additional processing step may be performed, or some of the processing steps may be omitted as appropriate.

(3) Variations

[0128] Note that the embodiment described above is only an exemplary one of various embodiments of the present disclosure and should not be construed as limiting. Rather, the exemplary embodiment may be readily modified in various manners depending on a design choice or any other factor without departing from the scope of the present disclosure. The functions of the sensor 1 (its control unit 9, in particular) and disaster prevention system according to the exemplary embodiment described above may also be implemented as, for example, a fire determination method, a computer program, or a non-transitory storage medium that stores the computer program.

[0129] The sensor 1 and disaster prevention system 100 according to the present disclosure each include a computer system. The computer system may include a processor and a memory as principal hardware components. The functions of the control unit 9 of the sensor 1 and the processing unit Y11 of the receiver Y1 according to the present disclosure may be performed by making the processor execute a program stored in the memory of the computer system. The program may be stored in advance in the memory of the computer system. Alternatively, the program may also be downloaded through a telecommunications line or be distributed after having been recorded in some non-transitory storage medium such as a memory card, an optical disc, or a hard disk drive, any of which is readable for the computer system. The processor of the computer system may be implemented as a single or a plurality of electronic circuits including a semiconductor integrated circuit (IC) or a large-scale integrated circuit (LSI). As used herein, the "integrated circuit" such as an IC or an LSI is called by a different name depending on the degree of integration thereof. Examples of the integrated circuits include a system LSI, a very large-scale integrated circuit (VLSI), and an ultra-large scale integrated circuit (ULSI). Optionally, a field-programmable gate array (FPGA) to be programmed after an LSI has been fabricated or a reconfigurable logic device allowing the connections or circuit sections inside of an LSI to be reconfigured may also be adopted as the processor. Those electronic circuits may be either integrated together on a single chip or distributed on multiple chips, whichever is appropriate. Those multiple chips may be integrated together in a single device or distributed in multiple devices without limitation. As used herein, the "computer system" includes a microcontroller including one or more processors and one or more memories. Thus, the microcontroller may also be implemented as a single or a plurality of electronic circuits including a semiconductor integrated circuit or a large-scale integrated circuit.

[0130] Also, in the embodiment described above, the plurality of constituent elements (or the functions) of the sensor 1 and receiver Y1 are integrated together in a single housing. However, this is not an essential configuration for the sensor 1 or the receiver Y1. Alternatively, those constituent elements (or functions) of the sensor 1 may be distributed in multiple different housings. Conversely, the plurality of functions of the sensor 1 may be integrated together in a single housing. Still alternatively, at least some functions of the sensor 1 and receiver Y1 (e.g., some functions of the sensor 1) may be implemented as a cloud computing system as well.

[0131] Next, variations of the exemplary embodiment will be enumerated one after another. The variations to be described below may be adopted in combination as appropriate. In the following description, the exemplary embodiment described above will be hereinafter sometimes referred to as a "basic example."

[0132] In the basic example described above, the board 2 is implemented as a single printed wiring board. However, this is only an example and should not be construed as limiting. Alternatively, the board 2 may be divided into two or more printed wiring boards. Nevertheless, even in that case, the plurality of printed wiring boards divided are suitably arranged on the same plane.

[0133] In the basic example described above, the number of the heat detecting elements 30 provided is eight. However, any other number of heat detecting elements 30 may be provided as long as the number is at least equal to two. In particular, the auxiliary heat detecting element 30B may be omitted. For example, only two main heat detecting elements 30A may be provided. In that case, one of the two main heat detecting elements 30A is suitably arranged on one end in the rightward/leftward direction on the board 2 and the other main heat detecting element 30A is suitably arranged on the other, opposite end on the board 2. If only two main heat detecting elements 30A are provided, the direction D1 of the fire source estimated may be one of two directions, e.g., either "north" or "south" (or "east" or "west").

[0134] The sensor 1 of the basic example may also be implemented as a fire alarm device which emits an alarm sound when detecting the presence of a fire. That is to say, the sensor 1 may further include a loudspeaker to emit an alarm sound and an audio circuit, for example. Optionally, the sensor 1 may also be implemented as a battery-driven fire alarm device. In that case, the sensor 1 may include a battery and a housing space for housing the battery, for example. In addition, the sensor 1 may also include an operating unit which allows the user to stop emitting the alarm sound and conduct an operation test. The operating unit may be exposed on the outer surface 53 of the front cover 51.

[0135] In the basic example described above, all of the plurality of heat detecting elements 30 are mounted on the second surface 22 (upper surface) of the board 2. However, this is only an example and should not be construed as limiting. Alternatively, at least one of the plurality of heat detecting elements 30 may also be mounted on the first surface 21 (lower surface) of the board 2. Particularly when the sensor 1 is implemented as a combination fire sensor which further includes a smoke detection unit, the smoke detection unit is highly likely to be arranged on the second surface 22 of the board 2. In that case, the plurality of heat detecting elements 30 may be mounted on the first surface 21 (lower surface) of the board 2.

[0136] Also, in the basic example described above, the estimation unit E1 is provided for each sensor 1. However, this is only an example and should not be construed as limiting. Alternatively, the estimation unit E1 may be provided for the receiver Y1 (reception terminal). In that case, the estimation unit E1 estimates, based on the result of detection received from one or more sensors 1, the direction D1 of the fire source. This contributes to simplifying the configuration of the sensor 1, compared to a situation where the estimation unit E1 is provided for each sensor 1.

[0137] Furthermore, in the basic example described above, the localization unit E2 is provided for the receiver Y1. However, this is only an example and should not be construed as limiting. Alternatively, the localization unit E2 may be provided for one of the sensors 1. For example, the localization unit E2 may be provided for a particular sensor 1 (such as a master device) that manages the plurality of other sensors 1 (slave devices). The localization unit E2 of the master device may receive the estimation information from the plurality of slave devices, generate localization information, and transmit the localization information to the receiver Y1.

