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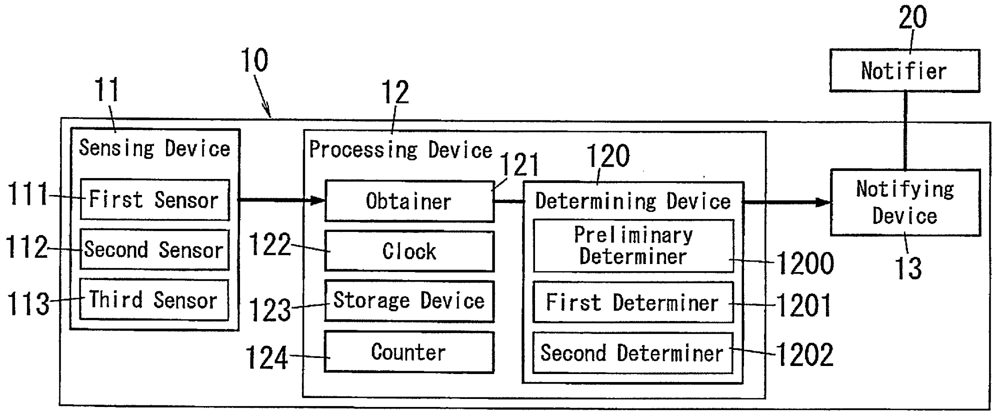
(54) DETECTOR, DETECTION METHOD, DETECTION SYSTEM, PROGRAM

(57) An objective is to suppress false notification without learning threshold values. The detector **(10)** includes a first sensor **(111)**, a second sensor **(112)**, a processing device **(12)**, and a notifying device **(13)**. The processing device determines whether a predetermined condition is satisfied with regard to a concentration of smoke measured by the first sensor **(111)** and a concentration of carbon monoxide measured by the second sensor **(112)**. The processing device **(12)** selects either a first condition or a second condition as the predetermined condition based on a result of determination of whether a switching condition for the concentration of smoke is satisfied. The first condition is for either the concentration of smoke or the concentration of carbon monoxide. The second condition is for both the concentration of smoke and the concentration of carbon monoxide.

FIG. 1



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Description

Technical Field

[0001] The present invention generally relates to detectors, detection methods, detection systems, and programs, and particularly relates to a detector for sensing a desired component in air, a detection method performed by the detector, a detection system including the detector, and a program used in the detector.

Background Art

[0002] In the past, there has been proposed a detector for sensing components in air such as carbon monoxide, smoke, and dust. For example, Document 1 (JP 4066761 B2) discloses a fire detector which outputs a fire warning signal warning about the possibility of a fire, based on a monitored concentration of smoke. Document 1 also discloses techniques of determining whether a fire has occurred, by use of a temperature difference in addition to an amount of smoke.

[0003] Document 2 (JP 2006-277138 A) discloses techniques of monitoring concentrations of smoke and carbon monoxide and determining that a fire has occurred when a rate of change in an amount of smoke or a rate of change in an amount of carbon monoxide exceeds a threshold value.

[0004] Document 1 discloses learning of threshold values for the information on smoke and the temperature difference in order to improve reliability of fire detection. Therefore, it may take a relatively long the time to start actual operation.

[0005] In contrast, Document 2 discloses that fire warning is given when a concentration of smoke or carbon monoxide exceeds a threshold value or when the rate of change in the amount of carbon monoxide. In other words, it may be determined that a fire has occurred, when only the concentration of smoke exceeds the threshold value. This may lead to false notification if there is steam or the like.

Summary of Invention

[0006] An objective of the present invention would be to propose a detector capable of suppressing false notification without learning threshold values. Other objectives of the present invention would be to propose a detection method performed by the detector, a detection system including the detector, and a program used in the detector.

[0007] The detector of one aspect in accordance with the present invention includes: a first sensor configured to measure a concentration of smoke in air; a second sensor configured to measure a concentration of carbon monoxide in air; a processing device configured to determine whether a predetermined condition is satisfied with regard to the concentration of smoke measured by the first sensor and the concentration of carbon monoxide measured by the second sensor; and a notifying device configured to output a notification signal when the predetermined condition is satisfied. The processing device is configured to select either a first condition or a second condition as the predetermined condition based on a result of determination of whether a switching condition for the concentration of smoke is satisfied, the first condition being for either the concentration of smoke or the concentration of carbon monoxide, and the second condition being for both the concentration of smoke and the concentration of carbon monoxide.

[0008] The detection method of one aspect in accordance with the present invention includes: obtaining, from a sensing device, a concentration of smoke in air and a concentration of carbon monoxide in air; determining, by a processing device, whether a predetermined condition is satisfied with regard to the obtained concentration of smoke and concentration of carbon monoxide; outputting, from a notifying device, a notification signal when the predetermined condition is satisfied. The method further includes selecting, by the processing device, either a first condition or a second condition as the predetermined condition based on a result of determination of whether a switching condition for the concentration of smoke is satisfied, the first condition being for either the concentration of smoke or the concentration of carbon monoxide, and the second condition being for both the concentration of smoke and the concentration of carbon monoxide.

[0009] The detection system of one aspect in accordance with the present invention includes: the above detector; and a notifier configured to give notice according to the notification signal outputted from the notifying device.

[0010] The program of one aspect in accordance with the present invention is for allowing one or more computers to function as the processing device and the notifying device of the above detector.

Brief Description of Drawings

[0011]

FIG. 1 is a block diagram of an embodiment.

FIG. 2 is an explanatory diagram of operation of the embodiment.

FIG. 3 is an explanatory diagram illustrating a flow chart of a reading process of the embodiment.

FIG. 4 is an explanatory diagram illustrating a flow chart of a notifying process of the embodiment.

FIG. 5 is an explanatory diagram of operation of the embodiment.

FIG. 6 is an explanatory diagram illustrating a flow chart of part of a fire determination process of the embodiment.

FIG. 7 is an explanatory diagram illustrating a flow chart of other part of a fire determination process of the embodiment.

FIG. 8 is an explanatory diagram illustrating a flow chart of other part of a fire determination process of the embodiment.

FIG. 9 is an explanatory diagram of operation of the embodiment.

FIG. 10 is an explanatory diagram of operation of the embodiment.

FIG. 11 is a diagram of a case where the embodiment applies.

FIG. 12 is a diagram of another case where the embodiment applies.

Description of Embodiments

[0012] As shown in **FIG. 1,** a detector **10** which is described later, includes a first sensor **111,** a second sensor **112,** a processing device **12,** and a notifying device **13.** The first sensor **111** is configured to measure a concentration **Cs** of smoke in air. The second sensor **112** is configured to measure a concentration **Cc** of carbon monoxide in air. The processing device **12** is configured to determine whether a predetermined condition is satisfied with regard to the concentration **Cs** of smoke measured by the first sensor **111** and the concentration **Cc** of carbon monoxide measured by the second sensor **112.** The notifying device **13** is configured to output a notification signal when the predetermined condition is satisfied. The processing device **12** is configured to select either a first condition or a second condition as the predetermined condition based on a result of determination of whether a switching condition for the concentration **Cs** of smoke is satisfied. The first condition is determined for either the concentration **Cs** of smoke or the concentration **Cc** of carbon monoxide. The second condition is determined for both the concentration **Cs** of smoke and the concentration **Cc** of carbon monoxide.

[0013] Preferably, the switching condition is that an amount Δ**Cs** of change in the concentration **Cs** of smoke within a predetermined reference time period equal to or larger than a first determination value **Vs2** and the processing device **12** is configured to determine whether the switching condition is satisfied.

[0014] Preferably, the processing device **12** includes a preliminary determiner **1200,** a first determiner **1201,** and a second determiner **1202.** The preliminary determiner **1200** is configured to determine whether the switching condition is satisfied. The first determiner **1201** is configured to determine, without considering the concentration **Cc** of carbon monoxide, whether the first condition including a condition that the concentration **Cs** of smoke is equal to or higher than a second determination value **Vs1** is satisfied. The second determiner **1202** is configured to determine whether the second condition is satisfied. The second condition includes a condition that the concentration **Cs** of smoke is equal to or higher than the second determination value **Vs1** in addition to a condition that an amount Δ**Cc** of change in the concentration **Cc** of carbon monoxide within a predetermined reference time period is equal to or larger than a third determination value **Vc2.** The preliminary determiner **1200** is configured to, when determining that the amount Δ**Cs** of change relating to smoke is smaller than the first determination value **Vs2,** select the first determiner **1201** and select the first condition as the predetermined condition. The preliminary determiner **1200** is configured to, when determining that the amount Δ**Cs** of change relating to smoke is equal to or larger than the first determination value **Vs2,** select the second determiner **1202** and select the second condition as the predetermined condition.

[0015] Additionally, the processing device **12** may be configured to cyclically repeat, by the preliminary determiner **1200,** a selection process of selecting according to the switching condition. This selection process is a process of selecting the first determiner **1201** when the amount Δ**Cs** of change relating to smoke is determined to be smaller than the first determination value **Vs2** and selecting the second determiner **1202** when the amount Δ**Cs** of change relating to smoke is determined to be equal to or larger than the first determination value **Vs2.** Preferably, the preliminary determiner **1200** is configured to, when a state where the amount Δ**Cs** of change relating to smoke is equal to or larger than the first determination value **Vs2** continues for a first determination time period **Td1**, start a mode of selecting the second determiner **1202** irrespective of the result of determination of whether the switching condition is satisfied. In this case, the preliminary determiner **1200** is configured to instruct the second determiner **1202** to determine whether a condition including a condition that the concentration **Cs** of smoke is equal to or higher than the second determination value **Vs1** in addition to a condition that the amount Δ**Cc** of change relating to carbon monoxide is equal to or larger than the third determination value **Vc2** is satisfied. Preferably, the preliminary determiner **1200** is configured to, when a state where the concentration **Cs** of smoke is smaller than a predetermined threshold value **Vs0** continues for a second determination time period **Td2,** start a mode of selecting either the first determiner **1201** or the second determiner **1202** based on the result of determination of whether the switching condition is satisfied. In this case, more preferably, the second determination time period **Td2** is set to a time period longer than the first determination time period **Td1**.

[0016] The detector **10** may further include a third sensor **113** configured to measure a temperature. In this case, the processing device **12** is configured to determine whether the predetermined condition is satisfied with regard to the temperature measured by the third sensor **113.**

[0017] A detection method described below includes: obtaining, from a sensing device **11,** a concentration **Cs** of smoke in air and a concentration **Cc** of carbon monoxide in air; and determining, by a processing device **12,** whether a predetermined condition is satisfied with regard to the obtained concentration **Cs** of smoke and concentration **Cc** of carbon monoxide. Additionally, the detection method includes outputting, from a notifying device **13,** a notification signal when a result of determination by the processing device **12** indicates that the predetermined condition is satisfied. The predetermined condition judged by the processing device **12** is selected from a first condition and a second condition based on a result of determination of whether a switching condition for the concentration of smoke is satisfied. The first condition is determined for either the concentration **Cs** of smoke or the concentration **Cc** of carbon monoxide. The second condition is determined for both the concentration **Cs** of smoke and the concentration of carbon monoxide.

[0018] The switching condition is that an amount of change in the concentration **Vs** of smoke within a predetermined reference time period is equal to or larger than a first determination value. The first condition includes a condition that the concentration **Cs** of smoke is equal to or higher than a second determination value **Vs1** is satisfied, but does not include a condition for the concentration **Cc** of carbon monoxide. Additionally, the second condition includes a condition that the concentration **Cs** of smoke is equal to or higher than the second determination value **Vs1** in addition to a condition that an amount Δ**Cc** of change in the concentration of carbon monoxide within a predetermined reference time period is equal to or larger than a third determination value **Vc2.** The processing device **12** selects the first condition when the amount Δ**Cs** of change relating to smoke is smaller than the first determination value **Vs2.** The processing device **12** selects the second condition when the amount Δ**Cs** of change relating to smoke is equal to or larger than the first determination value **Vs2**.

[0019] Hereinafter, the present embodiment is described in detail. In the present embodiment, the detector **10** is exemplified by a fire detector for sensing a fire. The described fire detector includes a housing (not shown) attached in use to a ceiling of a space to be monitored. This fire detector is of a smoke and heat complex type that determines whether a fire has occurred, by use of three types of information which are a concentration of carbon monoxide (hereinafter referred to as "CO"), a concentration of smoke, and a temperature. In other words, the fire detector is configured to determine whether a fire has occurred, based on monitored CO and smoke which are components in the desired space, and additionally a monitored temperature.

[0020] It is not always necessary to monitor the temperature of the desired space. The techniques of the present embodiment may apply to a detector monitoring only a concentration of CO, in addition to a detector monitoring two types of components which are CO and smoke. Additionally, the fire detector may be configured to detect a fire based on a result of monitoring of ultraviolet rays.

[0021] As shown in **FIG. 1,** the detector **10** of the present embodiment includes a sensing device **11,** the processing device **12,** and the notifying device **13.** The sensing device **11** includes the first sensor **111** configured to measure a concentration of smoke, the second sensor **112** configured to measure a concentration of CO, and the third sensor **113** configured to measure a temperature. The processing device **12** is configured to perform process described below to determine whether a fire has occurred.

