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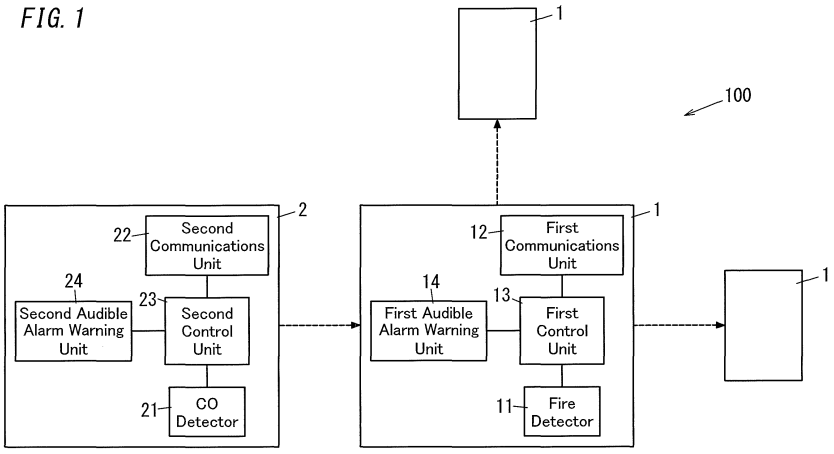
(54) SECURITY SYSTEM

(57) An object of the present invention is to send out an early warning of the presence of carbon monoxide to a location other than the origin of the carbon monoxide. A security system (100) includes a plurality of fire alarms (1) and a sensor (2). Each of the fire alarms (1) includes a fire detector (11), a first communications unit (12), and a first control unit (13). The sensor (2) includes a CO detector (21), a second communications unit (22), and a second control unit (23). Upon detection of carbon monoxide by the CO detector (21), the second control unit (23) makes the second communications unit (22) transmit a notification signal to the fire alarms (1). Upon receipt of the notification signal at the first communications unit (12), the first control unit (13) sends out a CO coordination alarm, and also makes the first communications unit (12) transmit the notification signal to the other fire alarms (1).

FIG. 1



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Description

Technical Field

[0001] The present invention generally relates to security systems, and more particularly relates to a security system including a sensor for detecting the presence of carbon monoxide.

Background Art

[0002] A fire alarm system, including a plurality of fire alarms and configured to transmit, via radio waves, a wireless signal between those fire alarms, has been known in the art. A fire alarm system of this type is disclosed, for example, in Patent Literature 1. In the fire alarm system disclosed in Patent Literature 1, a particular one of the fire alarms, having received a wireless signal conveying a fire warning message from any other one of the fire alarms, transmits the wireless signal with the fire warning message to all of the other fire alarms.

[0003] In this manner, at least one fire alarm's detecting the outbreak of a fire allows the fire alarm system of Patent Literature 1 to send out the fire warning to all of the other fire alarms in case of emergency situations.

[0004] Speaking of emergency situations, fire alarm systems (also called "security systems"), such as the one disclosed in the document cited above, have recently been increasingly required to detect not just the outbreak of a fire but also the presence of carbon monoxide as well. Such security systems need to send out an early warning of the presence of carbon monoxide to a location other than the origin of the carbon monoxide.

Citation List

Patent Literature

[0005] Patent Literature 1: JP 2013-37707 A

Summary of Invention

[0006] In view of the foregoing background, it is therefore an object of the present invention to provide a security system with the ability to send out an early warning of the presence of carbon monoxide to a location other than the origin of the carbon monoxide.

[0007] A security system according to an aspect of the present invention includes a plurality of fire alarms and a sensor. Each of the plurality of fire alarms includes a fire detector, a first communications unit, and a first control unit. The fire detector detects outbreak of a fire. The first communications unit transmits and receives a wireless signal via radio waves. The first control unit sends out, upon detection of the fire by the fire detector, a fire warning as an early warning of the outbreak of the fire. The sensor includes a CO detector, a second communications unit, and a second control unit. The CO detector detects presence of carbon monoxide. The second communications unit transmits and receives the wireless signal. In the sensor, the second control unit is configured to, upon detection of carbon monoxide by the CO detector, make the second communications unit transmit a notification signal to the plurality of fire alarms. In each of the plurality of fire alarms, the first control unit is configured to, upon receipt of the notification signal at the first communications unit, send out a CO coordination alarm as an early warning of the presence of carbon monoxide at a site of installation of the sensor and is also configured to make the first communications unit transmit the notification signal to the other fire alarms.

Brief Description of Drawings

[0008]

FIG. 1 is a block diagram of a security system according to an embodiment;
FIG. 2 is a sequence chart showing operations to be performed by the security system;
FIG. 3 is a sequence chart illustrating a fire coordination capability of the security system;
FIG. 4 illustrates an overall system configuration showing an application example of a security system according to a variation of the embodiment;
FIG. 5 illustrates an exemplary operation of the security system; and
FIG. 6 illustrates another exemplary operation of the security system.

Description of Embodiments

[0009] A security system according to an embodiment will be described below. Note that the configuration to be described below is only a non-limiting exemplary embodiment of the present invention. Such an embodiment should not be construed as limiting but numerous modifications or variations can be readily made depending on design choice or any other factor without departing from the true spirit and scope of the invention.

[0010] Note that in the following description, a plurality of fire alarms 1A, 1B, and so on will be collectively referred to as "fire alarms 1" unless there is a special need to distinguish them from each other.

[0011] As shown in FIG. 1, the security system 100 according to this embodiment includes a plurality of (e.g., three in this example) fire alarms 1 and a sensor 2. FIG. 1 illustrates the internal configuration of only one of the three fire alarms 1 without showing that of the other two fire alarms 1.

[0012] Each of the plurality of fire alarms 1 includes a fire detector 11, a first communications unit 12, and a first control unit 13. The fire detector 11 detects the outbreak of a fire. The first communications unit 12 transmits and receives a wireless signal via radio waves. The first control unit 13 sends out, upon detection of a fire by the

fire detector 11, a fire warning as an early warning of the outbreak of the fire.

[0013] The sensor 2 includes a CO detector 21, a second communications unit 22, and a second control unit 23. The CO detector 21 detects the presence of carbon monoxide. The second communications unit 22 transmits and receives the wireless signal.

[0014] In the sensor 2, the second control unit 23 is configured to, upon detection of carbon monoxide by the CO detector 21, make the second communications unit 22 transmit a notification signal to the plurality of fire alarms 1.

[0015] In each of the plurality of fire alarms 1, the first control unit 13 is configured to, upon receipt of the notification signal at the first communications unit 12, send out a CO coordination alarm as an early warning of the presence of carbon monoxide at a site of installation of the sensor 2, and is also configured to make the first communications unit 12 transmit the notification signal to the other fire alarms 1.

[0016] The security system 100 according to this embodiment will be described in detail with reference to FIG. 1. The security system 100 of this embodiment may be used in, for example, a single-family dwelling house. Naturally, the security system 100 according to this embodiment does not have to be used in a single-family dwelling house, but may also be used in any of various other types of buildings including multi-family dwelling houses (i.e., what are called "mansions" in Japan), business facilities, hospitals, hotels, and multi-tenant buildings.

[0017] As shown in FIG. 1, the security system 100 of this embodiment includes a plurality of (e.g., three on this example) fire alarms 1 (namely, fire alarms 1A, 1B, and 1C (see FIG. 2)) and a single sensor 2. Since the plurality of fire alarms 1 each has the same configuration and function, the configuration and function of only one of the plurality of fire alarms 1 will be described in the following description.

[0018] The fire alarm 1 has the ability to detect the outbreak of a fire, and may be mounted on the ceiling of a room of a single-family (or multi-family) dwelling house, for example. The fire alarm 1 includes a fire detector 11, a first communications unit 12, a first control unit 13, and a first audible alarm warning unit 14. Also, the fire alarm 1 may be driven by a battery such as a dry battery.