[0138] The estimation unit E1 according to the basic example may also be configured to estimate the direction D1 of the fire source based on not only the results of detection but also information about an environment where the one or more sensors 1 are installed (hereinafter referred to as "environmental information"). That is to say, the estimation unit E1 may estimate the direction D1 of the fire source based on not only the temperature values (detection values) provided by the plurality of heat detecting elements 30 but also the environmental information as well.

[0139] As used herein, the "environmental information" may include information about the installation location of the sensor 1, i.e., information indicating on which floor the sensor 1 is installed, in which area (such as an assembly room) of the floor the sensor 1 is located, and exactly where on the ceiling in that area (such as beside which wall, by which window, by which pillar, or by which door) the sensor 1 is installed. In addition, the "environmental information" may further include information about which of the plurality of heat detecting elements 30 faces the wall, the window, the pillar, or the door. The environmental information about each sensor 1 may be registered with the receiver Y1 by the installer of the sensor 1 during its installation.

[0140] Each sensor 1 acquires the "environmental information" of its own device from the receiver Y1 by transmitting a request signal to the receiver Y1 during the estimation processing. The environmental information may be registered with the memory of the control unit 9 of each sensor 1 at the time of installation. If there is any wall, window, pillar, or door around the sensor 1, the presence of such a building component may affect the flowing direction of hot air. The estimation unit E1 estimates the direction D1 of the fire source by adding weights to the respective temperature values provided by the heat detecting elements 30 with the environmental information taken into account. Consequently, this further improves the reliability of the direction D1 of the fire source estimated. Optionally, taking the environmental information into account may also be applied to the localization processing to be performed by the localization unit E2 of the receiver Y1.

(4) Recapitulation

[0141] As can be seen from the foregoing description, a sensor (1) according to a first aspect includes a plurality of heat detecting elements (30) and a decision unit (91). The decision unit (91) determines, by collating a plurality of heat detection values obtained by the plurality of heat detecting elements (30) with a predetermined decision condition, whether or not a fire is present. According to the first aspect, a comprehensive fire determination may be made based on the plurality of detection values obtained by the plurality of heat detecting elements (30). This reduces the chances of the reliability in terms of fire determination varying according to the locational relationship between the fire source location and the location where the sensor (1) is arranged. Consequently, this contributes to improving the reliability in terms of the fire determination.

[0142] A sensor (1) according to a second aspect, which may be implemented in conjunction with the first aspect, further includes a housing (5) to house the plurality of heat detecting elements (30). The plurality of heat detecting elements (30) are arranged in a peripheral area (50) that surrounds a center of the housing (5) when the housing (5) is viewed in a direction intersecting with an installation surface (X11) on which the sensor (1) is installed. The second aspect may further improve the reliability in terms of the fire determination, compared to a situation where the plurality of heat detecting elements (30) are arranged concentratedly around the center of the housing (5), for example.

[0143] A sensor (1) according to a third aspect, which may be implemented in conjunction with the first or second aspect, further includes a single board (2). The plurality of heat detecting elements (30) are mounted on the single board (2). The third aspect may reduce an increase in the number of parts required, compared to a situation where the plurality of heat detecting elements (30) are mounted to be distributed on a plurality of boards. In addition, the third aspect may also reduce a dispersion in arrangement between the plurality of heat detecting elements (30).

[0144] In a sensor (1) according to a fourth aspect, which may be implemented in conjunction with any one of the first to third aspects, the predetermined decision condition includes selecting a maximum value from the plurality of detection values. The decision unit (91) determines, based on at least the maximum value, whether or not a fire is present. The fourth aspect facilitates, compared to making a decision based on a minimum value by comparing the lowest temperature value with the same temperature threshold value, for example, shortening the time it takes for the decision unit (91) to decide that a fire should be present (i.e., increase the responsivity of the disaster prevention system 100 in terms of fire determination).

[0145] In a sensor (1) according to a fifth aspect, which may be implemented in conjunction with any one of the first to fourth aspects, the predetermined decision condition includes selecting a minimum value from the plurality of detection values. The decision unit (91) determines, based on at least the minimum value, whether or not a fire is present. The fifth aspect reduces, compared to making a decision based on the highest temperature value (maximum value) by comparing the highest temperature value with the same temperature threshold value, for example, the chances of the decision unit (91) deciding, by mistake, that a fire should be present (i.e., reduces the chances of providing incorrect information or false alarm).

[0146] In a sensor (1) according to a sixth aspect, which may be implemented in conjunction with any one of the first to fifth aspects, the predetermined decision condition includes determining the following number. Specifically, the predetermined decision condition includes determining the number of heat detecting elements (30) which have obtained detection values that are greater than a threshold value about fire determination, among the plurality of heat detecting elements (30) that have obtained the plurality of detection values. The decision unit (91) determines, based on at least the number of the heat detecting elements (30), whether or not a fire is present. The sixth aspect reduces the chances of the decision unit (91) deciding, by mistake, that a fire should be present (i.e., reduces the chances of providing incorrect information or false alarm).

[0147] In a sensor (1) according to a seventh aspect, which may be implemented in conjunction with any one of the first to sixth aspects, the predetermined decision condition includes calculating the average value of the plurality of detection values. The decision unit (91) determines, based on at least the average value, whether or not a fire is present. The seventh aspect further improves the reliability in terms of the fire determination.

[0148] In a sensor (1) according to an eighth aspect, which may be implemented in conjunction with any one of the first to seventh aspects, the predetermined decision condition includes using a plurality of detection values acquired at the same timing from a plurality of heat detecting elements (30). The eighth aspect increases, compared to using a plurality of detection values acquired within a predetermined period, for example, the responsivity of the disaster prevention system 100 in terms of the fire determination.