[0022] This detector **10** is used in combination with a notifier **20** to give a detection system. In summary, the detection system includes the detector **10** described below, and the notifier **20** configured to give notice according to the notification signal outputted from the notifying device **13.** Thus, when the processing device **12** determines that a fire has occurred, the notifying device **13** outputs the notification signal to the notifier **20.** The notifier **20** may include at least one of a device for audio notification such as a buzzer and a voice synthesis device and a device for visual notification such as one or more light emitting diodes and a liquid crystal display. As described above, when the processing device **12** determines that a fire has occurred, the notifying device **13** notifies one or more persons of occurrence of a fire by way of the notifier **20.**

[0023] The housing of the fire detector includes inside a space for receiving smoke. The first sensor **111** is of a photoelectric type that includes a light emitting device for emitting light to the space, and a light receiving device for receiving light from the space. The first sensor **111** is configured to measure the concentration of smoke by use of scattering of light caused by smoke. The first sensor **111** is configured to output a value corresponding to a rate of decrease in light, as the concentration of smoke. The first sensor **111** may be not limited to having a configuration using scattering of light caused by smoke, but may have a configuration using a property of smoke not transmitting light. Additionally, the first sensor **111** may not be limited to be of the photoelectric type but may be of an ionization type.

[0024] Principles of measurement of the second sensor **112** are not limited particularly, as long as the second sensor **112** can measure the concentration of CO. However, it is preferable to lower the cost of the second sensor **112,** and therefore the second sensor **112** is supposed to an electrochemical sensor in this embodiment. The electrochemical sensor may include a detection electrode containing catalyst, a counter electrode facing the detection electrode, an ion conductor between the detection electrode and the counter electrode. This sensor is configured so that a reaction of water vapor and CO in air with the catalyst in the detection electrode causes movement of charges between the detection electrode and the counter electrode.

[0025] This type of sensor has relatively low sensitivity and accuracy. Therefore, there may be a problem that this type of sensor has difficulty in ensuring detection accuracy when the concentration of CO is relatively low. In summary, when this type of sensor is used, it may be difficult to evaluate the concentration of CO by its absolute value in a range of low concentrations of CO. Note that, there may be other sensors for measuring CO in different principles with high accuracy even in a range of low concentrations. However, such sensors may be relatively expensive and large and thus using such sensors is difficult actually. The detector **10** described below can detect CO from a space if the space has a lower concentration of CO.

[0026] The third sensor **113** is configured to measure a temperature higher than about 50°C. The third sensor **113** may include a thermistor, for example.

[0027] The processing device **12** includes an obtainer **121** configured to obtain information measured by the sensing device **11.** The obtainer **121** serves an interface to the sensing device **11.** The obtainer **121** converts analog values respectively obtained from the first sensor **111,** the second sensor **112,** and the third sensor **113** into corresponding digital values. In the following, the digital value corresponding to the first sensor **111** is referred to as a concentration of smoke, and the digital value corresponding to the second sensor **112** is referred to as a concentration of CO, and the digital value corresponding to the third sensor **113** is referred to as a temperature value.

[0028] The processing device **12** includes a main hardware component including a device equipped with one or more processors operating according to a program. This type of device may include an MC (microcontroller) integrated with one or more memories, or a set of a device equipped with one or more processors and external one or more memories. Such a device may also function as the notifying device **13.** Therefore, the program allows a computer to function as the processing device **12** and the notifying device **13.**

[0029] The program is supposed to be preliminarily stored in a ROM (read only memory). However, the program may be stored in the ROM by use of an assisting device such as a computer connected to the ROM. In this case, the program provided to the assisting device may be supplied through telecommunication lines such as the Internet, or by use of a computer-readable recording medium.

[0030] The processing device **12** further includes a determining device **120** configured to determine whether a fire has occurred, by use of the concentration of CO, the concentration of smoke, and the temperature value. The processing device **12** further includes a clock **122,** a storage device **123,** and a counter **124.** The determining device **120** includes the preliminary determiner **1200,** the first determiner **1201,** and the second determiner **1202** (see **FIG. 1**).

[0031] The clock **122** measures the unit time **Tu,** and the processing device **12** decides a timing of obtaining information from the sensing device **11** based on the unit time **Tu.** The unit time **Tu** may be set to one second, for example. The storage device **123** stores therein the information obtained by the obtainer **121** from the sensing device **11,** if necessary. Functions of the counter **124** are described later.

[0032] The determining device **120** provided to the processing device **12** performs processes including a reading process **S10,** a notifying process **S20,** and a fire determining process **S30,** as shown in **FIG. 2.** The reading process **S10** is a process of obtaining, by the processing device **12,** information from the sensing device **11** by way of the obtainer **121.** The notifying process **S20** is a process of giving notice of occurrence of a fire by way of the notifying device **13.** Additionally, the fire determining process **S30** is a process of determining whether a fire has occurred, by use of information obtained from the sensing device **11** in the reading process **S10**. The fire determining process **S30** is performed by the preliminary determiner **1200,** the first determiner **1201,** and the second determiner **1202** of the determining device **120** (see **FIG. 1**).

[0033] While a fire has not been occurred, the processes are regularly repeated in the same order of the reading process **S10,** the notifying process **S20,** and the fire determining process **S30** for each cycle. In other words, processing cycles through a sequence of a link **L11,** a link **L12,** and a link **L13** for each cycle. Time necessary for one cycle of this sequence may fall within a range of time slightly longer than the unit time **Tu.** As described later, a time period for one cycle of the sequence of the reading process **S10,** the notifying process **S20,** and the fire determining process **S30** may contain time periods for various processes, in addition to a time period for waiting the unit time **Tu.** However, the time periods for the various processes are sufficiently shorter than the time period for waiting. Thus, the time period for one cycle of the sequence of the reading process **S10,** the notifying process **S20**, and the fire determining process **S30** may fall within a range of time periods similar to the unit time **Tu.**

[0034] In contrast, when a fire is determined to have occurred in the fire determining process **S30**, different routes are selected according to timings when the fire is determined to have occurred. Notice of occurrence of a fire may be given through either a route from the fire determining process **S30** to the notifying process **S20** through the reading process **S10,** or another route from the reading process **S10** to the notifying process **S20** through the notifying process **S20** and the fire determining process **S30.** In other words, when a fire is determined to have occurred in the fire determining process **S30,** notice is given through either a route including the link **L13** and the link **L11** or another route including the link **L11**, the link **L12** and a link **L14.** After the notice of occurrence of a fire is given in the notifying process **S20,** processing returns to the reading process **S10** by way of a link **L15.**

[0035] Hereinafter, the individual processes of the reading process **S10,** the notifying process **S20**, and the fire determining process **S30** are described in detail. As shown in **FIG. 3,** in the reading process **S10,** the determining device **120** obtains the temperature value θ from the third sensor **113** through the obtainer **121 (S11),** and obtains the concentration **Cs** of smoke from the first sensor **111** through the obtainer **121 (S12).** The determining device **120** may obtain which one of the temperature value θ and the concentration **Cs** of smoke before obtaining the other. The obtained concentration **Cs** of smoke is compared with a threshold value **Vs0** (e.g., 1 [%/m]) for determining whether smoke exists **(S13).** Note that, in the present embodiment, the concentration **Cs** of smoke is represented by a rate of decrease in light per one meter, and a unit thereof is [%/m].

[0036] When the concentration **Cs** of smoke is equal to or higher than the threshold value **Vs0 (S13:** yes), the obtainer **121** obtains the concentration **Cc** of CO from the second sensor **112 (S15).** In contrast, when the concentration **Cs** of smoke is lower than the threshold value **Vs0 (S13:** no) and when a count value n has reached a predetermined value **Mc** (**S14:** yes), the obtainer **121** obtains the concentration **Cc** of CO from the second sensor **112 (S15).** After the concentration **Cc** of CO is obtained **(S15),** the determining device **120** resets the count value n to **1** (**S16**). Additionally, when the concentration **Cs** of smoke is lower than the threshold value **Vs0 (S13:** no) and when the count value n have not yet reached the predetermined value **Mc** (**S14:** no), the determining device **120** adds **1** to the count value n (**S17**).

[0037] In summary, the obtainer **121** obtains the concentration **Cc** of CO at any of the following timings. When the concentration **Cs** of smoke is equal to or higher than the threshold value **Vs0**, the obtainer **121** obtains the concentration **Cc** of CO irrespective of the count value n. When a state where the concentration **Cs** of smoke is lower than the threshold value **Vs0** continues until the count value n reaches the predetermined value **Mc,** the obtainer **121** obtains the concentration **Cc** of CO at a timing when the count value n reaches the predetermined value **Mc.** In other words, the concentration **Cc** of CO is obtained immediately when smoke is detected, and the concentration **Cc** of CO is obtained at a relatively long time interval while smoke is not detected. The time interval at which the obtainer **121** obtains the concentration of CO while smoke is not detected is **Mc** times longer than a time interval in a case where smoke is detected, and **Mc** is set in a range of around 3 to 10.

[0038] As described above, the concentration **Cs** of smoke is obtained, and the concentration **Cc** of CO is obtained if necessary, and then the reading process **S10** ends. After the reading process **S10,** processing proceeds to the notifying process **S20.** As shown in **FIG. 4,** in the notifying process **S20**, the determining device **120** determines whether a fire has already been determined to have occurred in the fire determining process **S30** **(S21).** As described later, in the fire determining process **S30,** a fire flag **F1** is set to "1" when there is determined to be a probability that a fire has occurred, and the fire flag **F1** is set to "0" when a fire is determined to have not occurred.

[0039] When the fire flag **F1** is not "1" at step **S21** (**S21:** no), processing proceeds to the fire determining process **S30.** In contrast, when the fire flag **F1** is "1" at step **S21** (**S21:** yes), there would be a high probability that a fire has occurred, and thus the determining device **120** compares the concentration **Cs** of smoke obtained at step **S12** with the (second) determination value **Vs1 (S22).** The determination value **Vs1** is set to a value (e.g., 3.5 [%/m]) larger than the threshold value **Vs0.**

[0040] When the concentration **Cs** of smoke is equal to or higher than the determination value **Vs1** (**S22:** yes), notice of a fire is given through the notifying device **13** **(S26).** Accordingly, when the processing device **12** is informed of a high probability that a fire has occurred, and when the concentration **Cs** of smoke is equal to or higher than the determination value **Vs1,** the processing device **12** gives notice of a fire through the notifying device **13.**

[0041] When the probability that a fire has occurred is determined to be high (**S21:** yes) and when the concentration **Cs** of smoke is lower than the determination value **Vs1** (**S22:** no), the fire flag **F1** is reset to "0" (**S23**) and additionally a count value **Ic** is also reset to **0** (**S24**). The count value **Ic** is used for counting how many times determination described below has been done for the concentration **Cc** of CO in the fire determining process **S30.**

[0042] As described above, when the fire flag **F1** is "1" at step **S21** and there has been determined a probability that a fire has occurred, but when the concentration **Cs** of smoke does not meet a condition of a fire at subsequent step **S22,** the determining device **120** determines that a fire has not been occurred. After step **S24,** processing proceeds to the fire determining process **S30,** and it is determined whether a fire has occurred.

[0043] In the notifying process **S20,** the condition required for giving notice of a fire through the notifying device **13** also includes a condition that the fire flag **F1** is not "0" after the fire determining process **S30** (**S25**: no). Therefore, the determining device **120** gives notice of a fire through the notifying device **13** when any of the following conditions is satisfied **(S26).** In summary, when any of one condition that the fire flag **F1** is "1" and the concentration **Cs** of smoke is equal to or higher than the determination value **Vs1** and the other condition that the fire flag **F1** is not "0" even after the fire determining process **S30** is satisfied, the determining device **120** instructs the notifier **20** to give notice of a fire **(S26).**

[0044] When the fire flag **F1** is "0" after the fire determining process **S30** (**S25**: yes), it is determined that a fire has not been occurred. When the fire flag **F1** is "0" after the fire determining process **S30** (**S25:** yes), the determining device **120** returns to the reading process **S10** after a lapse of the unit time **Tu (S27).** The unit time **Tu** may be set to 1 second, for example. When the unit time **Tu** is set to 1 second, the time interval for obtaining the concentration **Cc** of CO at step **S15** is around **Mc** seconds in a time period when the state where the concentration **Cs** of smoke is lower than the threshold value **Vs0** continues. Actually, when processing time of the reading process **S10,** the notifying process **S20,** and the fire determining process **S30** is supposed to be **Tp,** the time interval for obtaining the concentration **Cc** of CO is equal to (1 + **Tp**) × **Mc** seconds. In this case, **Tp** is much less than 1, and thus the time interval for obtaining the concentration **Cc** of CO is substantially equal to **Mc** seconds.

[0045] In the instance of the notifying process **S20** shown in **FIG. 4,** processing returns to the reading process **S10** after a lapse of the unit time **Tu** (**S27**) even when notice of a fire is given at step **S26.** Therefore, after giving notice of a fire at step **S26**, the determining device **120** returns to the reading process **S10** while continuing giving notice of a fire. In summary, notice of a fire is continued once notice of a fire is given.

[0046] Note that, the notifying process **S20** may include a process of ending giving notice of a fire when notice of a fire is falsely given. When processing returns to the reading process **S10** and subsequently proceeds to the notifying process **S20,** the fire determining process **S30** may be done. In this fire determining process **S30,** giving notice may be ended when the fire flag **F1** becomes "0".