[0019] The fire detector 11 is configured to detect smoke produced by a fire and vary the detected quantity (such as a voltage value) according to the amount (e.g., concentration) of the smoke produced. Examples of smoke detection methods include a photoelectric one. The photoelectric smoke detection method is a method of detecting smoke produced by making a photodetector detect scattering light, which has been produced by reflection of a light beam emitted from a light-emitting element, from particles of the smoke. Naturally, the fire detector 11 may also be configured to detect the outbreak of a fire by a thermal method, i.e., based on the quantity of heat generated by the fire. In any case, the fire detector 11 compares the detected quantity with a threshold value, which has been set in advance by the fire detector 11, and determines that a fire has broken out, when finding the detected quantity greater than the threshold value.

[0020] The first communications unit 12 includes an antenna, a transmitter circuit, and a receiver circuit, and is configured to transmit and receive a wireless signal via radio waves. The transmitter circuit modulates data supplied from the first control unit 13 into a wireless signal and transmits the wireless signal via the antenna. The receiver circuit demodulates a wireless signal received at the antenna and outputs the demodulated data to the first control unit 13. The first communications unit 12 transmits and receives a wireless signal in compliance with the "Low Power Radio Station for Security System" standard defined in Article 6(4)(iii) of Rules for Enforcement of Radio Act for the country of Japan. Alternatively, the first communications unit 12 may also be configured to transmit and receive a wireless signal in compliance with the law of any other foreign country outside of Japan.

[0021] The first control unit 13 includes, as its major component, a microcomputer and performs a desired function by executing a program stored in a memory. Note that the program may be written in the memory in advance but may also be provided by being stored on some storage medium such as a memory card or be downloaded through a telecommunications line.

[0022] The first audible alarm warning unit 14 includes a buzzer for emitting a buzz specified by the first control unit 13 and a loudspeaker for emitting a voice warning specified by the first control unit 13.

[0023] The first control unit 13 has the capability of sending out, upon detection of a fire by the fire detector 11, a fire warning by controlling the first audible alarm warning unit 14. As used herein, the "fire warning" is an early warning, issued by the fire alarm 1 at the origin of a fire, of the outbreak of the fire. Specifically, the first control unit 13 may either make the buzzer of the first audible alarm warning unit 14 sound a buzz or have a verbal warning message such as "Fire! Fire!" announced through the loudspeaker of the first audible alarm warning unit 14.

[0024] The first control unit 13 also has the capability of sending out, upon receipt of a notification signal at the first communications unit 12, a CO coordination alarm by controlling the first audible alarm warning unit 14. As used herein, the "CO coordination alarm" is an early warning of the presence of carbon monoxide at the site of installation of the sensor 2. Specifically, the first control unit 13 may either make the buzzer of the first audible alarm warning unit 14 sound a different buzz from the fire warning or have a verbal warning message such as "Warning! Carbon monoxide over there! Get out of here ASAP" announced through the loudspeaker of the first audible alarm warning unit 14.

[0025] As for the scheme for giving such a warning, the first audible alarm warning unit 14 needs to include

at least one of the buzzer or the loudspeaker, and may be configured to include only the buzzer or only the loudspeaker. The first control unit 13 needs to have the capability of sending out the fire warning and the CO coordination alarm by controlling the first audible alarm warning unit 14 depending on the configuration of the first audible alarm warning unit 14.

[0026] Furthermore, the first control unit 13 has the capability of not only sending out the CO coordination alarm but also making the first communications unit 12 transmit a notification signal to the other fire alarms 1. Specifically, the first control unit 13 makes, with reference to a predefined routing table, the first communications unit 12 transmit the notification signal to the other fire alarms 1. In other words, the plurality of fire alarms 1 performs multi-hop communication with reference to the routing table. In this case, to increase the chances of the other fire alarms 1 receiving the notification signal successfully, the first control unit 13 may make the first communications unit 12 transmit the same notification signal over and over again for a predetermined period.

[0027] Optionally, the routing table may be updated on a regular basis by making the plurality of fire alarms 1 perform routing processing defined by a proactive routing protocol, for example. This enables the plurality of fire alarms 1 to maintain the multi-hop communication, even if radio waves are no longer receivable as well as previously due to relocation of some of the fire alarms 1, installation of an obstacle such as a piece of furniture, or any other factor.

[0028] The sensor 2 has the capability of detecting the presence of carbon monoxide (CO) and may be installed, for example, in the basement of a dwelling house or on the ceiling of a garage. Alternatively, the sensor 2 may also be installed in an insufficiently ventilated room such as a room with few windows or in a room where a heater such as a gas heater is used. This is because there is a good chance of carbon monoxide being produced by the use of a heater such as a gas heater in a closed space, incomplete combustion of a boiler or a gas-powered hot water supply, or incomplete fuel combustion in cars resulting in emission of poisonous exhaust gases, for example. For this reason, the sensor 2 is preferentially installed in a room where there is a good chance of carbon monoxide being present.

[0029] The sensor 2 includes a CO detector 21, a second communications unit 22, a second control unit 23, and a second audible alarm warning unit 24. The sensor 2 may be driven by a battery such as a dry battery.

[0030] The CO detector 21 is configured to detect the presence of carbon monoxide and vary the detected quantity (such as a voltage value) according to the amount (e.g., concentration) of the carbon monoxide present. Examples of methods of detecting carbon monoxide include an electrochemical method, a contact burning method, and a semiconductor method. The electrochemical method is a method of detecting the amount of carbon monoxide present by transforming chemical reaction energy, generated by oxidation-reduction reaction, into electrical energy. The contact burning method is a method of detecting the amount of carbon monoxide present by sensing a variation in voltage involved with an increase in the resistance of a detecting element when carbon monoxide burns by reacting to the detecting element. The semiconductor method is a method of detecting the amount of carbon monoxide present by sensing a variation in electric conductivity due to adsorption of a gas onto the surface of a metal-oxide semiconductor. The CO detector 21 compares the detected quantity with a threshold value that has been set in advance by the CO detector 21, and determines that carbon monoxide should be present when finding the detected quantity greater than the threshold value.

[0031] The second communications unit 22 includes an antenna, a transmitter circuit, and a receiver circuit, and is configured to transmit and receive a wireless signal via radio waves. The transmitter circuit modulates data supplied from the second control unit 23 into a wireless signal and transmits the wireless signal via the antenna. The receiver circuit demodulates a wireless signal received at the antenna and outputs the demodulated data to the second control unit 23. The second communications unit 22 transmits and receives a wireless signal in compliance with the "Low Power Radio Station for Security System" standard defined in Article 6(4)(iii) of Rules for Enforcement of Radio Act for the country of Japan. Alternatively, the second communications unit 22 may also be configured to transmit and receive a wireless signal in compliance with the law of any other foreign country outside of Japan.

[0032] The second control unit 23 includes, as its major component, a microcomputer and performs a desired function by executing a program stored in a memory. Note that the program may be written in the memory in advance but may also be provided by being stored on some storage medium such as a memory card or be downloaded through a telecommunications line.

[0033] The second audible alarm warning unit 24 includes a buzzer for sounding a buzz specified by the second control unit 23 and a loudspeaker for emitting a verbal warning message specified by the second control unit 23.

[0034] The second control unit 23 has the capability of sending out, upon detection of carbon monoxide by the CO detector 21, a CO alarm by controlling the second audible alarm warning unit 24. As used herein, the "CO alarm" is an early warning, sent out by the sensor 2 at the origin of carbon monoxide, of the presence of the carbon monoxide. Specifically, the second control unit 23 may either make the buzzer of the second audible alarm warning unit 24 sound a buzz, different from the fire warning and the CO coordination alarm, or have a verbal warning message such as "Warning! Carbon monoxide! Get out of here ASAP" announced through the loudspeaker of the second audible alarm warning unit 24.

[0035] As for the scheme for giving such a warning,

the second audible alarm warning unit 24 needs to include at least one of the buzzer or the loudspeaker, and may be configured to include only the buzzer or only the loudspeaker. The second control unit 23 needs to have the capability of sending out the CO alarm by controlling the second audible alarm warning unit 24 depending on the configuration of the second audible alarm warning unit 24.