[0149] In a sensor (1) according to a ninth aspect, which may be implemented in conjunction with any one of the first to eighth aspects, the predetermined decision condition includes finding an error value among the plurality of detection values and using all of the detection values but the error value. The ninth aspect further reduces the chances of the error value resulting in an erroneous decision when a comprehensive fire determination is made based on the plurality of detection values obtained by the plurality of heat detecting elements (30).

[0150] A sensor (1) according to a tenth aspect, which may be implemented in conjunction with any one of the first to ninth aspects, further includes a diagnosis unit (92) configured to make a diagnosis, based on a plurality of detection values, about whether or not any internal event has happened to the sensor (1) itself. The tenth aspect further improves the reliability in terms of the fire determination by making a diagnosis about whether or not any internal event (such as deterioration with time, dirtiness, malfunction, or disconnection) that may affect the fire determination has happened.

[0151] A disaster prevention system (100) according to an eleventh aspect includes one or more sensors (1) which may be implemented in conjunction with any one of the first to tenth aspects, and a reception terminal (receiver Y1) which communicates with the one or more sensors (1) to receive notification about the presence of a fire detected. The eleventh aspect provides a disaster prevention system (100) which contributes to improving the reliability in terms of the fire determination.

[0152] A fire determination method according to a twelfth aspect includes: acquiring a plurality of heat detection values obtained by a plurality of heat detecting elements (30) of a sensor (1); and determining, by collating the plurality of heat detection values obtained with a predetermined decision condition, whether or not a fire is present. The twelfth aspect provides a fire determination method which contributes to improving the reliability in terms of the fire determination.

[0153] A program according to a thirteenth aspect is designed to cause one or more processors to perform the fire determination method according to the twelfth aspect. The thirteenth aspect provides a function which contributes to improving the reliability in terms of the fire determination.

[0154] Note that the constituent elements according to the second to eleventh aspects are not essential constituent elements for the sensor (1) but may be omitted as appropriate.

Reference Signs List

[0155]

100	Disaster Prevention System
1	Sensor
2	Board
30	Heat Detecting Element
5	Housing
50	Peripheral Area
91	Decision Unit
92	Diagnosis Unit
Y1	Receiver (Reception Terminal)
X11	Installation Surface

Claims

1. A sensor (1) comprising:

a plurality of heat detecting elements (30); and
a decision unit (91) configured to determine, by collating a plurality of heat detection values obtained by the plurality of heat detecting elements (30) with a predetermined decision condition, whether or not a fire is present.

2. The sensor (1) of claim 1, further comprising a housing (5) configured to house the plurality of heat detecting elements (30), wherein
the plurality of heat detecting elements (30) are arranged in a peripheral area (50) surrounding a center of the housing (5) when viewed in a direction intersecting with an installation surface (X11) on which the sensor (1) is installed.

3. The sensor (1) of claim 1 or 2, further comprising a single board (2), wherein the plurality of heat detecting elements (30) are mounted on the single board (2).

4. The sensor (1) of any one of claims 1 to 3, wherein the predetermined decision condition includes selecting a maximum value from the plurality of the detection values, and
the decision unit (91) is configured to determine, based on at least the maximum value, whether or not a fire is present.

5. The sensor (1) of any one of claims 1 to 4, wherein the predetermined decision condition includes selecting a minimum value from the plurality of the detection values, and
the decision unit (91) is configured to determine, based on at least the minimum value, whether or not a fire is present.

6. The sensor (1) of any one of claims 1 to 5, wherein the predetermined decision condition includes determining a numerical number of heat detecting elements (30) which have obtained detection values that are greater than a threshold value about fire determination, among the plurality of heat detecting elements (30) that have obtained the plurality of detection values, and
the decision unit (91) is configured to determine, based on at least the numerical number of the heat detecting elements (30), whether or not a fire is present.

7. The sensor (1) of any one of claims 1 to 6, wherein the predetermined decision condition includes calculating an average value of the plurality of detection values, and
the decision unit (91) is configured to determine, based on at least the average value, whether or not a fire is present.

8. The sensor (1) of any one of claims 1 to 7, wherein the predetermined decision condition includes using the plurality of detection values acquired at a same timing from the plurality of heat detecting elements (30).

9. The sensor (1) of any one of claims 1 to 8, wherein the predetermined decision condition includes finding an error value among the plurality of detection values and using all of the detection values but the error value.

10. The sensor (1) of any one of claims 1 to 9, further comprising a diagnosis unit (92) configured to make a diagnosis, based on the plurality of detection values, about whether or not any internal event has happened to the sensor (1) itself.

11. A disaster prevention system (100) comprising:

the one or more sensors (1) of any one of claims 1 to 10, and
a reception terminal (Y1) configured to communicate with the one or more sensors (1) to receive notification about presence of a fire detected.

12. A fire determination method comprising:

acquiring a plurality of heat detection values obtained by a plurality of heat detecting elements (30) of a sensor (1); and
determining, by collating the plurality of heat detection values obtained with a predetermined decision condition, whether or not a fire is present.