[0047] Next, the fire determining process **S30** is described with reference to **FIG. 5** to **FIG. 8.** As shown in **FIG. 5,** the fire determining process **S30** mainly includes three different processes. A preliminary process **S31** determines whether there is a probability that a fire has occurred, based on only the temperature value θ obtained from the third sensor **113.** A first process **S32** determines whether there is a probability that a fire has occurred, based on only the concentration **Cs** of smoke. A second process **S33** determines whether there is a probability that a fire has occurred, based on the concentration **Cs** of smoke and the concentration **Cc** of CO. The preliminary process **S31** is performed by the preliminary determiner **1200,** and the first process **S32** is performed by the first determiner **1201,** and the second process **S33** is performed by the second determiner **1202.**

[0048] In summary, to determine whether a fire has occurred, the fire determining process **S30** includes the preliminary process **S31** using the temperature value θ only, the first process **S32** using the concentration **Cs** of smoke only, and the second process **S33** using a combination of the concentration **Cc** of CO and the concentration **Cs** of smoke. The second process **S33** also includes a process of determining that a fire has not occurred when any of the concentration **Cc** of CO, the concentration **Cs** of smoke, and the temperature value θ does not satisfy a corresponding condition. Additionally, the second process **S33** includes a process of determining, when any of the concentration **Cc** of CO, the concentration **Cs** of smoke, and the temperature value θ does not satisfy a corresponding condition, whether to assign task of determining whether a fire has occurred, to the following fire determining process **S30. FIG. 5** shows "confirmed" which means that it is confirmed that a fire has occurred, and "unconfirmed" which means that that it cannot be confirmed that a fire has occurred though there is a possibility that a fire has occurred.

[0049] As shown in **FIG. 6,** the preliminary determiner **1200** performs the preliminary process **S31**, thereby comparing the temperature value θ obtained from the third sensor **113** with a determination value **Vt1**, and also comparing an amount Δθ of change in the temperature value θ within a predetermined reference time period **T1** with a determination value **Vt2** (**S311**). For example, when θ**(t)** represents the temperature value at time t and Δθ**(t)** represents the amount of change in the temperature value at the time t, Δθ(**t**) is given by a relation of Δθ**(t)** = θ**(t) -** θ**(t-T1).** The amount Δθ of change is equal to a difference (an absolute value of a difference) between the two temperature values θ obtained at points of time between which an interval is equal to the reference time period **T1,** that is, points of time of start and end of the reference time period **T1.**

[0050] Accordingly, dividing the amount Δθ of change by the reference time period **T1** gives a temperature gradient. Additionally, provided that the reference time period **T1** is set to appropriate unit time (e.g., 60 seconds), the amount Δθ of change is equivalent to the temperature gradient. Therefore, the condition of step **S311** may employ the temperature gradient as an alternative to the amount Δθ of change within the reference time period **T1.**

[0051] For example, the determination value **Vt1** for the temperature value θ may be set to around 60 [°C] and the reference time period **T1** may be set to be in a range of around 1 to 3 minutes. In other words, the determination value **Vt1** is set to a temperature value which is not observed unless a fire has occurred. The reference time period **T1** is set based on a length of time in which rise in temperature is observed while a fire occurs.

[0052] Note that, the time interval at which the determining device **120** obtains the temperature value θ from the third sensor **113** is shorter than the reference time period **T1** (e.g., the time interval is around 1 second). Therefore, the amount Δθ of change relating to the temperature is obtained after the fire determining process **S30** is performed multiple times. The processing device **12** includes the storage device **123,** and the storage device **123** includes a storage region for storing the temperature value θ each time the obtainer **121** obtains the temperature value θ from the third sensor **113.** With regard to the storage device 123, the storage region for storing the temperature value θ functions equivalent to a shift register, and the amount Δθ of change is calculated as a difference between foremost data (earliest data) and rearmost data (latest data) of a series of data obtained by the reference time period **T1.**

[0053] At step **S311,** when at least one of conditions of θ ≥ **Vt1** and Δθ ≥ **Vt2** is satisfied, a fire is determined to have occurred, and thus the fire flag **F1** is set to "1" **(S34).** In contrast, at step **S311,** when any of the conditions of θ ≥ **Vt1** and Δθ ≥ **Vt2** is not satisfied, that is, when θ is smaller than **Vt1** and Δθ is smaller than **Vt2**, it is determined whether a temporary determination flag **F2** is "1" (**S312**).

[0054] The reference time period **T1** for calculating the amount $\Delta\theta$ of change is set to be relatively long, and this can facilitate distinguishing the amount $\Delta\theta$ of change in a time period when the temperature value θ sharply rises accompanied with occurrence of a fire from the amount $\Delta\theta$ of change in a time period when change in the temperature value θ is relatively small. Consequently, it is possible to easily determine whether an interested time period is the time period when the temperature value θ sharply rises accompanied with occurrence of a fire, or the time period when change in the temperature value θ is relatively small.

[0055] As described above, the detector **10** further includes the third sensor **113** configured to measure the temperature, and the processing device **12** is configured to determine whether the predetermined condition is satisfied with regard to the temperature measured by the third sensor **113.** Thus, the detector **10** can determine whether a fire has occurred, based on the temperature in addition to the concentration **Cs** of smoke and/or the concentration Cc of CO, and this may lead to improvement of accuracy.

[0056] The temporary determination flag **F2** is set to "1" when whether a fire has occurred is unconfirmed and such determination is assigned to the following fire determining process **S30.** In other words, the temporary determination flag **F2** is set to "1" when it cannot be confirmed that a fire has occurred but a probability that a fire has occurred cannot be denied. In contrast, when it can be confirmed that a fire has not occurred, the preliminary determiner **1200** sets the temporary determination flag **F2** to "0".

[0057] At step **S312,** when the temporary determination flag **F2** is not "1", the preliminary determiner **1200** compares an amount Δ**Cs** of change in the concentration **Cs** of smoke within a predetermined reference time period **T2** with a (first) determination value **Vs2** (**S313**). When **Cs(t)** represents the concentration of smoke at the time t and Δ**Cs(t)** represents the amount of change in the concentration **Cs** of smoke at the time t in a similar manner to the amount $\Delta\theta$ of change in the temperature value θ, Δ**Cs(t)** can be given by a relation $\Delta Cs(t) = Cs(t) - Cs(t-T2)$. The amount Δ**Cs** of change is equal to a difference (an absolute value of a difference) between the two concentrations **Cs** of smoke obtained at points of time between which an interval is equal to the reference time period **T2,** that is, points of time of start and end of the reference time period **T2.** Accordingly, dividing the amount Δ**Cs** of change by the reference time period **T2** gives a concentration gradient relating to smoke. Additionally, provided that the reference time period **T2** is set to appropriate unit time (e.g., 60 seconds), the amount Δ**Cs** of change is equivalent to the concentration gradient relating to smoke. Therefore, at step **S312** the concentration gradient may be used as an alternative to the amount Δ**Cs** of change within the reference time period **T2.**

[0058] The reference time period **T2** may be set to be in a range of around 30 seconds to 2 minutes. In other words, the reference time period **T2** is set to a time period sufficiently longer than the time interval at which the obtainer **121** obtains the concentration **Cs** of smoke in the reading process **S10**. However, the amount Δ**Cs** of change is updated every fire determining process **S30.**

[0059] **FIG. 9** shows a relationship among the concentration **Cs** of smoke, the reference time period **T2,** and the amount Δ**Cs** of change. This figure also shows a concentration gradient α**2** of the concentration **Cs** of smoke. As shown in the figure, the reference time period **T2** is set to be relatively long, and thus it is possible to find out a tendency of change in the concentration **Cs** of smoke even if the concentration **Cs** of smoke changes with time.

[0060] Note that, to calculate the amount Δ**Cs** of change in the concentration **Cs** of smoke within the reference time period **T2,** the concentration **Cs** of smoke obtained by the obtainer **121** is stored in the storage device **123** like a case of calculating the amount $\Delta\theta$ of change in the temperature value θ. In detail, the storage device **123** includes a storage region for storing the concentration **Cs** each time the obtainer **121** obtains the concentration **Cs** from the first sensor **111.** With regard to the storage device **123,** the storage region for storing the concentration **Cs** functions equivalent to a shift register, and the amount Δ**Cs** of change is calculated as a difference between foremost data (earliest data) and rearmost data (latest data) of a series of data obtained by the reference time period **T2.**

[0061] Note that, at step **S312,** when the temporary determination flag **F2** is "1", it is not confirmed whether a fire has occurred. Thus, it is necessary to confirm whether a fire has occurred in a subsequent process. Accordingly, when a state where the concentration **Cs** of smoke is lower than the threshold value **Vs0** continues for the second determination time period **Td2** (**S314**: yes), the temporary determination flag **F2** is set to "0" (**S315**) to confirm that a fire has not occurred. In other words, when the state where the concentration **Cs** of smoke is lower than the threshold value **Vs0** continues for a time period in which the fire determining process **S30** can be performed a number of times corresponding to the determination time period **Td2** (**S314**: yes), the preliminary determiner **1200** sets the temporary determination flag **F2** to "0" (**S315**).

[0062] The determination time period **Td2** is set to a time period sufficiently longer than a cycle (e.g., around 1 seconds) at which the determining device **120** obtains the concentration **Cs** of smoke from the first sensor **111,** and may be set to 60 seconds, for example. If the reading process **S10,** the notifying process **S20,** and the fire determining process **S30** are repeated at a cycle of about 1 second, the determination time period **Td2** is equivalent to time taken for the fire determining process **S30** to be performed sixty times. The threshold value **Vs0** is a lower limit value for determining that smoke has occurred, and thus is smaller than the determination value **Vs1** for determining that fire has occurred (e.g., $Vs0 \approx 0.3 \times Vs1$).

[0063] At step **S314,** when the state where the concentration **Cs** of smoke is lower than the threshold value **Vs0** does not continue for the determination time period **Td2** (**S314**: no), processing proceeds to the second process **S33.** In other words, when the concentration **Cs** becomes equal to or higher than the threshold value **Vs0** before a lapse of the determination time period **Td2,** processing proceeds to the second process **S33**. At step **S313,** when the amount Δ**Cs** of change in the concentration **Cs** of smoke is smaller than the determination value **Vs2** (or the concentration gradient α**2** relating to smoke is relatively low), processing proceeds to the first process **S32.** Further, at step **S313,** when the amount Δ**Cs** of change is equal to or larger than the determination value **Vs2** (or the concentration gradient α**2** relating to smoke is relatively high), process proceeds to the second process **S33.**

[0064] In brief, the condition [Δ**Cs** ≥ **Vs2**] at step **S313** in the preliminary process **S31** serves as a switching condition for determining which of the first process **S32** and the second process **S33** is selected. In summary, the switching condition is that the amount Δ**Cs** of change in the concentration **Cs** of smoke within the predetermined reference time period is equal to or larger than the first determination value **Vs2**, and the preliminary determiner **1200** determines whether the switching condition is satisfied. In other words, the preliminary determiner **1200** performs determination based on the switching condition relating to whether the amount Δ**Cs** of change in the concentration **Cs** of smoke within the predetermined reference time period is smaller than the first determination value **Vs2**. When the condition at step **S313** is not satisfied (**S313**: no), the processing device **12** selects the first process **S32.** When the condition at step **S313** is satisfied (**S313**: yes), the processing device **12** selects the second process **S33.**

[0065] The first process **S32** and the second process **S33** use a count value as described later. Hence, the processing device **12** includes the counter **124** configured to provide the count value. This counter **124** can increment and decrement the count value, and the minimum value of the count value is 0. When the fire flag **F1** is set to "0" in the notifying process **S20** (**S23**) or when the temporary determination flag **F2** is set to "0" in the fire determining process **S30** (**S315**), the count value of the counter **124** is reset to 0. The counter **124** is configured to provide the count value representing a continuous time period in which detection of smoke continues and the count value representing a continuous time period in which detection of CO continues.

[0066] The first determiner **1201** configured to perform the first process **S32** illustrated in **FIG. 7** determines whether a fire has occurred, based on the concentration **Cs** of smoke only, as described above. The first determiner **1201** employs a prerequisite that the temporary determination flag **F2** is "0" (**S312:** no, or **S315**) and the amount Δ**Cs** of change in the concentration **Cs** of smoke is smaller than the determination value **Vs2** (Δ**Cs** < **Vs2**) (**S313**: no). This prerequisite means that a fire has not occurred and change in the concentration Cs of smoke in the determination time period **Td2** has not been detected. In other words, satisfying the prerequisite of the first process **S32** indicates that there is a high probability that a fire has not occurred.

[0067] The condition for the first determiner **1201** to determine that a fire has occurred is that a state where the concentration **Cs** of smoke is high continues for a relatively long time period (e.g., around 10 seconds). The continuous time period in which detection of smoke continues is not limited to a time period in which the state where the concentration **Cs** of smoke obtained by the obtainer **121** is high is continuous. When the state where the concentration **Cs** is high is discontinuous but the state where the concentration **Cs** of smoke is high is considered continuous, the counter **124** provides the count value representing the continuous time period.

[0068] In the first process **S32**, the first determiner **1201** compares the concentration **Cs** of smoke obtained by the reading process **S10** with the determination value **Vs1** (**S321**). When the concentration **Cs** of smoke is equal to or higher than the determination value **Vs1** (**S321:** yes), the counter **124** increments the count value **Is** corresponding to smoke by one **(S322).** In contrast, when the concentration **Cs** of smoke is lower than the determination value **Vs1** (**S321:** no), the count value **Is** is decremented by two **(S323).** The count value **Is** is used for estimation of the continuous time period.