[0036] Furthermore, the second control unit 23 has the capability of not only sending out the CO alarm but also making the second communications unit 22 transmit a notification signal to the plurality of fire alarms 1. Specifically, the second control unit 23 makes the second communications unit 22 broadcast the notification signal. In this case, to increase the chances of at least one of the plurality of fire alarms 1 receiving the notification signal successfully, the second control unit 23 may make the second communications unit 22 broadcast the same notification signal over and over again for a predetermined period.

[0037] Next, it will be described with reference to FIG. 2 how the security system 100 of this embodiment works. First of all, suppose carbon monoxide has been produced at the site of installation of the sensor 2. In such a situation, the CO detector 21 of the sensor 2 detects the presence of carbon monoxide (in Step S101). Then, the second control unit 23 of the sensor 2 sends out a CO alarm by controlling the second audible alarm warning unit 24 (in Step S102). In addition, the second control unit 23 of the sensor 2 also makes the second communications unit 22 transmit a notification signal to the plurality of fire alarms 1 (in Step S103).

[0038] In this example, suppose a fire alarm 1A, among the plurality of fire alarms 1, has received the notification signal. In the fire alarm 1A, upon receipt of the notification signal at the first communications unit 12, the first control unit 13 sends out a CO coordination alarm by controlling the first audible alarm warning unit 14 (in Step S104). Then, the first control unit 13 makes the first communications unit 12 transmit the notification signal to the other fire alarms 1 (in Step S105). In this example, the first control unit 13 makes the first communications unit 12 transmit the notification signal to the fire alarms 1B and 1C, which are ready to communicate with the fire alarm 1A.

[0039] In the fire alarm 1B, upon receipt of the notification signal at the first communications unit 12, the first control unit 13 sends out a CO coordination alarm by controlling the first audible alarm warning unit 14 (in Step S106). Likewise, in the fire alarm 1C, upon receipt of the notification signal at the first communications unit 12, the first control unit 13 sends out a CO coordination alarm by controlling the first audible alarm warning unit 14 (in Step S107). In this case, no fire alarms 1 but the fire alarm 1A are ready to communicate with the fire alarms 1B and 1C. That is why neither the first control unit 13 of the fire alarm 1B nor that of the fire alarm 1C performs the processing of transmitting the notification signal to any other fire alarm 1.

[0040] As described above, in the security system 100 of this embodiment, on receiving the notification signal from the sensor 2, any one of the plurality of fire alarms 1 not only sends out the CO coordination alarm but also transmits the notification signal to the other fire alarms 1. That is why in the security system 100 of this embodiment, having all of the fire alarms 1 receive the notification signal allows all of those fire alarms 1 to send out an early warning of the presence of carbon monoxide in coordination with each other. Consequently, the security system 100 of this embodiment has the ability to send out an early warning of the presence of carbon monoxide to a location other than the origin of the carbon monoxide.

[0041] This is beneficial, because carbon monoxide will diffuse at a higher rate than smoke produced by a fire. In addition, carbon monoxide is much more poisonous, and much more harmful to humans, than smoke produced by a fire. For these reasons, when carbon monoxide is present, not only persons at the origin of the carbon monoxide but also everybody else inside the same building should get out of the building. The security system 100 of this embodiment has the ability to send out an early warning of the presence of carbon monoxide to a location other than the origin of the carbon monoxide, and therefore, is able to urge everybody else inside the building, not just the persons present at the origin of the carbon monoxide, to get out of the building as quickly as possible.

[0042] On top of that, in the security system 100 of this embodiment, the second control unit 23 of the sensor 2 is configured to, upon detection of carbon monoxide by the CO detector 21, send out a CO alarm as an early warning of the presence of carbon monoxide. Thus, the security system 100 of this embodiment gives an early warning of the presence of carbon monoxide to people present at the origin of the carbon monoxide as well, and therefore, is also able to urge those present at the origin of the carbon monoxide to get out of the building as soon as humanly possible. Note that such a configuration is just an option and does not always have to be taken. Furthermore, the security system 100 of this embodiment may also include both the sensor 2 with the capability to send out the CO alarm and an additional sensor 2 without the capability to send out the CO alarm.

[0043] Furthermore, in the security system 100 of this embodiment, the CO coordination alarm suitably has the same alarm sound/warning as the CO alarm. As used herein, the "alarm sound/warning" is at least one of the buzz sounded by the buzzer of the first audible alarm warning unit 14 (or the second audible alarm warning unit 24) or the verbal warning message announced through the loudspeaker. According to this configuration, a plurality of fire alarms 1 gives an early warning of the presence of carbon monoxide as if they were the sensor 2 at the origin of the carbon monoxide, thus allowing everybody inside the building to get out of the building as quickly as possible. Among other things, this configura-

tion makes it easier to prevent a person who has heard of the alarm from going to see what has happened at the origin of carbon monoxide, thus facilitating minimization of the expansion of human damage. Note that even if the sensor 2 is configured to send out no CO alarm, the plurality of fire alarms 1 may also send out the CO coordination alarm in the same alarm sound/warning as the CO alarm.

[0044] Besides, in the security system 100 of this embodiment, the first control unit 13 of each of the plurality of fire alarms 1 has a fire coordination capability. As used herein, the "fire coordination capability" is the fire detector's 11 capability of making, upon detection of a fire, the first communications unit 12 transmit a coordination signal to the other fire alarms 1. The "coordination signal" herein means a signal for sending out a fire coordination alarm as an early warning of the outbreak of a fire in coordination with the fire alarm 1 at the origin of the fire.

[0045] Also, in each of the plurality of fire alarms 1, the first control unit 13 is configured to, upon receipt of the notification signal at the first communications unit 12 while the fire coordination alarm is being sent out, send out the CO coordination alarm preferentially.

[0046] The fire coordination capability of the security system 100 of this embodiment will be described with reference to FIG. 3. First of all, suppose a fire has broken out at the site of installation of the fire alarm 1A. In such a situation, the fire detector 11 of the fire alarm 1A detects the outbreak of the fire (in Step S201). Then, the first control unit 13 of the fire alarm 1A sends out a fire warning by controlling the first audible alarm warning unit 14 (in Step S202). In addition, the first control unit 13 of the fire alarm 1A also makes the first communications unit 12 transmit a coordination signal to the other fire alarms 1 (in Step S203). In this example, the first control unit 13 makes the first communications unit 12 transmit the coordination signal to the fire alarms 1B and 1C that are ready to communicate with the fire alarm 1A.

[0047] In the fire alarm 1B, the first control unit 13 sends out, upon receipt of the coordination signal at the first communications unit 12, a fire coordination alarm by controlling the first audible alarm warning unit 14 (in Step S204). Specifically, the first control unit 13 may have a buzz, different from the fire warning and the CO coordination alarm, sounded by the buzzer of the first audible alarm warning unit 14 or have a verbal warning message such as "Warning! Fire over there!" announced through the loudspeaker of the first audible alarm warning unit 14. In the same way, in the fire alarm 1C, the first control unit 13 sends out, upon receipt of the coordination signal at the first communications unit 12, a fire coordination alarm by controlling the first audible alarm warning unit 14 (in Step S205). In this manner, upon detection of a fire by any one of the plurality of fire alarms 1, all of those fire alarms 1 send out an early warning of the outbreak of the fire in coordination with each other.

[0048] In this case, when the fire alarm 1B, among the plurality of fire alarms 1, receives a notification signal while all of those fire alarms 1 are sending out the fire coordination alarm (in Step S206), the first control unit 13 of the fire alarm 1B performs the following control. Specifically, the first control unit 13 of the fire alarm 1B sets off the CO coordination alarm instead of the fire coordination alarm by controlling the first audible alarm warning unit 14 (in Step S207). Then, the first control unit 13 makes the first communications unit 12 transmit a notification signal to the other fire alarms 1 (in Step S208). In this example, the first control unit 13 makes the first communications unit 12 transmit the notification signal to the fire alarms 1A and 1C that are ready to communicate with the fire alarm 1B.