13. A program designed to cause one or more processors to perform the fire determination method of claim 12.

FIG. 1A

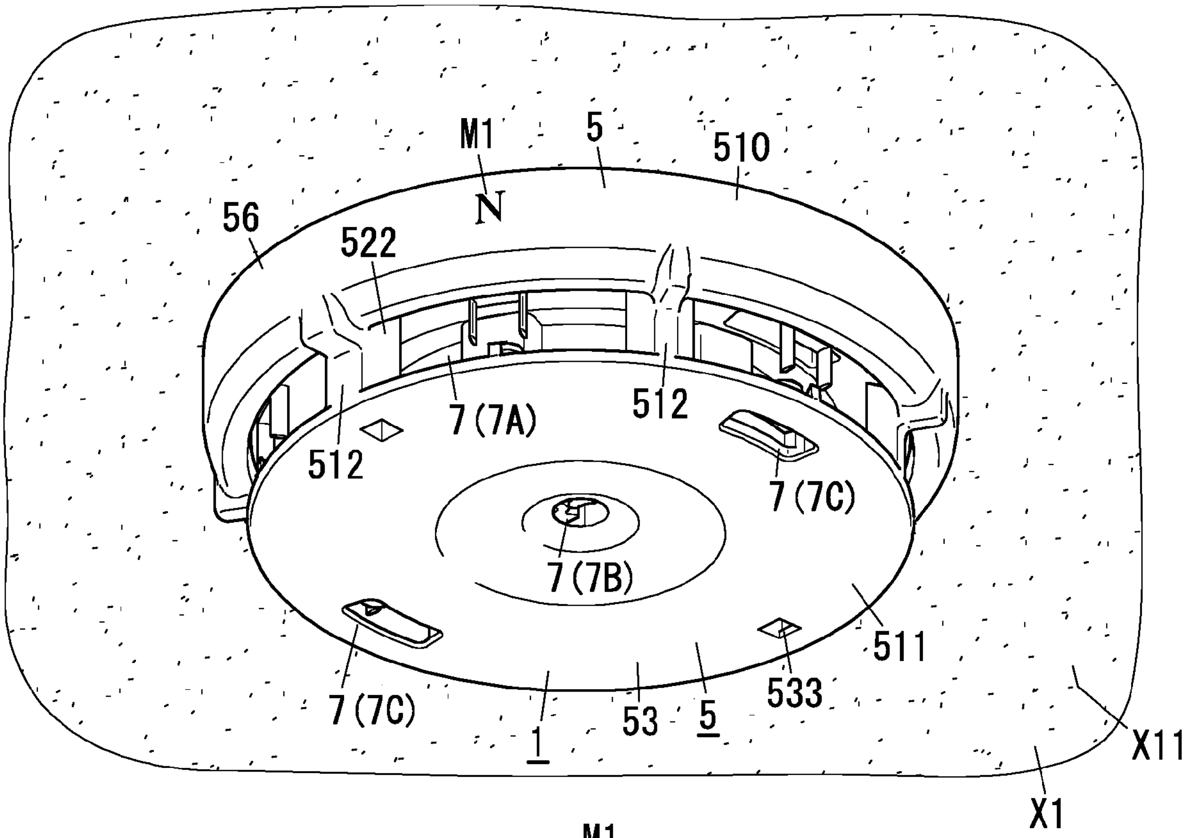
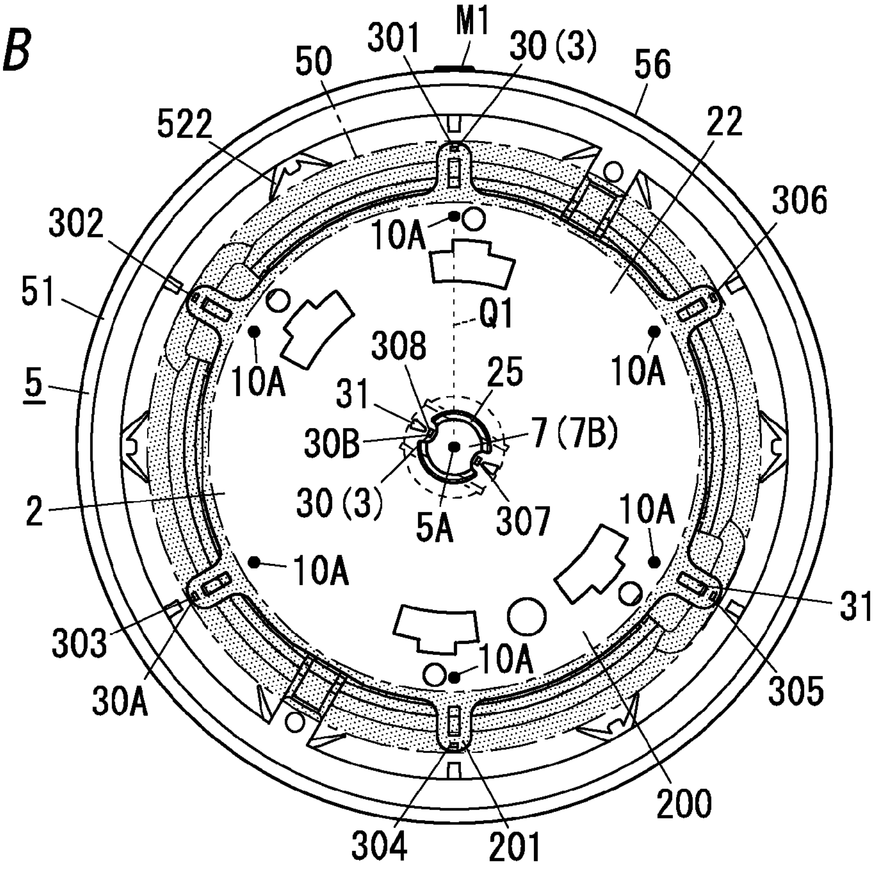

M1
5
510
N
56
522
512
7(7A)
512
7(7C)
7(7B)
511
533
7(7C)
53
5
1
X11
X1

FIG. 1B


M1
301
30(3)
50
56
522
22
306
302
10A
51
Q1
10A
10A
308
25
5
31
7(7B)
30B
2
30(3)
5A
307
10A
10A
31
303
10A
305
30A
304
201
200