[0069] The count value **Is** is compared with a reference value **Ns (S324).** When the count value **Is** is larger than the reference value **Ns** (**S324**: yes), the first determiner **1201** determines that the state where the concentration **Cs** of smoke is equal to or higher than the determination value **Vs1** has continued, and sets the fire flag **F1** to "1" **(S34).** Note that, when the count value **Is** is smaller than the reference value **Ns** (**S324:** no), the determining device **120** starts the notifying process **S20.**

[0070] The continuous time period is time taken for the count value **Is** to reach the reference value **Ns.** Hence, the concentration **Cs** of smoke is allowed to be lower than the determination value **Vs1** before the continuous time period reaches the reference value **Ns.** This is because the concentration **Cs** of smoke varies with time and therefore the concentration **Cs** of smoke is likely to be lower than the determination value **Vs1** temporary after the concentration **Cs** of smoke has been equal to or higher than the determination value **Vs1** due to a fire. As described above, even if the concentration **Cs** becomes low temporary, monitoring of the concentration **Cs** of smoke is continued. Therefore, as long as the concentration **Cs** of smoke continuously corresponds to a case where a fire has occurred continues, a fire is determined to have occurred. Consequently, failure in notification can be suppressed.

[0071] In contrast, there may be a probability that the concentration **Cs** of smoke becomes equal to or higher than the determination value **Vs1** temporary due to smoking, cooking, or the like. However, the count value **Is** does not reach the reference value **Ns.** Therefore, as long as the reference value **Ns** is set appropriately, false notification can be suppressed. Additionally, when the concentration **Cs** of smoke is lower than the determination value **Vs1,** the count value **Is** is decremented by two **(S323).** When the concentration **Cs** of smoke is low, time taken for the count value **Is** to reach the reference value **Ns** increases. Therefore, effects of suppressing false notification can be expected.

[0072] The second determiner **1202** configured to perform the second process **S33** uses the concentration **Cc** of CO in addition to the concentration **Cs** of smoke in order to determine whether a fire has occurred. There are two types of prerequisites for the second process **S33,** and the second process **S33** is executed when any one of these is satisfied. One of the prerequisites is that the temporary determination flag **F2** is "0" (**S312:** no) and the amount Δ**Cs** of change in the concentration **Cs** of smoke is equal to or larger than the determination value **Vs2** (Δ**Cs** $\geq$ **Vs2**) (**S313**: yes). The other of the prerequisites is that the temporary determination flag **F2** is "1" (**S312:** yes) and the state where the concentration **Cs** of smoke is lower than the threshold value **Vs0** does not continue for the determination time period **Td2** (**S314**: no). In terms of the second process **S33,** both of the prerequisites include a condition for the concentration **Cs** of smoke.

[0073] After step **S313** or step **S314** (**S313**: yes, or **S314:** no), the second determiner **1202** configured to perform the second process **S33** illustrated in **FIG. 8** compares the amount Δ**Cc** of change in the concentration **Cc** within a predetermined reference time period **T3** with the (third) determination value **Vc2** (**S331**). The reference time period **T3** is set to be in a range of about 30 seconds to 2 minutes like the reference time period **T2.** The amount Δ**Cc** of change is updated every fire determining process **S30.**

[0074] Note that, the concentration **Cc** of CO is not equal to the concentration **Cc** obtained by the obtainer **121** in the reading process **S10,** but is equal to a moving average of the concentration **Cc.** The number of concentrations **Cc** for calculating the moving average may be in a range of about 5 to 15, preferably. In other words, the concentration **Cc** of CO does not correspond to an actual value obtained by the obtainer **121,** but corresponds to an average of the predetermined number of concentrations **Cc** obtained within a predetermined time period prior to time of calculating the concentration **Cc.**

[0075] For example, the concentrations **Cc** of CO are supposed to be obtained by the obtainer **121** at a series of time points **C1, C2, ..., Cm.** When the moving average calculated based on twelve concentrations is used as the concentration **Cc** of CO, the moving averages of the concentration **Cc** are (**C1** + **C2 + ... + C12)/12, (C2 + C3 + ... + C13)/12, (C3 + C4** + ... + **C14**)/**12**, ...

[0076] The concentration **Cc** of CO is given by the moving average, and it is thus possible to detect at high accuracy change in the concentration **Cc** of CO even if the second sensor **112** for measuring the concentration of CO is an electrochemical sensor with relatively low measurement accuracy.

[0077] For example, when CO is derived from a fire, the concentration gradient of CO falls within at least a range of about 1 to 5 ppm/min. When the second sensor **112** is an electrochemical sensor, the concentration gradient can be calculated from adjacent concentrations **Cc** included in a time series of data on the concentration **Cc** of CO obtained every reading process **S10**. However, such a concentration gradient cannot give sufficient accuracy to an extent available for detection of a fire.

[0078] In contrast, in the present embodiment, with regard to the concentration **Cc** of CO, the amount Δ**Cc** of change in the concentration **Cc** is calculated by use of the moving average method, and it is determined whether a fire has occurred, based on the calculated amount Δ**Cc** of change. Therefore, it is easy to detect change in the concentration **Cc** of CO at high accuracy.

[0079] When the amount Δ**Cc** of change in the concentration **Cc** of CO is equal to or larger than the determination value **Vc2** (**S331:** yes), the counter **124** increments the count value **Ic** associated with CO by one **(S332),** and subsequently the concentration **Cs** of smoke is compared with the determination value **Vs1 (S334).**

[0080] When **Cc(t)** represents the concentration of CO at the time t and Δ**Cc**(**t**) represents the amount of change in the concentration **Cc** of CO at the time t in a similar manner to the amount Δ**Cs** of change in the concentration **Cs** of smoke, Δ**Cc**(**t**) can be given by a relation Δ**Cc(t) = Cc(t) - Cc(t-T3).** The amount Δ**Cc** of change is equal to a difference (an absolute value of a difference) between the two concentrations **Cc** of CO obtained at points of time between which an interval is equal to the reference time period **T3,** that is, points of time of start and end of the reference time period **T3.** Note that, the reference time period **T3** may be equal to or different from the reference time period **T2.**

[0081] Dividing the amount Δ**Cc** of change by the reference time period **T3** gives a concentration gradient of CO. Therefore, provided that the reference time period **T3** is set to appropriate unit time (e.g., 60 seconds), the amount Δ**Cc** of change is equivalent to the concentration gradient. Therefore, at step **S331,** the concentration gradient may be used as an alternative to the amount Δ**Cc** of change within the reference time period **T3.** As described above, the reference time period **T3** is set to be almost equal to the reference time period **T2.** Additionally, to facilitate internal processing of the processing device **12,** the reference time period **T3** may be preferably equal to the reference time period **T2.**

[0082] **FIG. 10** shows a relationship among the concentration **Cc** of CO, the reference time period **T3,** and the amount Δ**Cc** of change. This figure also shows a concentration gradient α**3** of the concentration **Cc** of CO. As shown in the figure, even if the accuracy of the concentration **Cc** within the reference time period **T3** is insufficient, it is possible to detect change in the concentration **Cc** of CO when the reference time period **T3** is set appropriately and there is a relatively large change in the concentration **Cc** of CO.

[0083] Note that, when the concentration **Cs** of smoke is equal to or higher than the determination value **Vs1** at step **S334 (S334:** yes), the count value **Is** associated with smoke is incremented by one **(S335).** Or, when the concentration **Cs** of smoke is lower than the determination value **Vs1** (**S334**: no), the count value **Is** associated with smoke is decremented by two **(S336).** Step **S334** to **S336** are the same as steps **S321** to **S323** in the first process **S32.** After the count value **Is** is decremented by two at step **S336,** the determining device **120** starts the notifying process **S20.**

[0084] After step **S335,** the second determiner **1202** compares the count value **Ic** associated with CO with a reference value **Nc (S337).** When the count value **Ic** is equal to or larger than the reference value **Nc** (**S337:** yes), the count value **Is** associated with smoke is also compared with the reference value **Ns (S338).** When the count value **Is** is equal to or larger than the reference value **Ns** (**S338:** yes), the second determiner **1202** sets the fire flag **F1** to "1" **(S34).** When the count value **Ic** is smaller than the reference value **Nc** (**S337**: no) or when the count value **Is** is smaller than the reference value **Ns** (**S338**: no), the determining device **120** starts the notifying process **S20.**

[0085] In the second process **S33** illustrated in **FIG. 8,** when the amount Δ**Cc** of change in the concentration **Cc** of CO is smaller than the determination value **Vc2** at step **S331** (**S331:** no), the counter **124** decrements the count value **Ic** associated with CO by two **(S333).** Further, after step **S333,** it is determined whether the state where the amount Δ**Cs** of change in the concentration **Cs** of smoke is equal to or larger than the determination value **Vs2** continues for a (first) determination time period **Td1** (**S339**).

[0086] When the state where the amount Δ**Cs** of change in the concentration **Cs** of smoke is equal to or larger than the determination value **Vs2** continues for a time period in which the fire determining process **S30** is performed a number of times corresponding to the determination time period **Td1** (**S339:** yes), the temporary determination flag **F2** is set to "1" (**S340**). When a time period in which the state where the amount Δ**Cs** of change in the concentration **Cs** of smoke is equal to or larger than the determination value **Vs2** continues does not reach the determination time period **Td1** or after step **S340,** the determining device **120** starts the notifying process **S20** again.

[0087] The determination time period **Td1** is set in order to identify the continuous time period of a state where the concentration **Cs** of smoke increases sharply. When smoke is caused by a fire, a situation where the concentration **Cs** of smoke increases sharply continues for more than about 10 seconds. Hence, the determination time period **Td1** is set to around 10 seconds. In other words, the (second) determination time period **Td2** used by the preliminary determiner **1200** is set to a time period longer than the (first) determination time period **Td1** used by the second determiner **1202.**

[0088] As described above, in the fire determining process **S30,** the preliminary process **S31** determines whether a fire has occurred, based on the temperature value θ, and additionally defines the prerequisites for the first process **S32** and the second process **S33.** The prerequisite for the first process **S32** is that change in the concentration **Cs** of smoke is small (Δ**Cs** < **Vs2**) while a fire is determined to have occurred **(F2 = 0).** There are two types of prerequisites defined for the second process **S33**. The first one of the prerequisites is that the concentration **Cs** of smoke increases sharply (Δ**Cs** $\geq$ **Vs2**) while a fire is determined to have not occurred **(F2** = **0).** The second one of the prerequisites is that it is not confirmed whether a fire has occurred **(F2** = **1)** and the state where the concentration **Cs** of smoke is lower than the threshold value **Vs0** does not continue for the determination time period **Td2** (**S314**: no).

[0089] As described above, the preliminary determiner **1200** compares the amount Δ**Cs** of change in the concentration **Cc** of smoke with the first determination value **Vs2** at step **S313**. The preliminary determiner **1200** selects the first determiner **1201** when a relation of Δ**Cs** < **Vs2** is satisfied, and selects the second determiner **1202** when a relation of Δ**Cs** $\geq$ **Vs2** is satisfied. The first determiner **1201** performs determination with regard to the concentration **Cs** of smoke without taking into account the concentration **Cs** of carbon monoxide. In contrast, the second determiner **1202** performs determination with regard to the concentration **Cs** of smoke in addition to the amount Δ**Cc** of change in the concentration **Cc** of carbon monoxide.

[0090] In summary, the detector **10** selects, as the condition for subsequent determination, either a first condition for either the concentration **Cs** of smoke or the concentration **Cc** of carbon monoxide, or a second condition for both the concentration **Cs** of smoke and the concentration **Cc** of carbon monoxide, based on a result of determination of the switching condition. Accordingly, when there is difficulty in performing the determination by use of the concentration **Cs** of smoke only, the detector **10** can additionally use the concentration **Cc** of carbon monoxide for the determination. Consequently, it is possible to suppress false notification without learning threshold values.

[0091] Additionally, the processing device **12** sets the temporary determination flag **F2** to "1" when the state where the amount Δ**Cs** of change in the concentration **Cs** of smoke is equal to or larger than the (first) determination value **Vs2** continues for the first determination time period **Td1** in the second process **S33.** As a result, the preliminary determiner **1200** terminates the process of comparing the amount Δ**Cs** of change in the concentration **Cs** of smoke with the first determination value **Vs2**. Consequently, the second determiner **1202** continues the second process **S33**.

[0092] In summary, when the state where the amount Δ**Cs** of change relating to smoke is equal to or larger than the first determination value **Vs2** continues for the first determination time period **Td1**, the preliminary determiner **1200** proceeds to a mode of selecting the second determiner **1202** irrespective of the result of determination of whether the switching condition is satisfied. In other words, when the state where the amount Δ**Cs** of change relating to smoke is equal to or larger than the first determination value **Vs2** continues for the first determination time period **Td1**, the processing device **12** proceeds to a mode in which the preliminary determiner **1200** selects the second determiner **1202** irrespective of whether the switching condition is satisfied. In short, the processing device **12** proceeds to a mode of the temporary flag **F2** being "1". When the state where the concentration **Cs** of smoke is smaller than the predetermined threshold value **Vs0** continues for the second determination time period **Td2** in this mode, the preliminary determiner **1200** proceeds to a mode of selecting either the first determiner **1201** or the second determiner **1202** based on the result of determination of whether the switching condition is satisfied. In other words, when the state where the concentration **Cs** of smoke is smaller than the predetermined threshold value **Vs0** continues for the second determination time period **Td2,** the processing device **12** proceeds to a mode in which the preliminary determiner **1200** selects either the first determiner **1201** or the second determiner **1202** based on the result of determination of whether the switching condition is satisfied. In short, the processing device **12** proceeds to a mode of the temporary flag **F2** being "0".

