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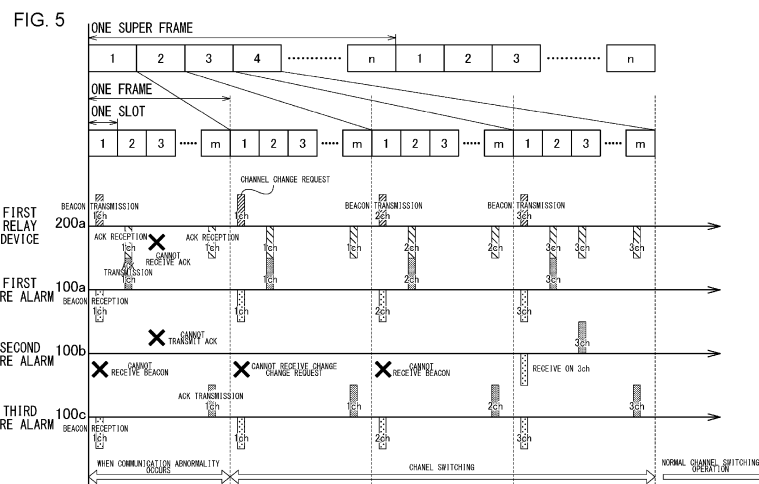
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(54) **ALARM SYSTEM, RELAY DEVICE, CHANNEL DETERMINATION METHOD, PROGRAM**

(57) A technology for facilitating channel management even when channel switching could occur. A relay device 200a transmits a beacon signal to a plurality of fire alarms 100a, 100b, etc. on a first channel. Upon receiving the beacon signal, the fire alarms 100a, 100b, etc. transmit a response signal to the relay device 200a on the first channel. When the response signal from one fire alarm 100b is not received, the relay device 200a

transmits the beacon signal to the plurality of fire alarms 100a, 100b, etc. on a second channel. Upon receiving the beacon signal, the fire alarms 100a, 100b etc. transmit a response signal to the relay device 200a on the second channel. Upon receiving the response signal from all fire alarms 100a, 100b etc., the relay device 200a determines to use the second channel in an alarm system 1000.



Description

[TECHNICAL FIELD]

[0001] The present disclosure relates to alert technology and, more particularly, to an alarm system, a relay device, a channel determination method, and a program that use one of a plurality of channels.

[BACKGROUND ART]

[0002] Home fire alarms (hereinafter, "fire alarms") detect a fire in a house and output an alarm. As a plurality of fire alarms communicate with each other, abnormality information in one fire alarm is also output by other fire alarms. As the number of fire alarms increases, the occurrence of collisions of radio signals transmitted from fire alarms also increases. In order to avoid a collision, time division multiple access (TDMA) is used (see, for example, patent document 1).

[0003] [Patent Literature 1] JP2009-169552

[SUMMARY OF INVENTION]

[TECHNICAL PROBLEM]

[0004] A plurality of channels are prepared for wireless communication in a plurality of fire alarms. In a normal state, the relay device and a plurality of fire alarms communicate by using one channel. When a communication abnormality occurs between the relay device and one of the fire alarms, the channel used between the relay device and the relevant fire alarm is switched. Meanwhile, the channel used between the relay device and the other fire alarms is not switched. Thus, a plurality of channels are used for communication between the relay device and the plurality of fire alarms. This complicates management of the channels.

[0005] The present disclosure addresses this issue, and a purpose thereof is to provide a technology for facilitating channel management even when channel switching could occur.

[SOLUTION TO PROBLEM]

[0006] An alarm system according to an embodiment of the present disclosure includes: a relay device; and a first alarm and a second alarm that can communicate with the relay device. The relay device transmits a beacon signal to the first alarm and the second alarm on a first channel, when the first alarm and the second alarm receive the beacon signal on the first channel, the first alarm and the second alarm transmit a response signal to the relay device on the first channel, when the relay device receives the response signal from the first alarm and the second alarm on the first channel, the relay device determines to use the first channel in the alarm system, when the relay device does not receive the response

signal from at least one of the first alarm or the second fire alarm on the first channel, the relay device transmits the beacon signal to the first alarm and the second alarm on a second channel different from the first channel, when the first alarm and the second alarm receive the beacon signal on the second channel, the first alarm and the second alarm transmit the response signal to the relay device on the second channel, and, when the relay device receives the response signal from the first alarm and the second alarm on the second channel, the relay device determines to use the second channel in the alarm system.