[0049] In the fire alarm 1A, the first control unit 13 sets off, upon receipt of the notification signal at the first communications unit 12, the CO coordination alarm instead of the fire coordination alarm by controlling the first audible alarm warning unit 14 (in Step S209). In the same way, in the fire alarm 1C, the first control unit 13 sets off, upon receipt of the notification signal at the first communications unit 12, the CO coordination alarm instead of the fire coordination alarm by controlling the first audible alarm warning unit 14 (in Step S210).

[0050] As can be seen from the foregoing description, the security system 100 of this embodiment is able to give higher priority to sending out an early warning of the presence of carbon monoxide, which is more urgent than sending out an early warning of the presence of smoke produced by a fire, considering the devastating effects of carbon monoxide on humans. That is why the security system 100 of this embodiment allows everybody inside the building to evacuate more quickly, and reduces the expansion of human damage much more significantly, than just sending out the fire coordination alarm continuously.

[0051] Note that not all of those fire alarms 1 necessarily have the fire coordination capability. In other words, the security system 100 of this embodiment may include both fire alarms 1 with the fire coordination capability and fire alarms 1 with no fire coordination capability. Also, not all of those fire alarms 1 preferentially set off the CO coordination alarm while sending out the fire coordination alarm. Optionally, upon receipt of the notification signal at the first communications unit 12 while the fire warning is being sent out, the first control unit 13 of some of the plurality of fire alarms 1 may send out the fire warning preferentially, while the first control unit 13 of the other fire alarms 1 may send out the CO coordination alarm preferentially. Alternatively, in each of the plurality of fire alarms 1, the first control unit 13 may send out, upon receipt of the notification signal at the first communications unit 12 while the fire warning is being sent out, the fire warning and the CO coordination alarm alternately.

[0052] If necessary, in the security system 100 of this embodiment, at least one fire alarm 1, among the plurality of fire alarms 1, may further include the CO detector 21 as an additional element. According to such a configuration, in the fire alarm 1 with the CO detector 21, the

first control unit 13 sends out, upon detection of carbon monoxide by the CO detector 21, the CO coordination alarm (or the CO alarm) by controlling the first audible alarm warning unit 14. Then, the first control unit 13 makes the first communications unit 12 transmit the notification signal to the other fire alarms 1.

[0053] Alternatively or additionally, in the security system 100 of this embodiment, the sensor 2 may further include the fire detector 11 as an additional element. According to such a configuration, the second control unit 23 of the sensor 2 sends out, upon detection of a fire by the fire detector 11, the fire warning by controlling the second audible alarm warning unit 24.

[0054] Furthermore, the security system 100 of this embodiment is configured to make the plurality of fire alarms 1 perform multi-hop communication. Alternatively, the security system 100 may also be configured to make the sensor 2, as well as the fire alarms 1, perform the multi-hop communication. In that case, the second control unit 23 of the sensor 2 makes, upon detection of carbon monoxide by the CO detector 21, the second communications unit 22 transmit the notification signal to at least one of the plurality of fire alarms 1.

[0055] Optionally, in the security system 100 of this embodiment, the plurality of fire alarms 1 may be made up of one master station and one or more other slave stations. According to such a configuration, the master station is suitably arranged at such a location where the master station is able to establish communication with all of the slave stations. In the master station, the first control unit 13 sends out, upon receipt of the notification signal at the first communications unit 12 from the sensor 2, the CO coordination alarm by controlling the first audible alarm warning unit 14. Then, the first control unit 13 makes the first communications unit 12 transmit the notification signal to all of the slave stations. In each of those slave stations, the first control unit 13 sends out, upon receipt of the notification signal at the first communications unit 12, the CO coordination alarm by controlling the first audible alarm warning unit 14. That is to say, upon detection of carbon monoxide by the sensor 2, all of the fire alarms 1 send out the CO coordination alarm in coordination with each other.

[0056] In the master station, the first communications unit 12 sometimes receives the notification signal from the sensor 2 and sometimes receives the notification signal from any of the slave stations. If any slave station transmits (or relays) the notification signal from the sensor 2 to the master station, then the first control unit 13 of the slave station may set off the CO coordination alarm earlier than the master station.

[0057] Optionally, in transmitting the notification signal to all of the slave stations, the first control unit 13 of the master station may send, along with the notification signal, an instruction for the slave stations to return an acknowledgement (ACK). In that case, in each of those slave stations, the first control unit 13 makes, upon receipt of the notification signal at the first communications unit 12, the first communications unit 12 transmit the ACK to the master station. Then, the first control unit 13 of the master station makes, upon receipt of the ACK at the first communications unit 12 from every slave station, the first communications unit 12 transmit a synch signal, also serving as a notification signal, in regular cycles to every slave station. That is to say, the first control unit 13 of the master station may make every slave station send out the CO coordination alarm by the time division multiple access (TDMA) method using the synch signal.

[0058] The security system 100 according to the exemplary embodiment described above includes three fire alarms 1. However, this is only an example and should not be construed as limiting. Alternatively, the security system 100 may also include two fire alarms 1 or four or more fire alarms 1. Furthermore, even though the security system 100 according to the exemplary embodiment described above includes one sensor 2, the security system 100 may also include two or more sensors 2.

[0059] Furthermore, in the security system 100 according to this embodiment, the second communications unit 22 and the first communications unit 12 may be implemented as a single piece of hardware or may have their functions executed by a single software program.

<Variations>

[0060] An exemplary application of a security system 100A according to a variation of the exemplary embodiment to a single-family dwelling house A1 (hereinafter simply referred to as a "house A1") will be described. Note that the security system 100A according to this variation is basically the same as the security system 100 according to the exemplary embodiment. Therefore, in the following description, any constituent member of this variation, having the same function as a counterpart of the security system 100 according to the embodiment described above, will not be described all over again to avoid redundancies. Also, in the following description, a plurality of sensors 2A and 2B will be collectively referred to as "sensors 2" unless there is a special need to distinguish the sensors 2A and 2B from each other.

[0061] As shown in FIG. 4, a garage B1 for accommodating a car C1 is built on the premises of the house A1. Also, the house A1 is a two-story building with two rooms A11 and A12 on the first floor, two more rooms A21 and A22 on the second floor, a flight of stairs A3 connecting the first and second floors, and a basement A4.

[0062] The security system 100A according to this variation includes five fire alarms 1 (namely, fire alarms 1A, 1B, 1C, 1D, and 1E) and two sensors 2 (namely, sensors 2A and 2B).

[0063] The fire alarm 1A is mounted on the ceiling of the room A11 on the first floor of the house A1. The fire alarm 1B is mounted on the ceiling of the room A12 on the first floor of the house A1. The fire alarm 1C is mounted on the ceiling of a stairwell with the stairs A3 of the house A1. The fire alarm 1D is mounted on the ceiling of

the room A22 on the second floor of the house A1. The fire alarm 1E is mounted on the ceiling of the room A21 on the second floor of the house A1.

[0064] The sensor 2A is mounted on the ceiling of the garage B1. The sensor 2B is mounted on the ceiling of the basement A4 of the house A1. The sensors 2A and 2B are each installed at such a location from which a notification signal, broadcast from the sensor 2A or 2B, is able to reach at least one of the plurality of fire alarms 1. Specifically, according to this variation, the sensor 2A is installed at such a location from which the notification signal is able to reach the fire alarm 1A. Also, according to this variation, the sensor 2B is installed at such a location from which the notification signal is able to reach the fire alarm 1B.

[0065] According to this variation, the plurality of fire alarms 1A-1E performs multi-hop communication through one of the routes shown in FIGS. 5 and 6. Specifically, if the source of a wireless signal received is the sensor 2A, then the fire alarm 1A relays the wireless signal to the fire alarm 1B. If the source of a wireless signal received is the fire alarm 1A, then the fire alarm 1B relays the wireless signal to the fire alarm 1C. On the other hand, if the source of a wireless signal received is the sensor 2B, then the fire alarm 1B relays the wireless signal to the fire alarms 1A and 1C. Furthermore, if the source of a wireless signal received is the fire alarm 1C, then the fire alarm 1B relays the wireless signal to the fire alarm 1A.