[0093] The preliminary process illustrated in **FIG. 6** is defined so that, when the temporary flag **F2** is "1", the preliminary determiner **1200** does not determine whether the switching condition (Δ**Cs** ≥ **Vs2**) is satisfied. However, the preliminary determiner **1200** may determine whether the switching condition is satisfied. Note that, even in a case where the preliminary determiner **1200** determines whether the switching condition is satisfied, the preliminary determiner **1200** still selects the second determiner **1202** irrespective of whether the switching condition is satisfied, as long as the temporary flag **F2** is "1". This operation obviously indicates that the temporary flag **F2** functions to inform the preliminary determiner **1200** of a result of determination that the condition judged by the second determiner **1202** (the relation of Δ**Cs** ≥ **Vs2** continues for the determination time period **Td1**) is satisfied.

[0094] The second determiner **1202** determines whether a condition is satisfied, this condition including a condition that the concentration **Cs** of smoke is equal to or higher than the (second) determination value **Vs1** in addition to a condition that the amount Δ**Cc** of change in the concentration **Cc** of carbon monoxide is equal to or larger than the (third) determination value **Vc2.** Note that, when the state where the concentration **Cs** of smoke is lower than the threshold value **Vs0** continues for the (second) determination time period **Td2,** the preliminary determiner **1200** returns to the mode of selecting either the first determiner **1201** or the second determiner **1202** according to the switching condition. In the example of operation illustrated in **FIG. 6,** at step **S313,** the preliminary determiner **1200** returns to a mode in which the process of comparing the amount Δ**Cs** of change in the concentration **Cs** of smoke with the (first) determination value **Vs2** is performed.

[0095] Note that, in the meaning of numerical values, the threshold value **Vs0** is determined based on the determination value **Vs1** for the concentration **Cs** of smoke and the determination value **Vs2** for the amount Δ**Cs** of change in the concentration **Cs** of smoke so as to satisfy a relation of **Vs0** < **Vs1** - **Vs2**. This is because of suppressing the concentration **Cs** of smoke from being equal to or higher than the determination value **Vs1** immediately after the preliminary determiner **1200** switches the temporary determination flag **F2** from "1" to "0" and thereby returns to the process passing through step **S313**. In a case where the threshold value **Vs0** is equal to or larger than **Vs1 - Vs2**, **Vs0** + **Vs2** is equal to or larger than the determination value **Vs1** even if the amount Δ**Cs** of change is smaller than the determination value **Vs2** at step **S313**. Thus, the concentration **Cs** of smoke is equal to or higher than the determination value **Vs1,** and thereby the count value **Is** associated with smoke is incremented by one. In contrast, in the present embodiment, the threshold value **Vs0** is equal to or smaller than **Vs1 - Vs2**, and therefore **Vs0** + **Vs2** is smaller than the determination value **Vs1** at step **S313**. Hence, increment of the count value **Is** associated with smoke can be suppressed.

[0096] A state of a fire may vary according to various causes such as types of substances burning in a fire and environments of places where a fire has occurred. The state of a fire is categorized into about ten types. There are known cases relating to time variations of the concentration **Cs** of smoke and the concentration **Cc** of CO due to a fire. In one of the cases the concentration **Cs** of smoke and the concentration **Cc** of CO increase sharply in a short time, and in the other of the cases the concentration **Cs** of smoke and the concentration **Cc** of CO increase gradually in a relatively long time. Additionally, the concentrations **Cs** and **Cc** may increase to relatively high values, or increase to only relatively low values, or be saturated, or increase and then decrease, depending on the state of a fire.

[0097] Additionally, time from occurrence of a fire to start of increase in the concentrations **Cs** and **Cc** may vary depending on the state of a fire. In some cases, the concentration **Cs** of smoke and the concentration **Cc** of CO may start to increase at different timings. Generally, it is known that timings of start of increase in the concentration **Cs** of smoke and the concentration **Cc** of CO appear to have similar tendencies. Note that, fire detectors need to detect a fire within about 10 minutes from occurrence of the fire. As mentioned in the above, fire detectors need to determine, within about 10 minutes, whether a fire has occurred, with regard to various states of fires.

[0098] In the aforementioned configuration example, the first process **S32** in the fire determining process **S30** allows detection of occurrence of a fire in a state where the concentration **Cs** of smoke continuously and gradually increases. Further, a fire in a state where the concentration **Cs** of smoke increases sharply can be detected by the second process **S33.** In the second process **S33**, it is determined, referring to an increasing tendency of the first process **S32**, whether a fire causing a sharp increase in the concentration **Cs** of smoke has occurred. If the concentration **Cc** of CO is relatively low, a fire can be determined to have occurred provided that the amount Δ**Cc** of change in the concentration **Cc** of CO is equal to or larger than the determination value **Vc2.**

[0099] In summary, when the concentration **Cc** of CO is relatively low but the amount Δ**Cc** of change in the concentration **Cc** of CO is relatively large, the second process **S33** allows judgement of a fire while repeating the fire determining process **S30** multiple times. In this process, the condition for determining that a fire has occurred includes a condition that the state where the concentration **Cs** of smoke is equal to or higher than the determination value **Vs1** continues. To sum up, a fire determined to have occurred by the second process **S33** may be in a state where the state where the concentration **Cs** of smoke is relatively high continues and the concentration **Cs** of smoke increases sharply and the state where the concentration **Cc** of CO increases also continues.

[0100] The second process **S33** does not determine that a fire has occurred, when the state where the concentration **Cs** of smoke sharply increases can continue for only a short time and the amount Δ**Cc** of change in the concentration **Cc** of CO is relatively small. Such a situation may be supposed to occur due to white smoke caused by dry ice, steam, or the like. Thus, the second process **S33** can distinguish smoke caused by a fire from white smoke caused by dry ice or steam.

[0101] In short, when the amount Δ**Cc** of change in the concentration **Cc** of CO is relatively small but the state where the concentration **Cs** of smoke sharply increases continues for a relatively long time, it is difficult to deny a probability that a fire has occurred. Therefore, in such a case, the temporary determination flag **F2** is set to "1", and confirmation of the result of determination is appointed to the subsequent fire determining process **S30.**

[0102] **FIG. 11** shows an example of change in the measurement value (the concentration **Cs**) in a case where the first sensor **111** measures steam generated by an electric pot (so-called "electric kettle") with no heat retention function. In this figure, time from start of increase in the concentration **Cs** of smoke to the time **t4** is about 6 minutes. Further, in the figure, the maximum of the concentration **Cs** is about 15 %/m.

[0103] Note that, in the example shown in **FIG. 11,** the concentration **Cs** of smoke is supposed to be equal to or higher than the threshold value **Vs0** during an almost entire time period to the time **t4.** In this example, at step **S311** in the fire determining process **S30,** the temperature value θ does not satisfy the condition for determining that a fire has occurred. In summary, processing proceeds to step **S312** from step **S311**.

[0104] Further, in the example illustrated in the figure, in a time period from the concentration **Cs** being equal to or higher than the threshold value **Vs0** due to start of generation of steam to the time **t3,** the concentration **Cs** increases. In a time period from the time **t3** to the time **t4,** the concentration **Cs** decreases. Further, the time **t1** represents a point of time at which the condition (the relation of Δ**Cs** $\geq$ **Vs2** continues for the determination time period **Td1**) of step **S339** in the fire determining process **S30** is satisfied, and at this point of time the temporary determination flag **F2** becomes "1". The time **t2** subsequent to the time **t1** represents a point of time at which the condition (the relation of **Cs** < **Vs0** continues for the determination time period **Td2**) of step **S314** is satisfied. Accordingly, the time **t1** corresponds to a point of time at which the determination time period **Td1** elapses after the concentration **Cs** of smoke is equal to or higher than the threshold value **Vs0.** The time **t2** corresponds to a point of time at which the determination time period **Td2** elapses thereafter.

[0105] In the example illustrated in the figure, when the condition (**Cs** $\geq$ **Vs0**) of step **S13** in the reading process **S10** is satisfied and subsequently the condition (Δ**Cs** $\geq$ **Vs2**) of step **313** in the fire determining process **S30,** processing proceeds to the second process **S33**. Note that, until the time **t1**, the condition (the relation of Δ**Cs** $\geq$ **Vs2** continues for the determination time period **Td1**) of step **S339** is not satisfied and therefore processing passes through steps **S312** and **S313** and thereby the second process **S33** is selected.

[0106] When this state continues until the determination time period **Td1** passes, the condition of step **S339** is satisfied, and thereby the temporary determination flag **F2** is set to "1". Therefore, in the subsequent fire determining process **S30,** the condition **(F2** = **1**) of step **S312** is satisfied and thus step **S314** is selected. In this regard, since the state where the concentration **Cs** of smoke is high continues, the condition (the relation **Cs** < **Vs0** continues for the determination time period **Td2)** of step **S314** is not satisfied, and the state where the temporary determination flag **F2** is kept to be "1", and thus the second process **S33** is selected (see **FIG. 6).**

[0107] This state continues until the temporary determination flag **F2** becomes "0". After the time **t3,** the concentration **Cs** of smoke further decreases after the time **t3** and thus the condition (the relation of Δ**Cs** $\geq$ **Vs2** continues for the determination time period **Td1**) of step **S339** is not satisfied. However, the temporary determination flag **F2** is kept to be "1". Hence, the condition **(F2 = 1)** of step **S312** is satisfied but the condition (the relation of **Cs** < **Vs0** continues for the determination time period **Td2)** of step **S314** is not satisfied. Hence, the second process **S33** is still selected even after the time **t3.**

[0108] At the time **t4,** the condition **(F2 = 1)** of step **S312** is satisfied and further the condition (the relation of **Cs** < **Vs0** continues for the determination time period **Td2**) of step **S314** is also satisfied. Thus, processing proceeds to step **S315** and therefore the temporary determination flag **F2** becomes "0". Thereafter, by way of step **S313** the first process **S32** is selected. However, the concentration **Cs** of smoke already decreases, and hence the condition (**Cs** ≥ **Vs1**) of step **S321** is not satisfied and the count value **Is** associated with smoke is not incremented. Accordingly, the condition (**Is** ≥ **Vs1**) of step **S324** is not satisfied, and thus the fire flag **F1** does not become "1". This can lead to avoidance of occurrence of false notification.

[0109] In summary, in a case where CO is absent a similar to a case of steam from an electric pot, the fire determining process **S30** mainly selects the second process **S33**. When CO is not detected, the temporary determination flag **F2** becomes "1", and a state where steam is temporary determined to have occurred continues. While the temporary determination flag **F2** is "1", step **S313** is not selected until the concentration **Cs** of smoke becomes lower than the threshold value **Vs0.** Therefore, always the second process **S33** is selected. As a result, while CO is not detected, the state where the temporary determination flag **F2** is "1" and then the second process **S33** is selected is maintained until the concentration **Cs** of smoke decreases. Hence, occurrence of false notification can be suppressed.

[0110] In a supposed case where the temporary determination flag **F2** is not used in the fire determining process **S30**, the determination at step **S313** is performed always. In this case, even if the concentration **Cs** of smoke starts to decrease at the time **t3,** the condition (Δ**Cs** ≥ **Vs2**) of step **S313** is no longer satisfied and thus processing proceeds to the first process **S32** and accordingly the condition (**Cs** ≥ **Vs1**) of step **S321** is satisfied. As a result, the count value **Is** associated with smoke is incremented every fire determining process, and finally the fire flag **F1** becomes "1". Thus, the notifying process **S20** gives notice of a fire through the notifying device **13** **(S26),** and this may lead to false notification. According to the configuration of the present embodiment, the aforementioned scheme can suppress such false notification.

[0111] **FIG. 12** shows an example in which the concentration **Cs** of smoke varies periodically. In the example illustrated in the figure, a state where the concentration **Cs** of smoke becomes temporarily high appears periodically. In summary, the concentration **Cs** of smoke illustrated in the figure varies so as to show a bell-shape at a cycle **Tp.** The concentration **Cs** of smoke has its local maximum at the cycle **Tp,** and a difference Δ**Cp** between local maximum values becomes relatively small. Note that, in the example illustrated in the figure, it is supposed that the local maximum values of the concentration **Cs** of smoke are equal to or larger than the determination value **Vs1** and the cycle **Tp** and the determination time period **Td2** satisfy a relation of **Tp** ≈ **Td2.** Additionally, the cycle **Tp** is supposed to be almost equal to the reference time periods **T2** and **T3.**

[0112] When the concentration **Cs** of smoke varies as shown in **FIG. 12,** there is a high probability that smoke is not caused by a fire. According to the present embodiment, when the concentration **Cs** of smoke varies as shown in **FIG. 12,** the condition (the state in which **Cs** < **Vs0** continues for the determination time period **Td2**) of step **S314** in the fire determining process **S30** is not satisfied, and thus processing proceeds to the second process **S33**. When CO is not detected, processing passes through step **S339** but the condition (the state in which Δ**Cs** ≥ **Vs2** continues for the determination time period **Td1**) of step **S339** is not satisfied and accordingly each of the fire flag **F1** and the temporary determination flag **F2** is kept to be "0".