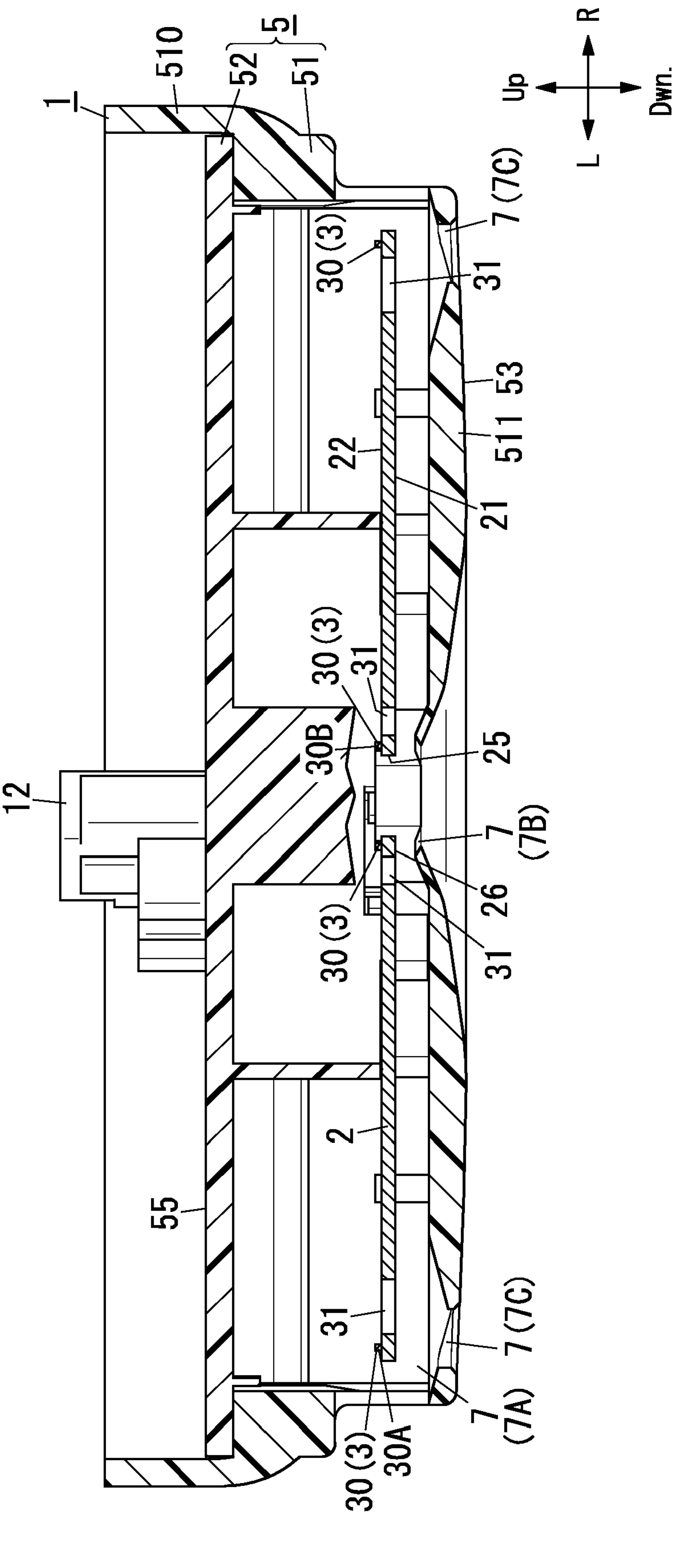

1
510
52
5
51
Up
Dwn.
R
L
7 (7C)
30 (3)
31
53
511
22
21
30B
25
12
26
7
(7B)
2
55
30A
7
(7A)