[0066] If the source of a wireless signal received is the fire alarm 1B, then the fire alarm 1C relays the wireless signal to the fire alarms 1D and 1E. Conversely, if the source of a wireless signal received is either the fire alarm 1D or the fire alarm 1E, then the fire alarm 1C relays the wireless signal to the fire alarm 1B. Unless the source of a wireless signal received is the fire alarm 1C, the fire alarms 1D and 1E each relay the wireless signal to the fire alarm 1C.

[0067] Next, it will be described how the security system 100A according to this variation operates. Suppose carbon monoxide has been produced in the basement A4, for example. In that case, the CO detector 21 of the sensor 2B detects the presence of the carbon monoxide. Then, the second control unit 23 of the sensor 2B makes the second communications unit 22 broadcast the notification signal as shown in FIG. 5.

[0068] The notification signal from the sensor 2B is received at the first communications unit 12 of the fire alarm 1B. Then, in the fire alarm 1B, the first control unit 13 sends out the CO coordination alarm by controlling the first audible alarm warning unit 14 and makes the first communications unit 12 relay the notification signal to the fire alarms 1A and 1C. In each of the fire alarms 1A and 1C, the first control unit 13 sends out, upon receipt of the notification signal at the first communications unit 12, the CO coordination alarm by controlling the first audible alarm warning unit 14. Also, in the fire alarm 1C, the first control unit 13 makes the first communications unit 12 relay the notification signal to the fire alarms 1D and 1E. In each of the fire alarms 1D and 1E, the first control unit 13 sends out, upon receipt of the notification signal at the first communications unit 12, the CO coordination alarm by controlling the first audible alarm warning unit 14.

[0069] Meanwhile, suppose carbon monoxide has been produced in the garage B1, for example. In that case, the CO detector 21 of the sensor 2A detects the presence of the carbon monoxide. Then, the second control unit 23 of the sensor 2A makes the second communications unit 22 broadcast the notification signal as shown in FIG. 6.

[0070] The notification signal from the sensor 2A is received at the first communications unit 12 of the fire alarm 1A. Then, in the fire alarm 1A, the first control unit 13 sends out the CO coordination alarm by controlling the first audible alarm warning unit 14 and makes the first communications unit 12 relay the notification signal to the fire alarm 1B. In the fire alarm 1B, the first control unit 13 sends out, upon receipt of the notification signal at the first communications unit 12, the CO coordination alarm by controlling the first audible alarm warning unit 14, and makes the first communications unit 12 relay the notification signal to the fire alarm 1C. In the fire alarm 1C, the first control unit 13 sends out, upon receipt of the notification signal at the first communications unit 12, the CO coordination alarm by controlling the first audible alarm warning unit 14, and makes the first communications unit 12 relay the notification signal to the fire alarms 1D and 1E. In each of the fire alarms 1D and 1E, the first control unit 13 sends out, upon receipt of the notification signal at the first communications unit 12, the CO coordination alarm by controlling the first audible alarm warning unit 14.

[0071] In this manner, as soon as either the sensor 2A or the sensor 2B detects the presence of carbon monoxide, all of the fire alarms 1A-1E in the house A1 send out an early warning of the presence of the carbon monoxide in coordination with each other. This allows every resident of the house A1 to be aware of the presence of the carbon monoxide and quickly leave the premises of the house A1, no matter where in the house A1 they are.

[0072] In the security system 100A according to this variation, all of the fire alarms 1A-1E may naturally be arranged so as to be able to directly communicate with each other. In that case, a fire alarm 1, having received a notification signal from any one of the two sensors 2A and 2B, may transmit or relay the notification signal to all of the other fire alarms 1.

[0073] Optionally, the security system 100A according to this variation may further include an alarm transfer device 3 as shown in FIG. 4. The alarm transfer device 3 is configured to transfer a notification signal received to a location outside of the house A1. In this variation, the fire alarm 1D, installed in the same room as the alarm transfer device 3, is configured to relay the notification signal to the alarm transfer device 3. That is to say, ac-

cording to this variation, upon detection of carbon monoxide by any one of the two sensors 2A and 2B, the alarm transfer device 3 is able to notify a device outside of the house A1 that carbon monoxide has been produced in the premises of the house A1. Note that this alarm transfer device 3 is just an optional device, not an essential constituent element, for the security system 100A according to this variation.

[0074] As can be seen from the foregoing description, a security system (100, 100A) according to a first aspect includes a plurality of fire alarms (1) and a sensor (2). Each of the plurality of fire alarms (1) includes a fire detector (11), a first communications unit (12), and a first control unit (13). The fire detector (11) detects outbreak of a fire. The first communications unit (12) transmits and receives a wireless signal via radio waves. The first control unit (13) sends out, upon detection of the fire by the fire detector (11), a fire warning as an early warning of the outbreak of the fire. The sensor (2) includes a CO detector (21), a second communications unit (22), and a second control unit (23). The CO detector (21) detects presence of carbon monoxide. The second communications unit (22) transmits and receives the wireless signal. In the sensor (2), the second control unit (23) is configured to, upon detection of carbon monoxide by the CO detector (21), make the second communications unit (22) transmit a notification signal to the plurality of fire alarms (1). In each of the plurality of fire alarms (1), the first control unit (13) is configured to, upon receipt of the notification signal at the first communications unit (12), send out a CO coordination alarm as an early warning of the presence of carbon monoxide at a site of installation of the sensor (2) and is also configured to make the first communications unit (12) transmit the notification signal to the other fire alarms (1).

[0075] In a security system (100, 100A) according to a second aspect, which may be implemented in conjunction with the first aspect, the second control unit (23) of the sensor (2) is configured to, upon detection of carbon monoxide by the CO detector (21), send out a CO alarm as an early warning of the presence of the carbon monoxide.

[0076] In a security system (100, 100A) according to a third aspect, which may be implemented in conjunction with the second aspect, the CO coordination alarm has the same alarm sound/warning as the CO alarm.

[0077] In a security system (100, 100A) according to a fourth aspect, which may be implemented in conjunction with any one of the first to third aspects, in each of the plurality of fire alarms (1), the first control unit (13) has a fire coordination capability. The fire coordination capability allows the first control unit (13) to make, upon detection of the fire by the fire detector (11), the first communications unit (12) transmit a coordination signal to the other fire alarms (1). The coordination signal is transmitted to send out, in coordination with the fire alarm (1) at an origin of the fire, a fire coordination alarm as an early warning of the outbreak of the fire. In each of the plurality of fire alarms (1), the first control unit (13) is configured to, upon receipt of the notification signal at the first communications unit (12) while the fire coordination alarm is being sent out, send out the CO coordination alarm preferentially.

[0078] In a security system (100, 100A) according to a fifth aspect, which may be implemented in conjunction with any one of the first to fourth aspects, in each of the plurality of fire alarms (1), the first control unit (13) is configured to, upon receipt of the notification signal at the first communications unit (12) while the fire warning is being sent out, send out the fire warning and the CO coordination alarm alternately.

[0079] In a security system (100, 100A) according to a sixth aspect, which may be implemented in conjunction with any one of the first to fifth aspects, the first control unit (13) is configured to make, with reference to a predefined routing table, the first communications unit (12) transmit the notification signal to the other fire alarms (1). The routing table is updated on a regular basis by having each of the plurality of fire alarms (1) perform routing processing.

[0080] The security system (100, 100A) has the ability to send out an early warning of the presence of carbon monoxide to a location other than the origin of the carbon monoxide.

Reference Signs List

[0081]

1, 1A, 1B	Fire Alarm
11	Fire Detector
12	First Communications Unit
13	First Control Unit
2, 2A, 2B	Sensor
21	CO Detector
22	Second Communications Unit
23	Second Control Unit
100, 100A	Security System

Claims

1. A security system comprising
a plurality of fire alarms; and
a sensor,
each of the plurality of fire alarms including:

a fire detector configured to detect outbreak of a fire;
a first communications unit configured to transmit and receive a wireless signal via radio waves; and
a first control unit configured to, upon detection of the fire by the fire detector, send out a fire warning of the outbreak of the fire,
the sensor including:

a CO detector configured to detect presence of carbon monoxide;
a second communications unit configured to transmit and receive the wireless signal; and
a second control unit,

the second control unit of the sensor being configured to, upon detection of carbon monoxide by the CO detector, make the second communications unit transmit a notification signal to the plurality of fire alarms, and
the first control unit of each of the plurality of fire alarms being configured to, upon receipt of the notification signal at the first communications unit, send out a CO coordination alarm as an early warning of the presence of carbon monoxide at a site of installation of the sensor and make the first communications unit transmit the notification signal to the other fire alarms.