[0113] Alternatively, when CO is detected, processing may pass through step **S334** but the concentration **Cs** of smoke varies periodically. Hence, the concentration **Cs** of smoke does not continuously satisfy the condition (**Cs** ≥ **Vs1**) of step **S334.** Accordingly each of the fire flag **F1** and the temporary determination flag **F2** is kept to be "0".

[0114] As described above, when the concentration **Cs** of smoke varies periodically as shown in **FIG. 12,** a fire is not determined to have occurred, and thus occurrence of false notification can be suppressed. Similarly, even if steam from a bathroom continuously stays in an undressing room or dust stays for a long time, CO is not detected and thus occurrence of false notification can be suppressed.

[0115] Note that, in the aforementioned configuration example, the second sensor **112** for measuring the concentration of CO is an electrochemical sensor, and uses a moving average of the concentration **Cc** of CO to calculate the amount Δ**Cc** of change in the concentration **Cc** of CO. However, if the second sensor **112** has relatively high measurement accuracy, it is allowed to use a configuration of using the amount Δ**Cc** of change directly calculated from the concentration **Cc** measured by the second sensor **112** instead of the moving average of the concentration **Cc** of CO. Additionally, the reference time period **T2** is set to be equal to the time interval at which the obtainer **121** obtains the concentration **Cs** of smoke from the first sensor **111,** and the reference time period **T3** is set to be equal to the time interval at which the obtainer **121** obtains the concentration **Cc** of smoke from the second sensor **112.** However, these time periods may be extended appropriately.

[0116] The aforementioned configuration example may preferably perform an additional reset process in case false notification occurs.

[0117] Note that, in the aforementioned configuration example, it is supposed that the notifier **20** operates according to the notification signal outputted from the notifying device **13** and the sensing device **11,** the processing device **12,** the notifying device **13,** and the notifier **20** are accommodated in a common housing. However, the notifier **20** may be accommodated in a separate housing and the notifying device **13** may output the notification signal to the notifier **20** through telecommunications.

[0118] Further, the notifier **20** may be replaced with a receiver for monitoring occurrence of a fire, and the receiver may be connected to multiple fire detectors so that the multiple fire detectors output their own notification signals to the receiver. Such a receiver has functions of managing the multiple fire detectors intensively and monitoring whether a fire has occurred for each of individual places where the multiple fire detectors are installed.

Claims

1. A detector comprising:

a first sensor configured to measure a concentration of smoke in air;
a second sensor configured to measure a concentration of carbon monoxide in air;
a processing device configured to determine whether a predetermined condition is satisfied with regard to the concentration of smoke measured by the first sensor and the concentration of carbon monoxide measured by the second sensor; and
a notifying device configured to output a notification signal when the predetermined condition is satisfied,
the processing device being configured to select either a first condition or a second condition as the predetermined condition based on a result of determination of whether a switching condition for the concentration of smoke is satisfied, the first condition being for either the concentration of smoke or the concentration of carbon monoxide, and the second condition being for both the concentration of smoke and the concentration of carbon monoxide.

2. The detector of claim **1,** wherein:

the switching condition is that an amount of change in the concentration of smoke within a predetermined reference time period is equal to or larger than a first determination value; and
the processing device is configured to determine whether the switching condition is satisfied.

3. The detector of claim **2,** wherein:

the processing device includes

a preliminary determiner configured to determine whether the switching condition is satisfied,
a first determiner configured to determine, without considering the concentration of carbon monoxide, whether the first condition including a condition that the concentration of smoke is equal to or higher than a second determination value is satisfied, and
a second determiner configured to determine whether the second condition is satisfied, the second condition including a condition that the concentration of smoke is equal to or higher than the second determination value in addition to a condition that an amount of change in the concentration of carbon monoxide within a predetermined reference time period is equal to or larger than a third determination value; and

the preliminary determiner is configured to,

when determining that the amount of change relating to smoke is smaller than the first determination value, select the first determiner and select the first condition as the predetermined condition, and
when determining that the amount of change relating to smoke is equal to or larger than the first determination value, select the second determiner and select the second condition as the predetermined condition.

4. The detector of claim **3,** wherein:

the processing device is configured to cyclically repeat, by the preliminary determiner, a process of selecting the first determiner when the amount of change relating to smoke is determined to be smaller than the first determination value and selecting the second determiner when the amount of change relating to smoke is determined to be equal to or larger than the first determination value; and
the preliminary determiner is configured to, when a state where the amount of change relating to smoke is equal to or larger than the first determination value continues for a first determination time period, proceed to a mode of selecting the second determiner irrespective of the result of determination of whether the switching condition is satisfied, and instructs the second determiner to determine whether a condition including a condition that the concentration of smoke is equal to or higher than the second determination value in addition to a condition that the amount of change relating to carbon monoxide is equal to or larger than the third determination value is satisfied.

5. The detector of claim **4,** wherein
the preliminary determiner is configured to, when a state where the concentration of smoke is smaller than a predetermined threshold value continues for a second determination time period, proceed to a mode of selecting either the first determiner or the second determiner based on the result of determination of whether the switching condition is satisfied.

6. The detector of claim **5,** wherein
the second determination time period is set to a time period longer than the first determination time period.

7. The detector of any one of claims **1** to **6,** further comprising a third sensor configured to measure a temperature,
wherein the processing device is configured to determine whether the predetermined condition is satisfied with regard to the temperature measured by the third sensor.

8. A detection method comprising:

obtaining, from a sensing device, a concentration of smoke in air and a concentration of carbon monoxide in air;
determining, by a processing device, whether a predetermined condition is satisfied with regard to the obtained concentration of smoke and concentration of carbon monoxide;
outputting, from a notifying device, a notification signal when the predetermined condition is satisfied,
the method further comprising selecting, by the processing device, either a first condition or a second condition as the predetermined condition based on a result of determination of whether a switching condition for the concentration of smoke is satisfied, the first condition being for either the concentration of smoke or the concentration of carbon monoxide, and the second condition being for both the concentration of smoke and the concentration of carbon monoxide.

9. The detection method of claim **8,** wherein
the switching condition is that an amount of change in the concentration of smoke within a predetermined reference time period is equal to or larger than a first determination value.

10. The detection method of claim **9,** wherein:

the first condition includes a condition that the concentration of smoke is equal to or higher than a second determination value is satisfied, but does not include a condition for the concentration of carbon monoxide;
the second condition includes a condition that the concentration of smoke is equal to or higher than the second determination value in addition to a condition that an amount of change in the concentration of carbon monoxide within a predetermined reference time period is equal to or larger than a third determination value;
the processing device selects the first condition when the amount of change relating to smoke is smaller than the first determination value; and
the processing device selects the second condition when the amount of change relating to smoke is equal to or larger than the first determination value.

11. A detection system comprising:

the detector of any one of claims **1** to **7;** and
a notifier configured to give notice according to the notification signal outputted from the notifying device.

12. A program for allowing one or more computers to function as the processing device and the notifying device of the detector of any one of claims **1** to **7.**

FIG. 1

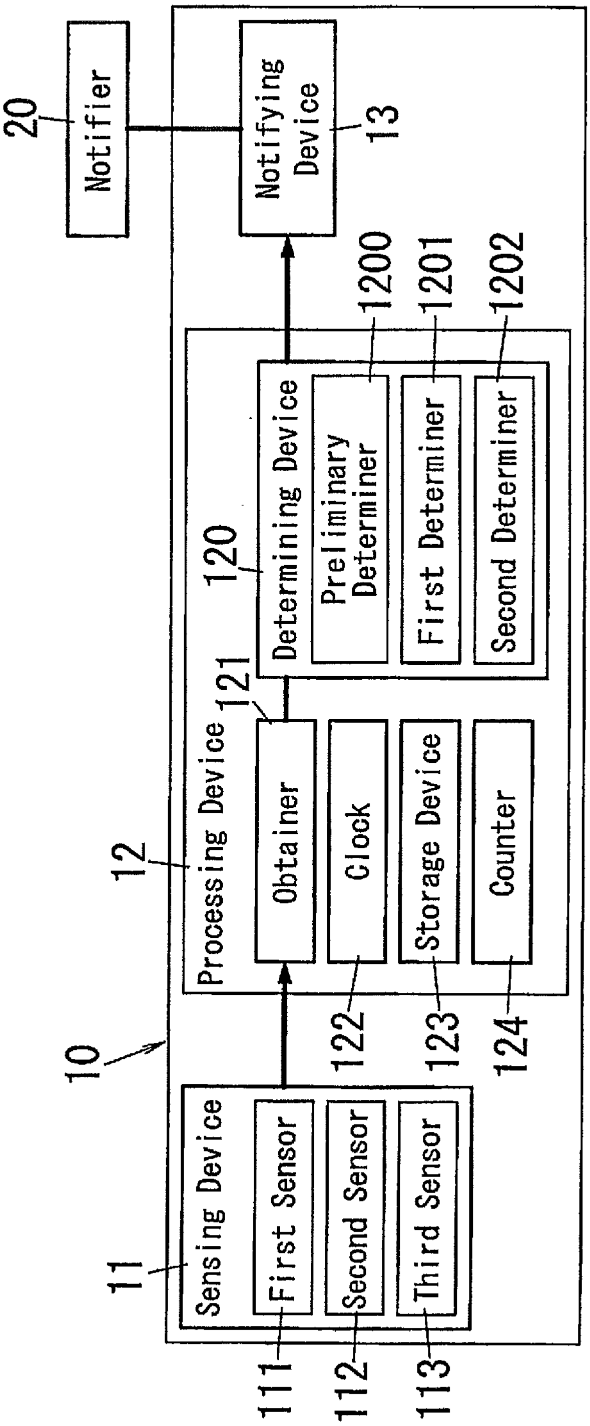

Sensing Device
First Sensor
Second Sensor
Third Sensor
Processing Device
Obtainer
Clock
Storage Device
Counter
Determining Device
Preliminary Determiner
First Determiner
Second Determiner
Notifying Device
Notifier
10
11
12
13
20
111
112
113
120
121
122
123
124
1200
1201
1202

FIG. 2

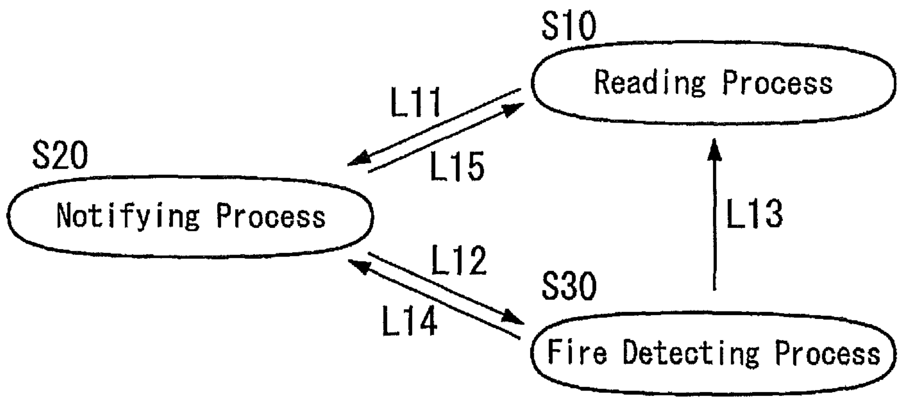

S10
Reading Process
L11
L15
S20
Notifying Process
L13
L12
S30
L14
Fire Detecting Process

FIG. 3

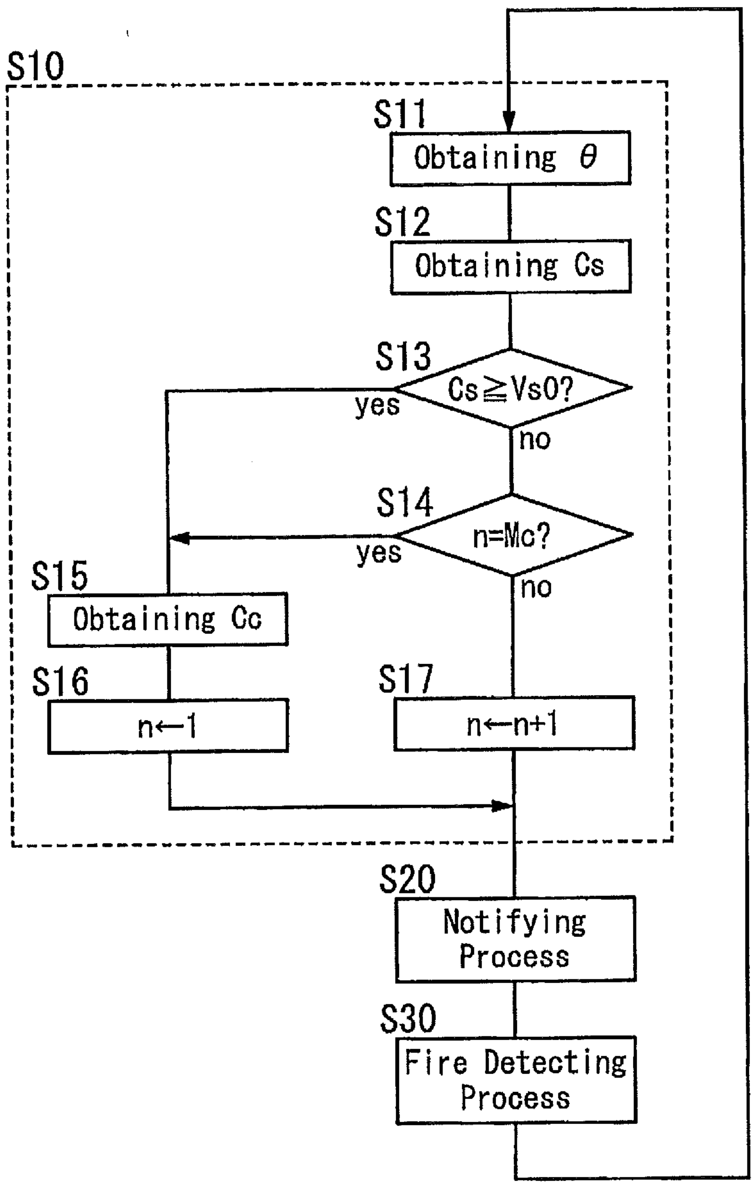

S10
S11
Obtaining θ
S12
Obtaining Cs
S13
Cs≧Vs0?
yes
no
S14
n=Mc?
yes
no
S15
Obtaining Cc
S16
n←1
S17
n←n+1
S20
Notifying Process
S30
Fire Detecting Process