FIG. 2

FIG. 3A

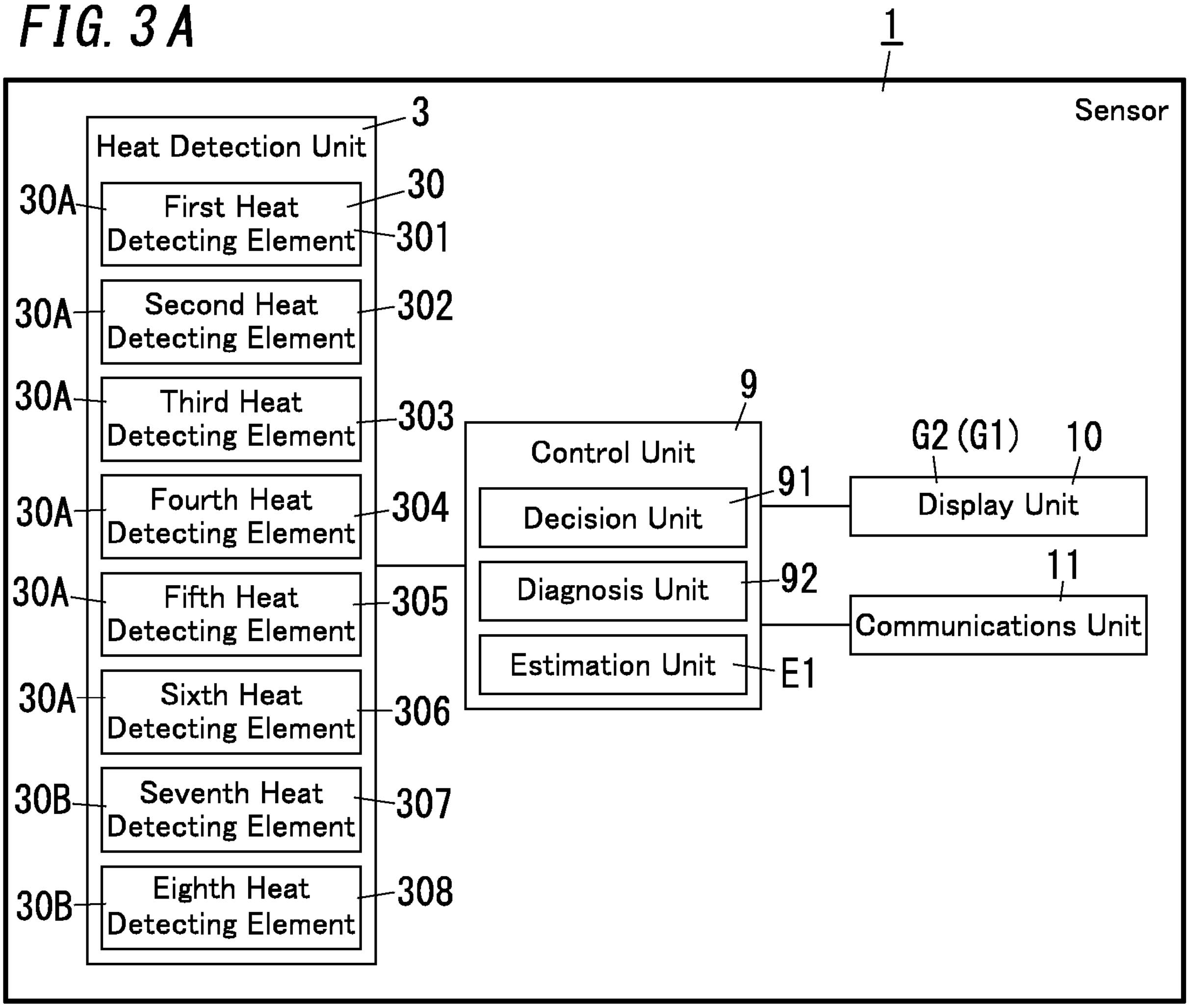

1
Sensor
Heat Detection Unit
3
30
First Heat Detecting Element
301
Second Heat Detecting Element
302
Third Heat Detecting Element
303
Fourth Heat Detecting Element
304
Fifth Heat Detecting Element
305
Sixth Heat Detecting Element
306
Seventh Heat Detecting Element
307
Eighth Heat Detecting Element
308
30A
30B
9
Control Unit
Decision Unit
91
Diagnosis Unit
92
Estimation Unit
E1
G2 (G1)
10
Display Unit
11
Communications Unit

FIG. 3B

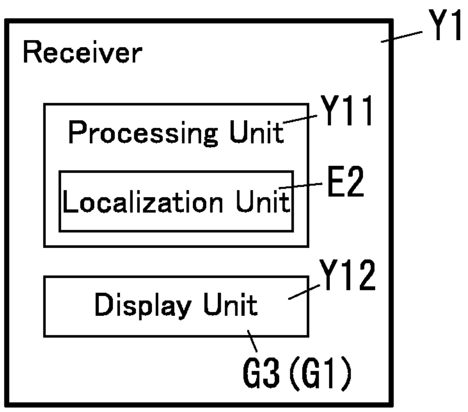

Receiver
Y1
Processing Unit
Y11
Localization Unit
E2
Display Unit
Y12
G3 (G1)