2. The security system of claim 1, wherein
the second control unit of the sensor is configured to, upon detection of carbon monoxide by the CO detector, send out a CO alarm as an early warning of the presence of the carbon monoxide.

3. The security system of claim 2, wherein
the CO coordination alarm has the same alarm sound/warning as the CO alarm.

4. The security system of any one of claims 1 to 3, wherein
in each of the plurality of fire alarms, the first control unit is configured to, upon detection of the fire by the fire detector, make the first communications unit transmit a coordination signal to the other fire alarms, the coordination signal being transmitted to send out, in coordination with the fire alarm at an origin of the fire, a fire coordination alarm as an early warning of the outbreak of the fire, and
in each of the plurality of fire alarms, the first control unit is configured to, upon receipt of the notification signal at the first communications unit while the fire coordination alarm is being sent out, send out the CO coordination alarm preferentially.

5. The security system of any one of claims 1 to 4, wherein
in each of the plurality of fire alarms, the first control unit is configured to, upon receipt of the notification signal at the first communications unit while the fire warning is being sent out, send out the fire warning and the CO coordination alarm alternately.

6. The security system of any one of claims 1 to 5, wherein
the first control unit is configured to make, with reference to a predefined routing table, the first communications unit transmit the notification signal to the other fire alarms, and
the routing table is updated on a regular basis by having each of the plurality of fire alarms perform routing processing.

FIG. 1

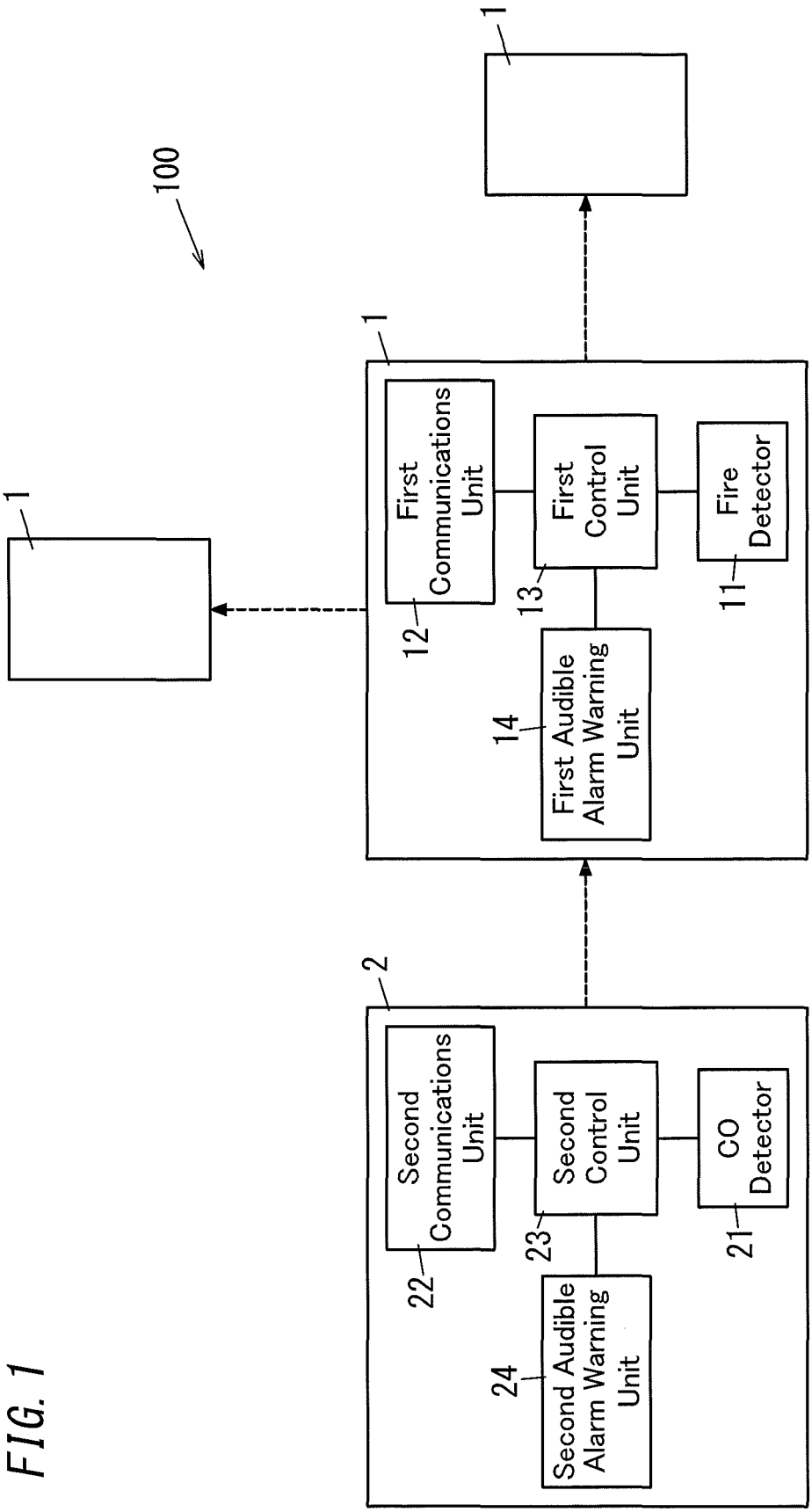

100
1
1
1
First Communications Unit
12
First Control Unit
13
Fire Detector
11
First Audible Alarm Warning Unit
14
2
Second Communications Unit
22
Second Control Unit
23
CO Detector
21
Second Audible Alarm Warning Unit
24

FIG. 2

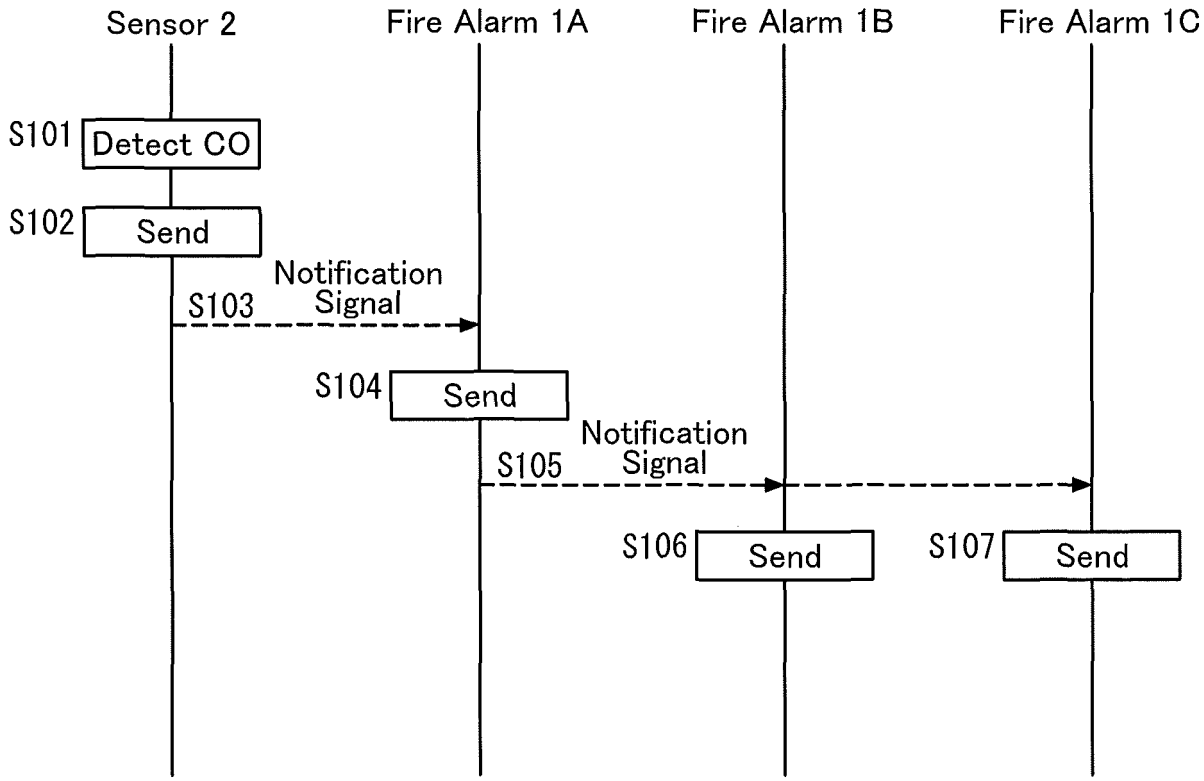

Sensor 2
Fire Alarm 1A
Fire Alarm 1B
Fire Alarm 1C
S101
Detect CO
S102
Send
S103
Notification Signal
S104
Send
S105
Notification Signal
S106
Send
S107
Send