FIG. 4

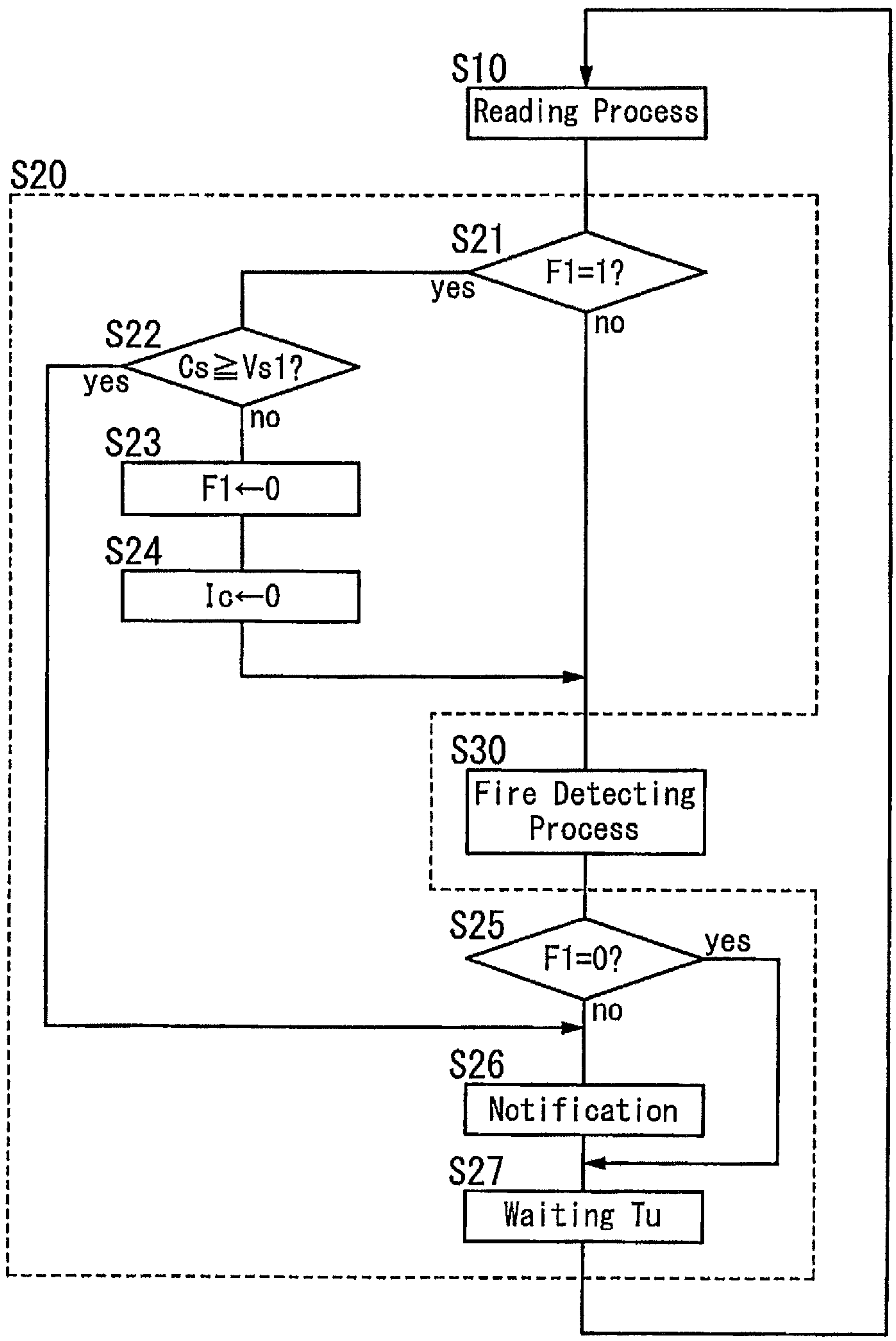

S10
Reading Process
S20
S21
F1=1?
yes
no
S22
Cs≧Vs1?
yes
no
S23
F1←0
S24
Ic←0
S30
Fire Detecting Process
S25
F1=0?
yes
no
S26
Notification
S27
Waiting Tu

FIG. 5

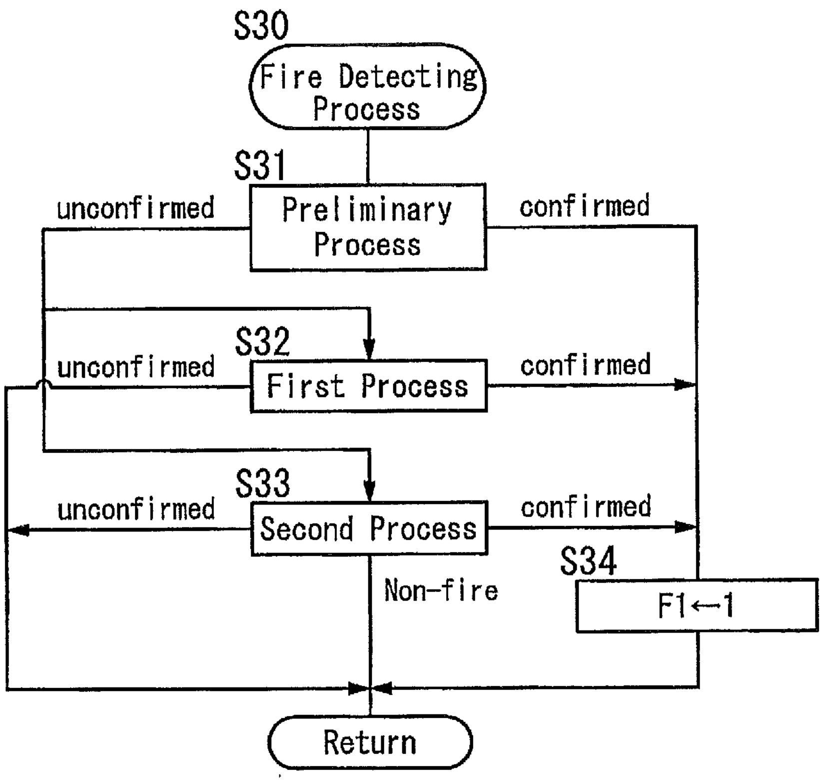

S30
Fire Detecting Process
S31
Preliminary Process
unconfirmed
confirmed
S32
First Process
unconfirmed
confirmed
S33
Second Process
unconfirmed
confirmed
Non-fire
S34
F1←1
Return

FIG. 6

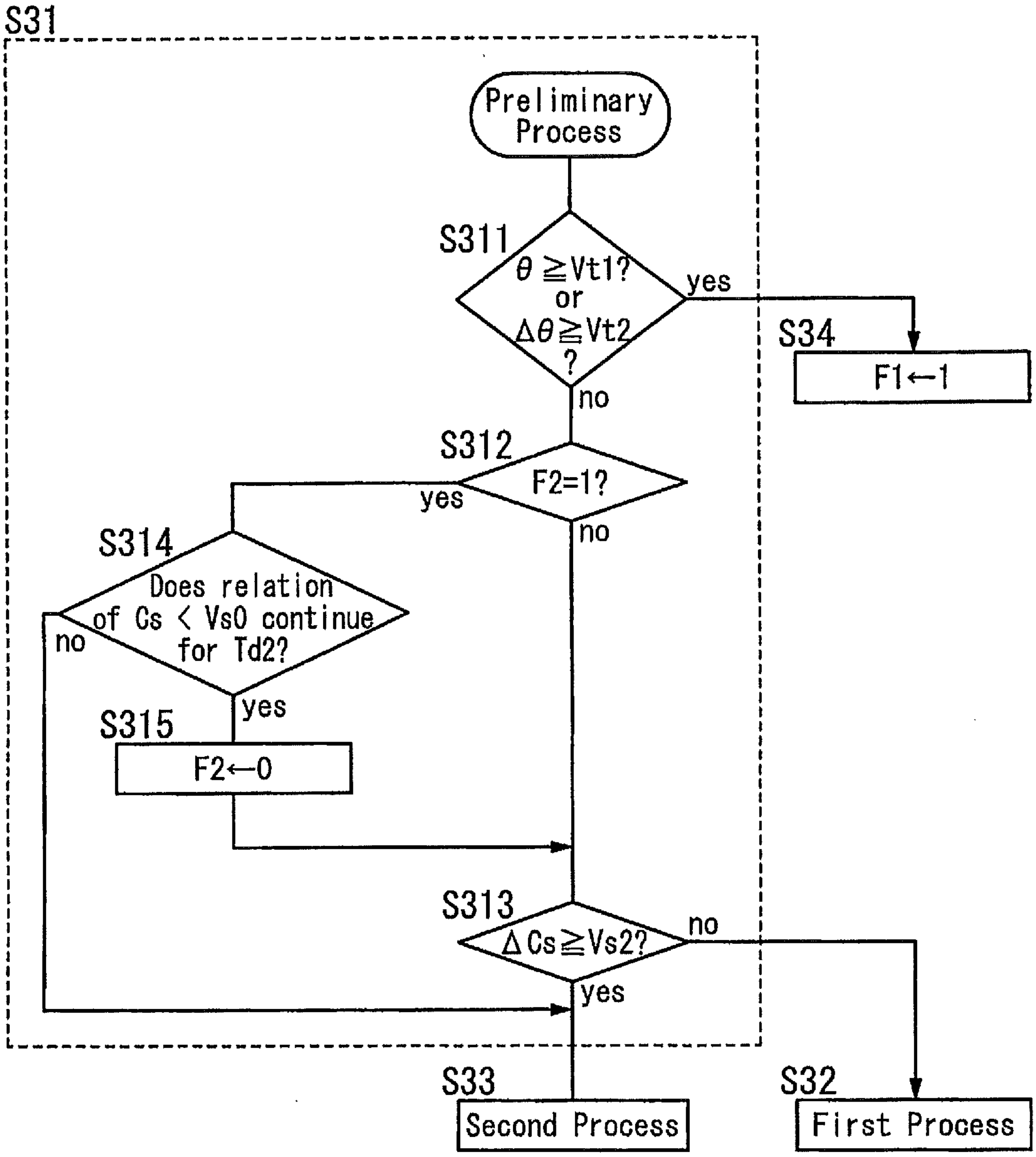

S31
Preliminary Process
S311
θ ≧Vt1? or Δθ≧Vt2 ?
yes
no
S34
F1←1
S312
F2=1?
yes
no
S314
Does relation of Cs < Vs0 continue for Td2?
no
yes
S315
F2←0
S313
ΔCs≧Vs2?
no
yes
S33
Second Process
S32
First Process

FIG. 7

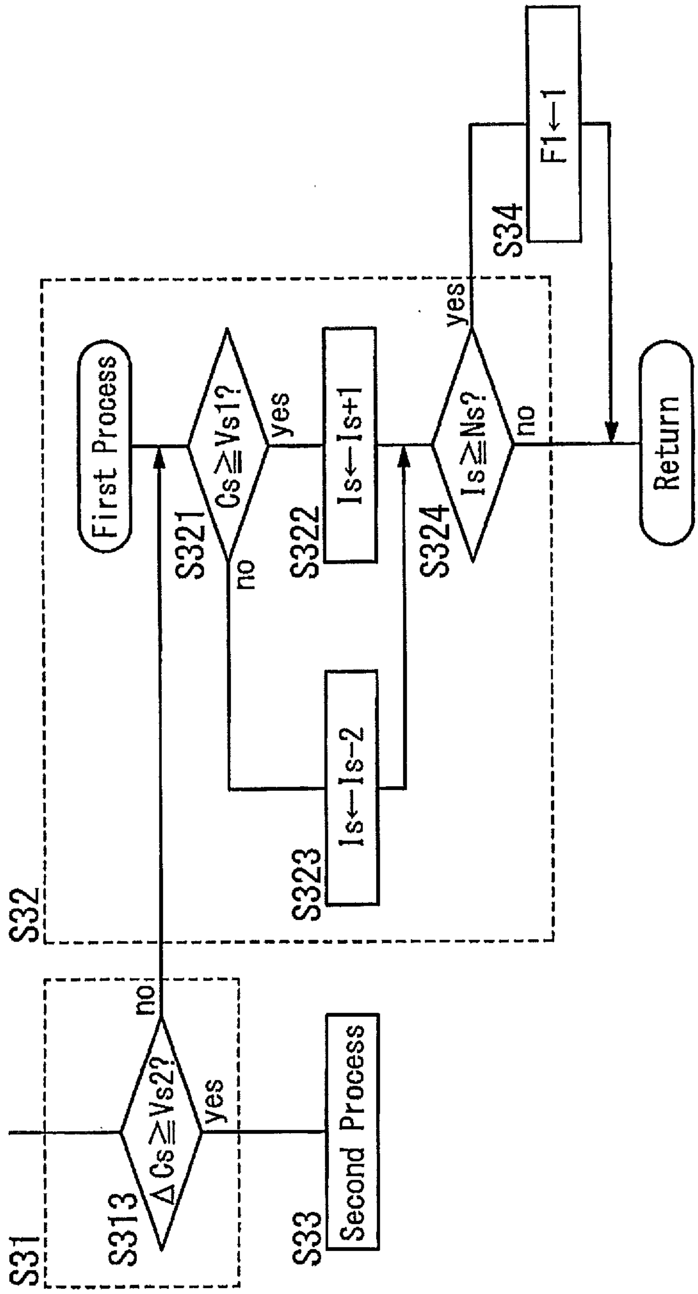

S31
S313
ΔCs≧Vs2?
yes
no
S33
Second Process
S32
First Process
S321
Cs≧Vs1?
yes
no
S322
Is←Is+1
S323
Is←Is-2
S324
Is≧Ns?
yes
no
S34
F1←1
Return