FIG. 4

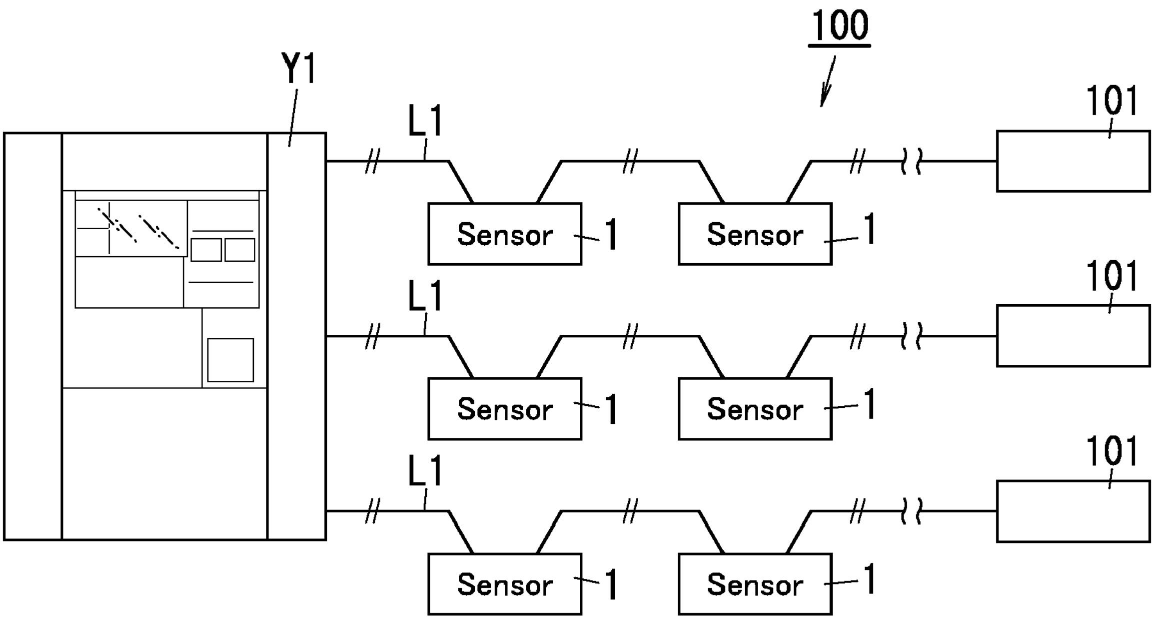

100
Y1
L1
L1
L1
101
101
101
Sensor
Sensor
Sensor
Sensor
Sensor
Sensor
1
1
1
1
1
1

FIG. 5

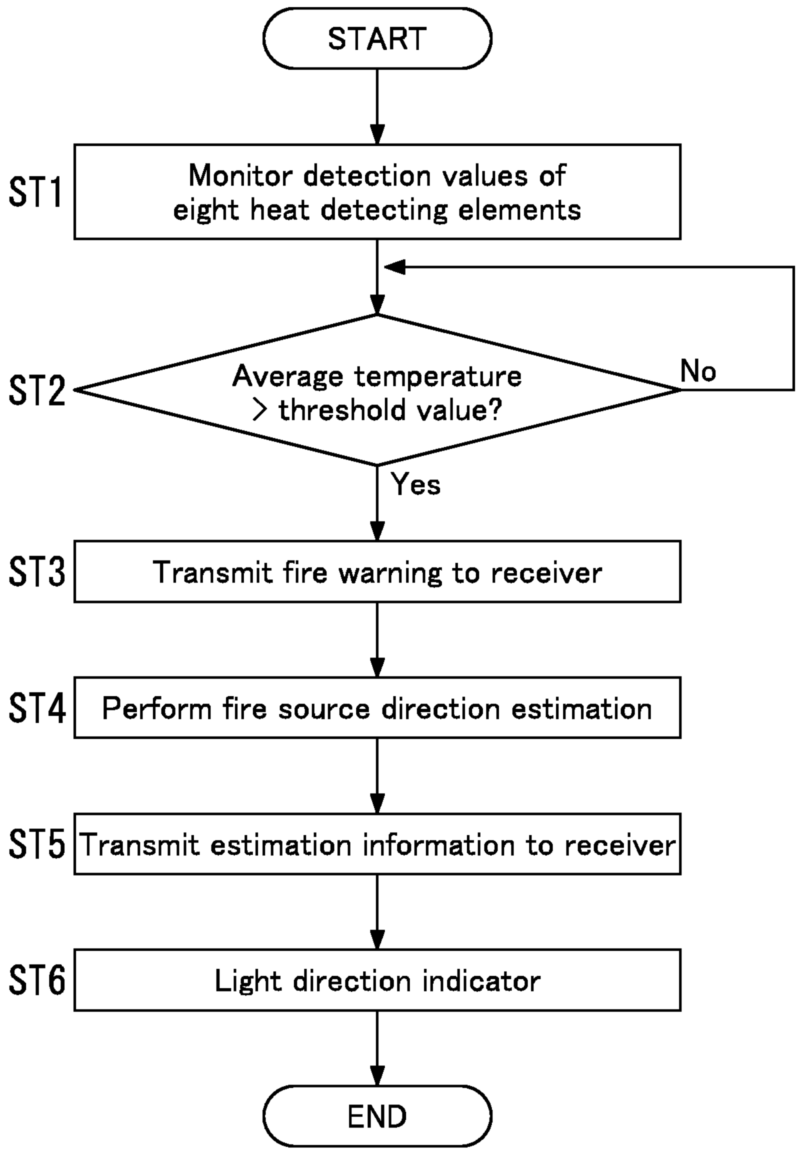

START
ST1
Monitor detection values of eight heat detecting elements
ST2
Average temperature > threshold value?
No
Yes
ST3
Transmit fire warning to receiver
ST4
Perform fire source direction estimation
ST5
Transmit estimation information to receiver
ST6
Light direction indicator
END