FIG. 3

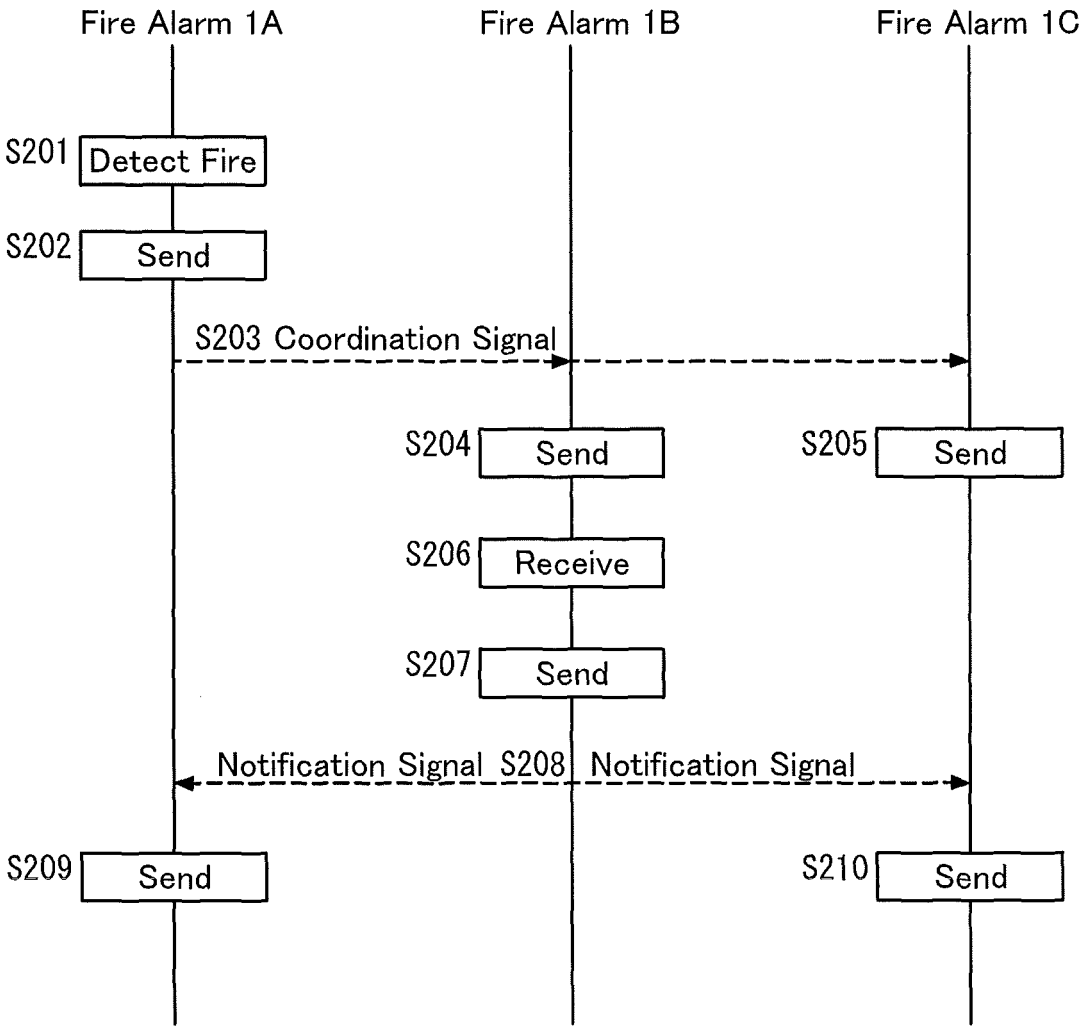

Fire Alarm 1A
Fire Alarm 1B
Fire Alarm 1C
S201
Detect Fire
S202
Send
S203 Coordination Signal
S204
Send
S205
Send
S206
Receive
S207
Send
Notification Signal S208 Notification Signal
S209
Send
S210
Send