FIG. 8

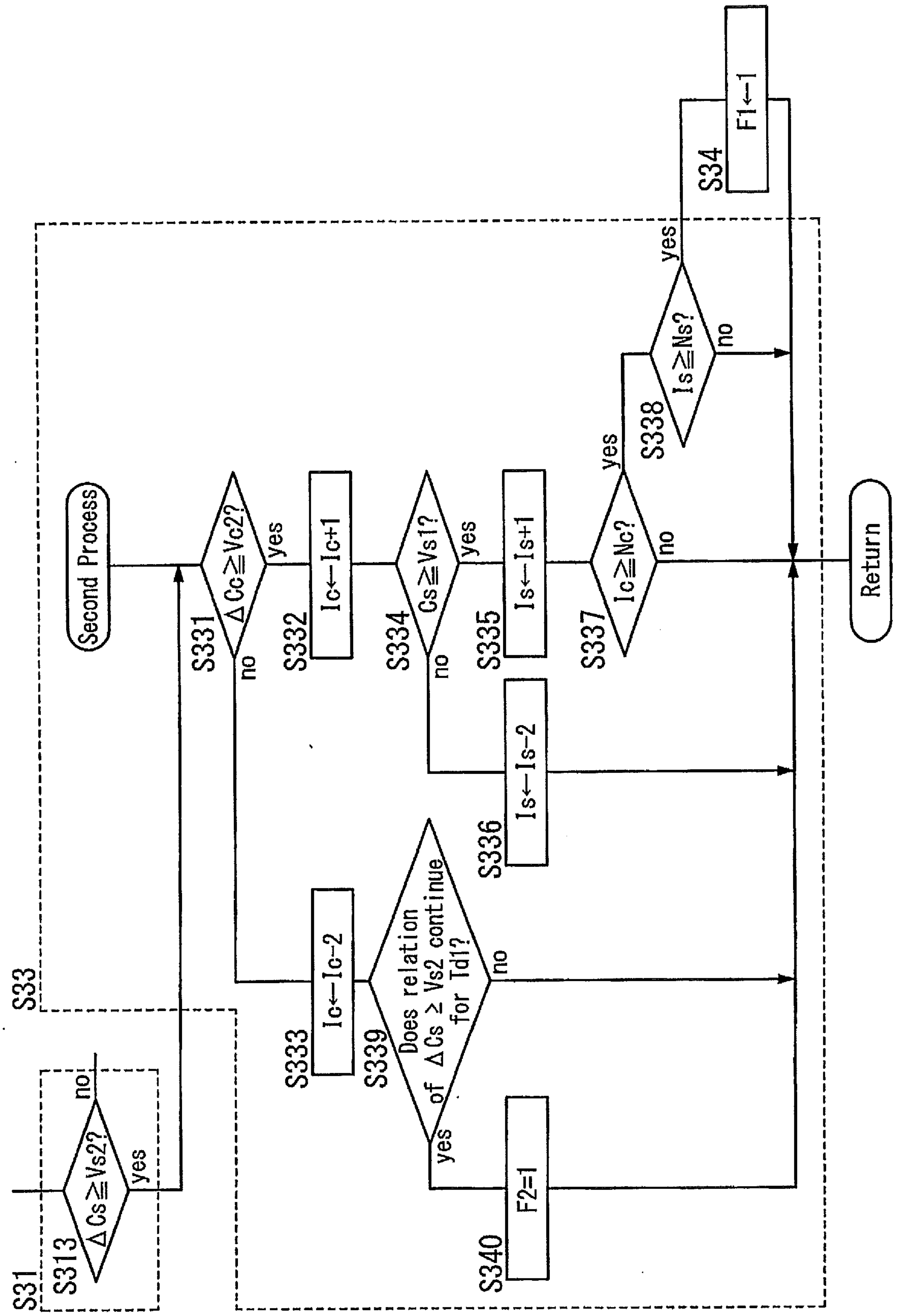

S31
S313
ΔCs≧Vs2?
yes
no
S33
Second Process
S331
ΔCc≧Vc2?
yes
no
S332
Ic←Ic+1
S333
Ic←Ic-2
S334
Cs≧Vs1?
yes
no
S335
Is←Is+1
S336
Is←Is-2
S337
Ic≧Nc?
yes
no
S338
Is≧Ns?
yes
no
S34
F1←1
S339
Does relation of ΔCs ≥ Vs2 continue for Td1?
yes
no
S340
F2=1
Return

FIG. 9

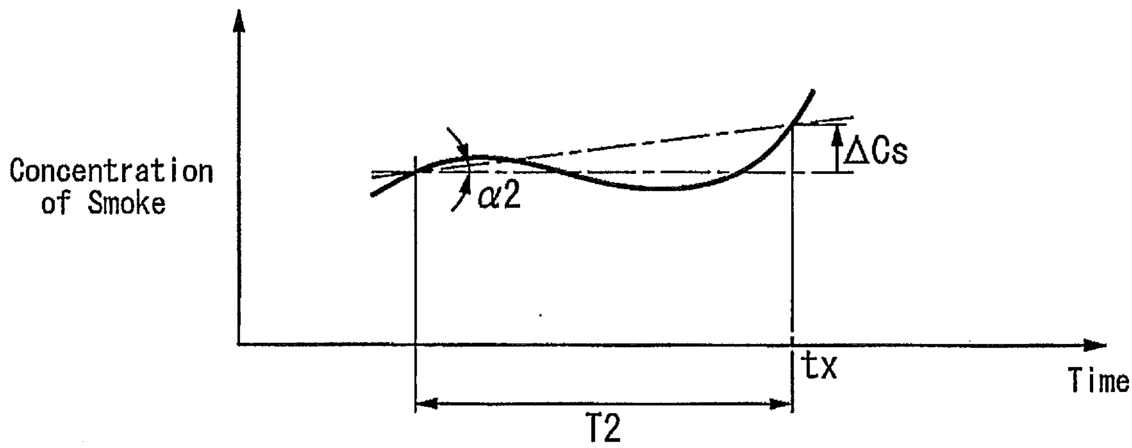


FIG. 10

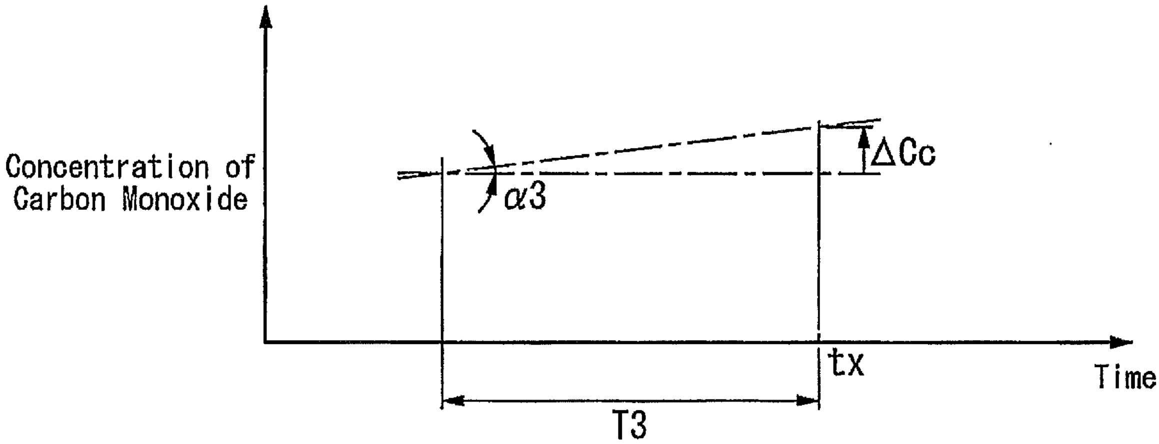


FIG. 11

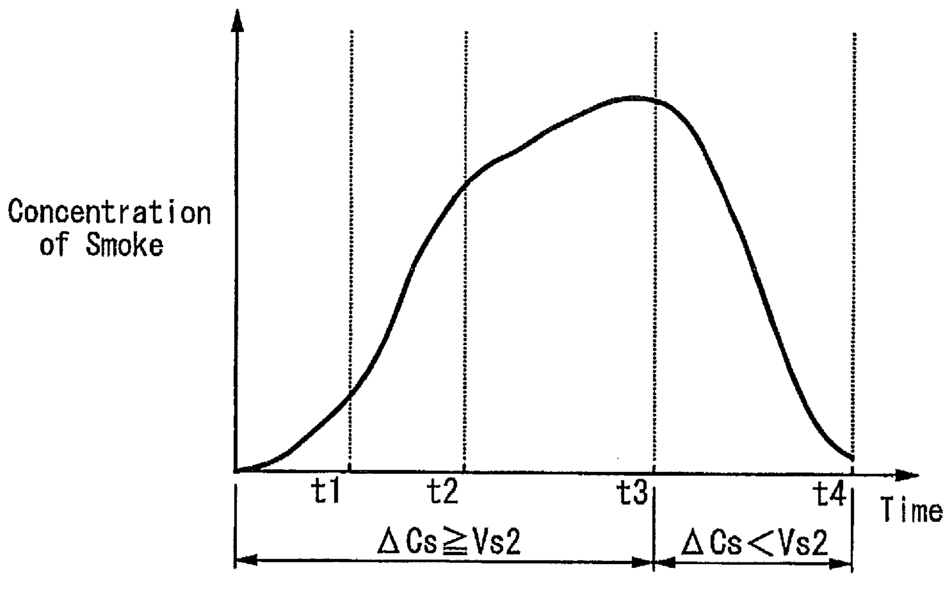
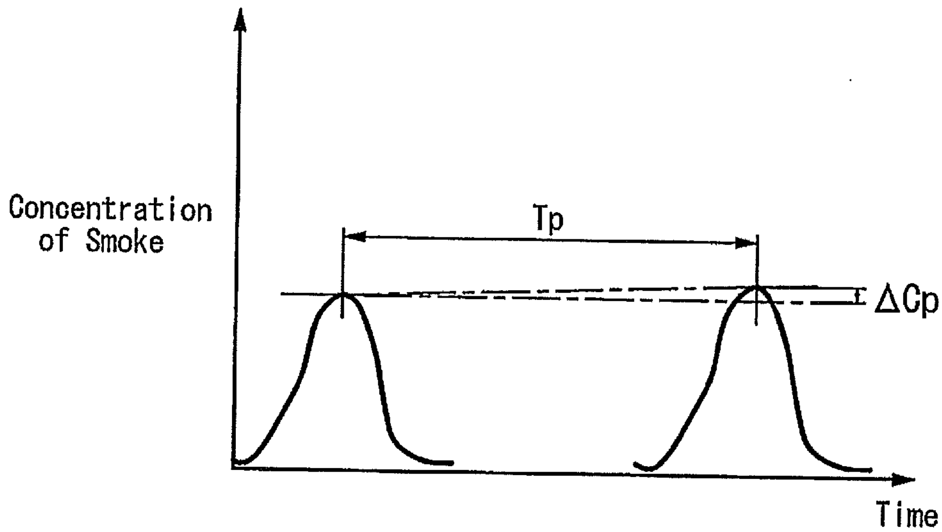


FIG. 12



INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2015/000307

A. CLASSIFICATION OF SUBJECT MATTER

G08B17/06(2006.01)i, *G08B17/107*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G08B17/06, G08B17/107

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2015
Kokai Jitsuyo Shinan Koho	1971-2015	Toroku Jitsuyo Shinan Koho	1994-2015

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2000-504132 A (Engelhard Sensor Technologies, Inc.), 04 April 2000 (04.04.2000), page 23, line 9 to page 38, line 1; fig. 1 to 11 & US 5691704 A & WO 1997/027571 A1 & EP 877995 A & DE 69735933 D & AU 1755597 A & CN 1209896 A & TW 316970 B & AU 5371598 A & HK 1055149 A	1-12
A	JP 2011-86306 A (Hochiki Corp.), 28 April 2011 (28.04.2011), entire text; all drawings (Family: none)	1-12

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

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 April 2015 (16.04.15)	28 April 2015 (28.04.15)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 4066761 B **[0002]**
- JP 2006277138 A **[0003]**