[0007] Another embodiment of the present disclosure relates to a relay device. The device includes: a communication unit that can communicate with a first alarm and a second alarm; and a control unit that controls the communication unit. The communication unit transmits a beacon signal to the first alarm and the second alarm on a first channel, when the first alarm and the second alarm receive the beacon signal on the first channel, the first alarm and the second alarm transmit a response signal on the first channel, and, when the communication unit receives the response signal from the first alarm and the second alarm on the first channel, the control unit determines to use the first channel in an alarm system, when the communication unit does not receive the response signal from at least one of the first alarm or the second alarm on the first channel, the communication unit transmits the beacon signal to the first alarm and the second alarm on a second channel different from the first channel, and, when the first alarm and the second alarm receive the beacon signal on the second channel, the first alarm and the second alarm transmit the response signal on the second channel, and, when the communication unit receives the response signal from the first alarm and the second alarm on the second channel, the control unit determines to use the second channel in the alarm system.

[0008] Still another embodiment of the present disclosure relates to a channel determination method. The method including: transmitting a beacon signal to the first alarm and the second alarm on a first channel, wherein, when the first alarm and the second alarm receive the beacon signal on the first channel, the first alarm and the second alarm transmit a response signal on the first channel, the method including, when the response signal from the first alarm and the second alarm is received on the first channel, determining to use the first channel in an alarm system, the method including, when the response signal from at least one of the first alarm or the second alarm is not received, transmitting the beacon signal to the first alarm and the second alarm on a second channel different from the first channel, wherein, when the first alarm and the second alarm receive the beacon signal on the second channel, the first alarm and the second alarm transmit the response signal on the second channel, the method including, when the response signal from the first alarm and the second alarm is received on the

second channel, determining to use the second channel in the alarm system.

[0009] Optional combinations of the aforementioned constituting elements, and implementations of the disclosure in the form of methods, apparatuses, systems, recording mediums, and computer programs may also be practiced as additional modes of the present disclosure.

[ADVANTAGEOUS EFFECTS OF INVENTION]

[0010] According to the present disclosure, channel management is facilitated even when channel switching could occur.

[BRIEF DESCRIPTION OF DRAWINGS]

[0011]

Fig. 1 shows a configuration of an alarm system according to embodiment 1;

Fig. 2 shows a configuration of the fire alarm and the relay device of Fig. 1;

Fig. 3 shows an outline of communication between the fire alarm and the relay device of Fig. 1;

Fig. 4 shows an outline of a channel determination process for determination of a channel between the fire alarm and the relay device of Fig. 2;

Fig. 5 shows an outline of a further channel determination process for determination of a channel between the fire alarm and the relay device of Fig. 2;

Fig. 6 shows an outline of a high-speed intermittent reception process in the fire alarm of Fig. 5;

Fig. 7 is a flowchart showing a sequence of steps performed by the relay device of Fig. 2 to determine a channel;

Fig. 8 shows an outline of a channel determination process according to embodiment 2 for determination of a channel between the fire alarm and the relay device; and

Fig. 9 is a flowchart showing a sequence of steps according to embodiment 2 performed by the relay device to determine a channel.

[DESCRIPTION OF EMBODIMENTS]

(Embodiment 1)

[0012] A brief summary will be given before describing the present disclosure in specific details. Embodiment 1 relates to an alarm system provided in a facility such as a multiunit apartment building, an independent housing, an office, and a hospital. In the alarm system, a relay device is connected to a management device, and a plurality of fire alarms are connected to the relay device. In this tree structure, the management device represents the higher level, and the fire alarm represents the lower level. When any of the fire alarms detects an outbreak

of a fire, the fire alarm transmits a result of detection to the relay device. The relay device transmits the result of detection to the management device by relaying the result of detection. Upon receiving the result of detection, the management device selects a fire alarm that should sound an alarm. The management device transmits an instruction to sound an alarm to the selected fire alarm via the relay device. The fire alarm receiving the instruction to sound an alarm outputs an alert sound.

[0013] In the case a signal is transmitted from a plurality of fire alarms to the relay device, the larger the number of fire alarms, the more likely the signals collide each other. In order to inhibit the occurrence of collisions of signals, TDMA is used for communication between the relay device and the plurality of fire alarms. In TDMA, the relay device and the plurality of fire alarms are allocated to mutually different time slots, and the plurality of time slots are arranged on the time axis. The relay device transmits a signal in a time slot assigned to the relay device, and the fire alarm receives the signal in the time slot assigned to the relay device. Each fire alarm transmits a signal in a time slot assigned to the fire alarm, and the relay device receives the signal in the time slot assigned to the fire alarm. Given that the line for a signal from the relay device to the fire alarm is referred to as ["downlink line", the line for a signal from the fire alarm to the relay device is referred to as "uplink line".

[0014] The alarm system defines a frame that includes one time slot for communication on a downlink line (hereinafter, "downlink communication time slot) and a plurality of time slots for communication on an uplink line (hereinafter, "uplink communication time slot"). Moreover, one super frame is formed by arranging a plurality of frames on the time axis. Further, the alarm system can use a plurality of channels, and one of the channels is used for communication. For example, the relay device switches the channel when it cannot communicate with one of the fire alarms. To facilitate channel management even when channel switching could occur, the alarm system according to the embodiment performs the following process.