FIG. 6

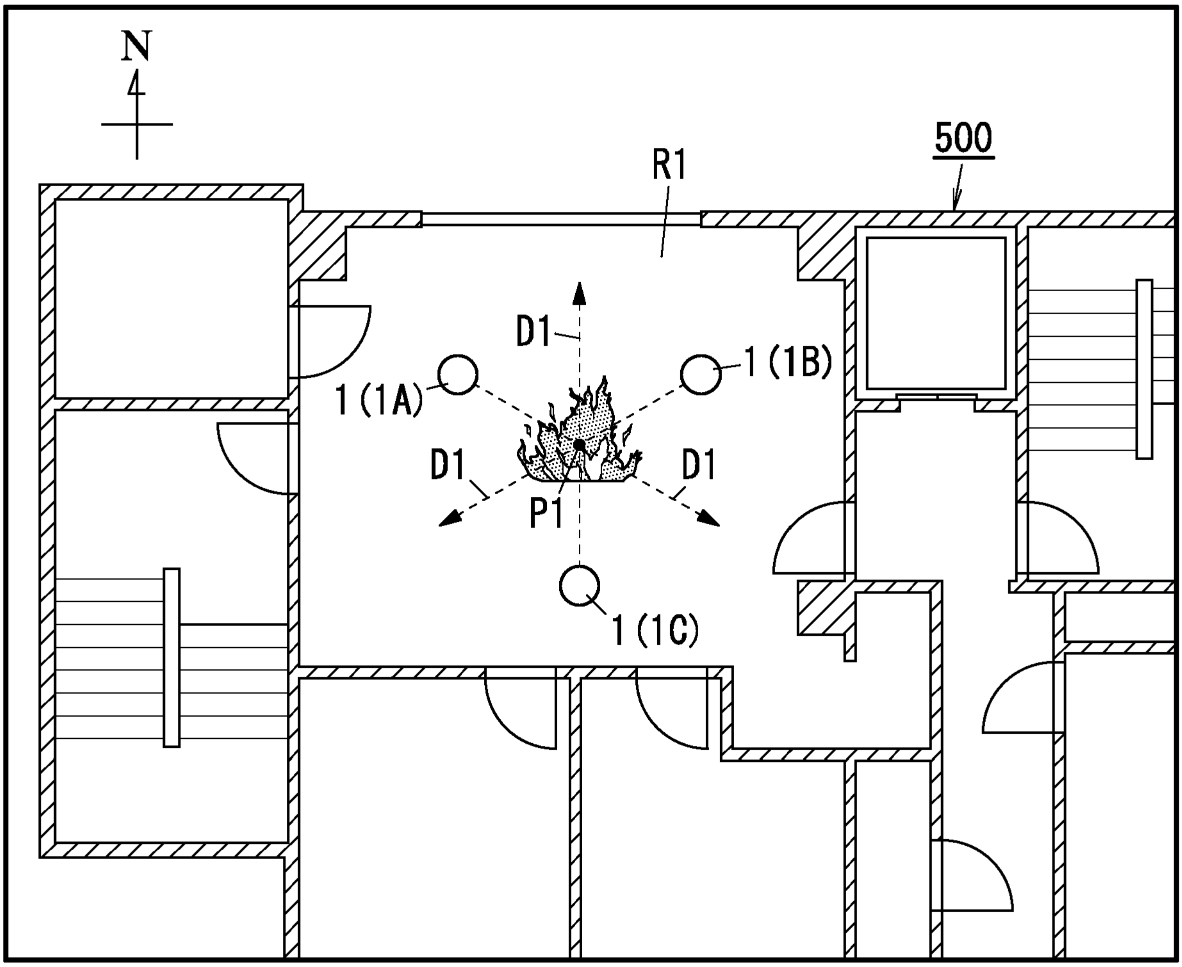
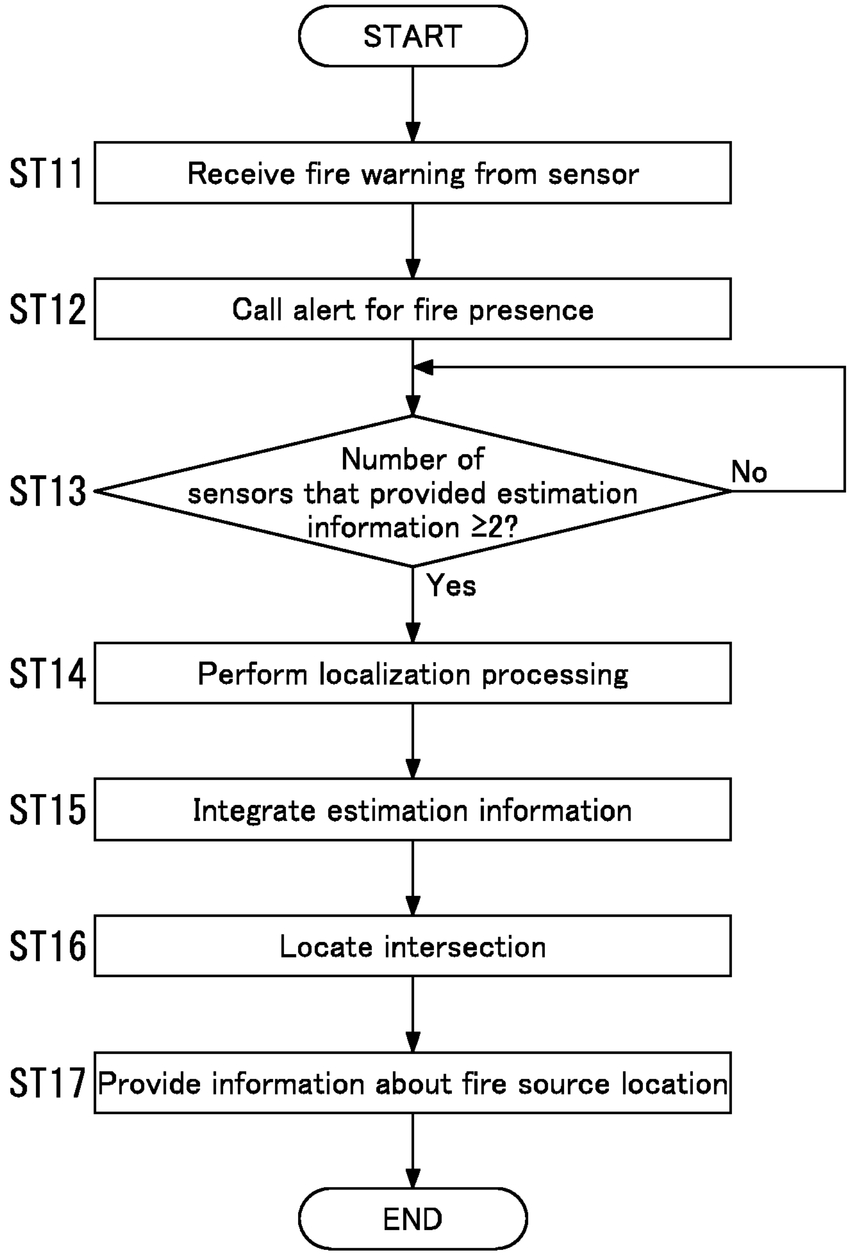


FIG. 7


START
ST11
Receive fire warning from sensor
ST12
Call alert for fire presence
ST13
Number of sensors that provided estimation information ≥2?
No
Yes
ST14
Perform localization processing
ST15
Integrate estimation information
ST16
Locate intersection
ST17
Provide information about fire source location
END

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EUROPEAN SEARCH REPORT

Application Number
EP 21 18 3008

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

G08B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	19 November 2021	Heß, Rüdiger

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19-11-2021

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JP 2019212269 A	12-12-2019	EP 3806057 A1	14-04-2021
		JP 2019212269 A	12-12-2019
		TW 202004692 A	16-01-2020
WO 2020026499 A1	06-02-2020	JP WO2020026499 A1	03-06-2021
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