FIG. 4

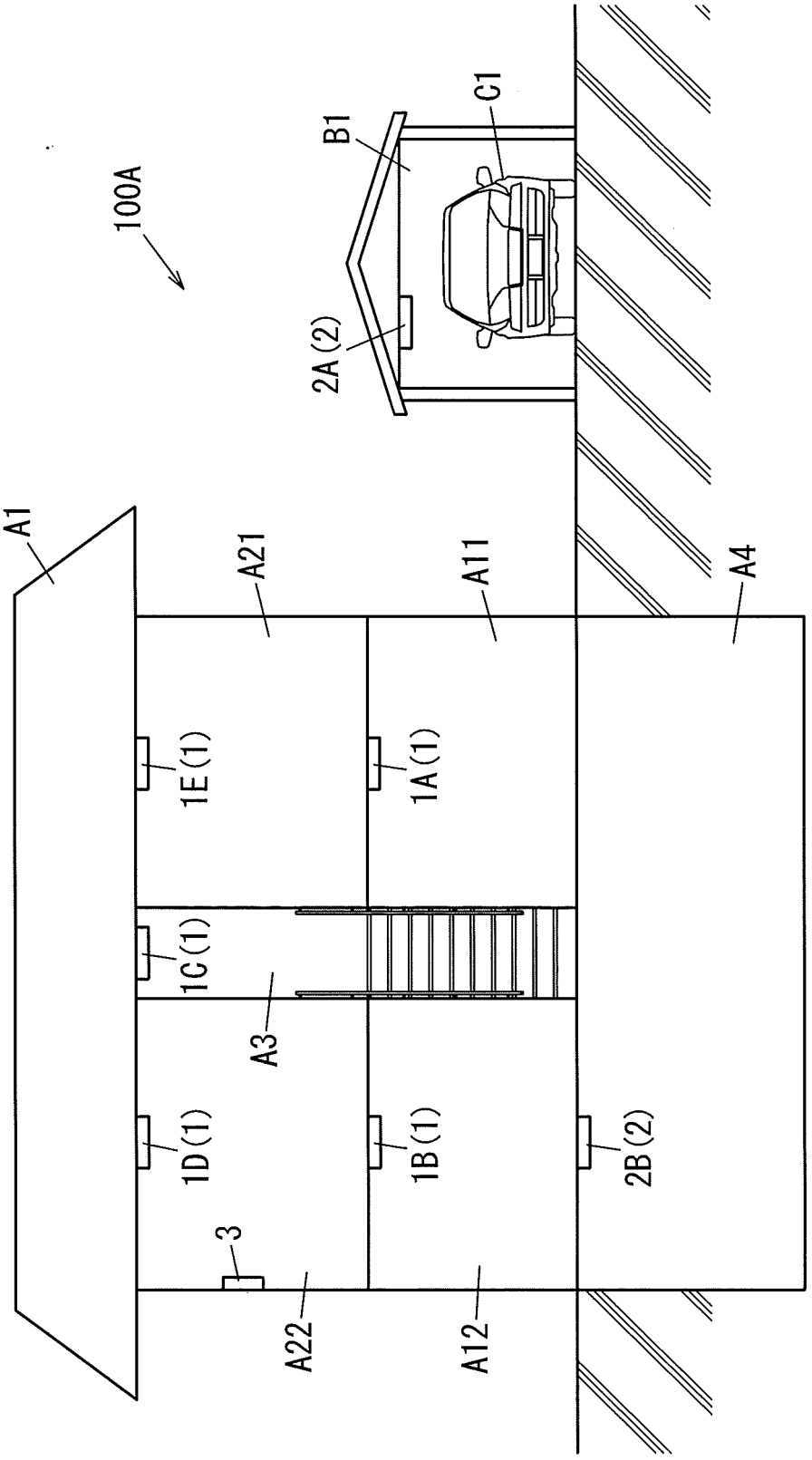


FIG. 5

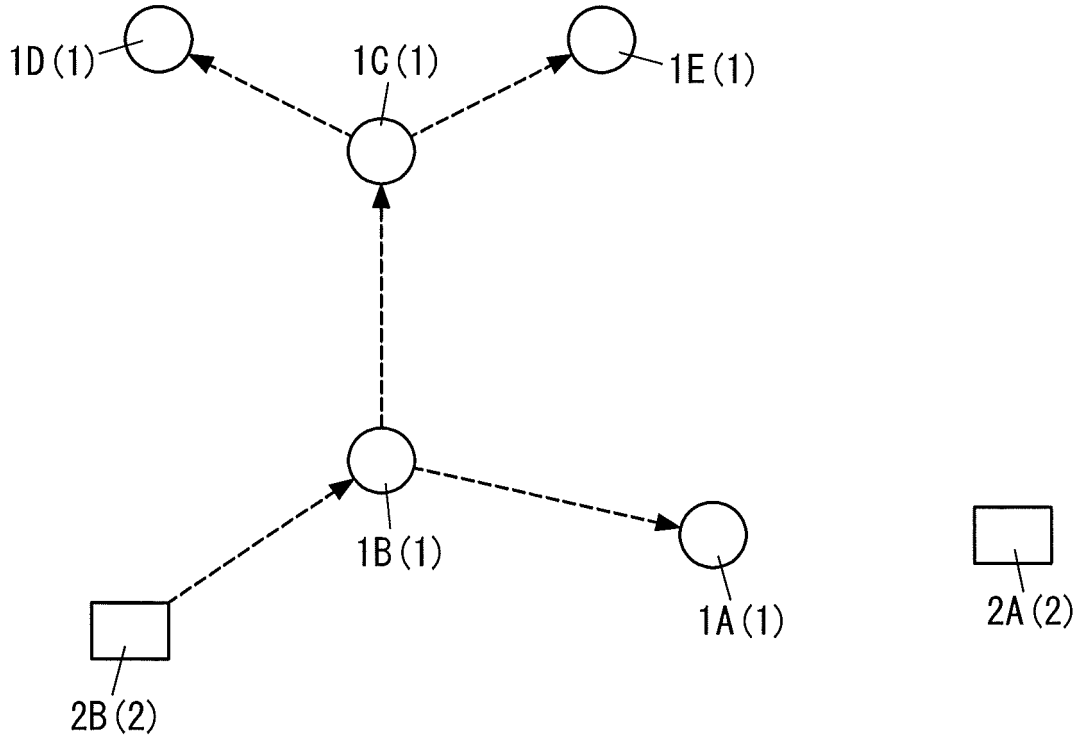
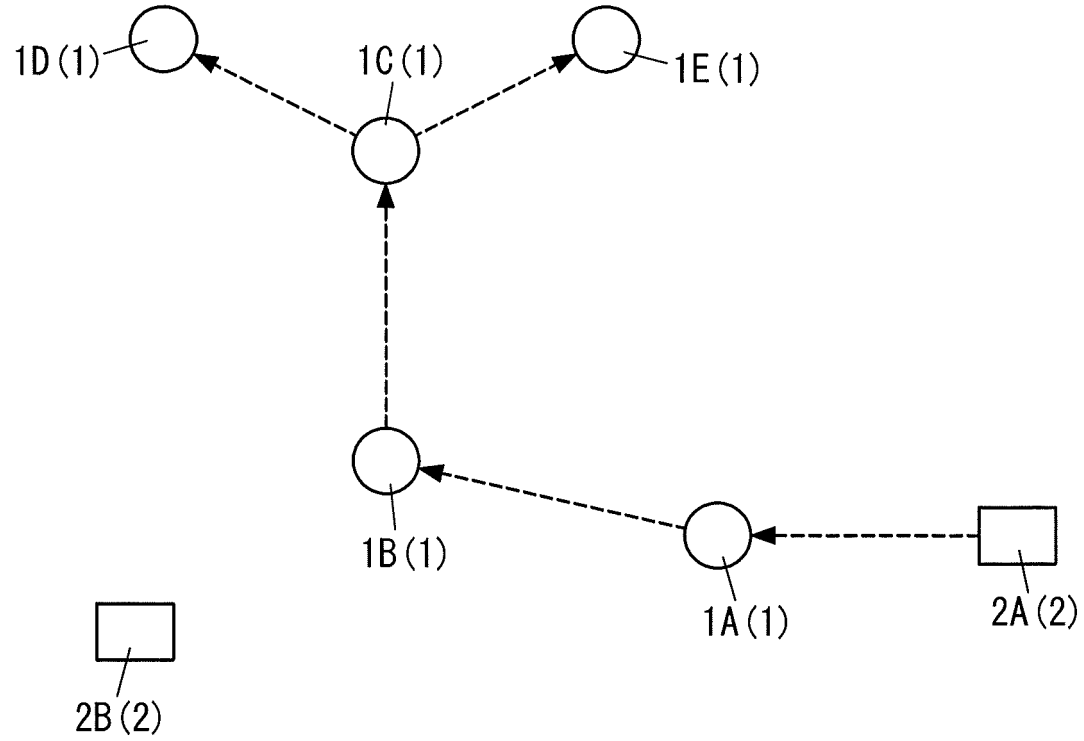


FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/010336

A. CLASSIFICATION OF SUBJECT MATTER
G08B25/10(2006.01)i, *G08B17/00*(2006.01)i, *G08B21/14*(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)
G08B25/10, G08B17/00, G08B21/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2017
Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2010-176172 A (Panasonic Corp.), 12 August 2010 (12.08.2010), paragraphs [0019] to [0024], [0027], [0028]; fig. 4 (Family: none)	1 2-6
Y	JP 2011-165109 A (Nohmi Bosai Ltd.), 25 August 2011 (25.08.2011), paragraphs [0017] to [0036]; fig. 1 to 5 (Family: none)	1-6
Y	JP 2006-18597 A (Tokyo Gas Co., Ltd.), 19 January 2006 (19.01.2006), paragraphs [0029], [0037] to [0043] (Family: none)	1-6

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

* Special categories of cited documents:
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"P" document published prior to the international filing date but later than the priority date claimed
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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
19 May 2017 (19.05.17)	30 May 2017 (30.05.17)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/010336

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2008-40555 A (Yazaki Corp.), 21 February 2008 (21.02.2008), paragraphs [0017] to [0023], [0047] to [0052]; fig. 1 to 6 (Family: none)	2-6
Y	JP 2010-33194 A (Panasonic Electric Works Co., Ltd.), 12 February 2010 (12.02.2010), paragraphs [0013] to [0036]; fig. 1 to 5 (Family: none)	2-6
Y	JP 2010-272040 A (Hochiki Corp.), 02 December 2010 (02.12.2010), paragraphs [0022] to [0038], [0066] to [0069], [0121] to [0124]; fig. 1 to 6 (Family: none)	4-6
Y	WO 2014/049975 A1 (Panasonic Corp.), 03 April 2014 (03.04.2014), paragraphs [0002] to [0006], [0044] to [0049] & JP 2014-71563 A	6
A	JP 2015-87885 A (Hochiki Corp.), 07 May 2015 (07.05.2015), entire text; all drawings (Family: none)	1-6

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REFERENCES CITED IN THE DESCRIPTION

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