[0015] When a communication abnormality occurs, the relay device transmits a channel change request to all fire alarms to cause all fire alarms to switch to the same channel. After transmitting the channel change request, the relay device transmits a beacon signal, switching the channel sequentially for each frame. Upon receiving the channel change request, the fire alarm in which the communication abnormality does not occur receives the beacon signal, switching the channel sequentially for each frame. Meanwhile, the fire alarm in which the communication abnormality occurs receives the beacon signal transmitted in varying channels, by performing high-speed intermittent reception in all channels. Each of the fire alarms transmits a response signal (ACK signal) to the relay device when it receives the beacon signal. When the ACK signals from all fire alarms are received, the relay device determines to use the channel then in use.

[0016] Fig. 1 shows a configuration of an alarm system 1000. The alarm system 1000 includes a first fire alarm 100a through a sixth fire alarm 100f, which are generically referred to as fire alarms 100, a first relay device 200a, a second relay device 200b, which are generically referred to as relay devices 200, and a management device 300. The number of fire alarms 100 is not limited to "6", and the number of relay devices 200 is not limited to "2".

[0017] The alarm system 1000 is a system applied to a facility such as a house, an office, and a commercial facility to detect a fire and alert that a fire has broken out. The plurality of fire alarms 100 are, for example, home fire alarms and are provided with fire detection sensors. The plurality of fire alarms 100 are provided on, for example, the ceilings of the facility but may be provided on the walls, etc.

[0018] The first fire alarm 100a through the third fire alarm 100c communicate with the first relay device 200a wirelessly, and the fourth fire alarm 100d through the sixth fire alarm 100f communicate with the second relay device 200b wirelessly. In other words, star-type network topologies centered around the first relay device 200a and the second relay device 200b are formed. Further, the first relay device 200a and the second relay device 200b can communicate with the management device 300 by wire or wirelessly.

[0019] The management device 300 is, for example, a controller of a home energy management system (HEMS) provided in the facility. The management device 300 can communicate with a plurality of appliances provided in the facility. The plurality of appliances include, for example, air conditioners, illumination appliances, hot water dispensers, etc. having a communication function. Further, the management device 300 can communicate with the first relay device 200a and the second relay device 200b provided in the facility. The management device 300 can also communicate with the plurality of fire alarms 100 via the first relay device 200a and the second relay device 200b.

[0020] Fig. 2 shows a configuration of the fire alarm 100 and the relay device 200. The fire alarm 100 includes a communication unit 120, a processing unit 122, a control unit 124, a fire detection sensor 150, and a buzzer 152, and the relay device 200 includes a communication unit 220, a processing unit 222, and a control unit 224. In Fig. 2, the communication function in the relay device 200 for communication with the management device 300 is omitted.

[0021] A publicly known technology may be used in the fire detection sensor 150 in the fire alarm 100. For example, the fire detection sensor 150 may be an optical smoke detection sensor and may detect a fire by detecting the smoke in a fire by utilizing diffuse reflection of light. For example, the fire detection sensor 150 may be a heat detection sensor and may detect a fire by detecting the heat from a fire. For example, the fire detection sensor 150 may be a carbon monoxide detection sensor and may detect a fire by detecting the density of carbon mon-

oxide generated by combustion in a fire. For example, the fire detection sensor 150 may be an infrared detection sensor and may detect a fire by detecting infrared rays radiated by combustion in a fire.

[0022] The communication unit 120 communicates with the relay device 200 wirelessly. The processing unit 122 processes a signal received by the communication unit 120 or generates a signal that should be transmitted from the communication unit 120. The control unit 124 controls the operation of the communication unit 120 and the processing unit 122. The buzzer 152 can output a buzzer sound. The fire alarm 100 may be configured not to include the buzzer 152 and include the fire detection sensor 150. In other words, the fire alarm 100 may be configured to have the detection function and the communication function. The fire alarm 100 configured as described above can be said to be a sensor capable of alerting that a fire is detected.

[0023] The communication unit 220 in the relay device 200 communicates with the fire alarm 100 wirelessly. The processing unit 222 processes a signal received by the communication unit 220 or generates a signal that should be transmitted from the communication unit 220. The control unit 224 controls the operation of the communication unit 220 and the processing unit 222.

[0024] Fig. 3 shows an outline of communication between the fire alarm 100 and the relay device 200. The horizontal axis in Fig. 2 represents time, and "1", "2", ..., "m" denotes slot numbers. Slot "1" is a downlink communication time slot, and slots "2", ... "m" are uplink communication time slots. One frame is formed by arranging a plurality of slots on the time axis. In this case, the frames are ordered in time as "first frame" through "sixth frame". Further, one super frame is formed by arranging a plurality of frames on the time axis.

[0025] The first relay device 200a transmits a beacon signal in the downlink communication time slot "1" of the first frame. By receiving the beacon signal, the first fire alarm 100a through the third fire alarm 100c form frames and super frames synchronized with the first relay device 200a. The first relay device 200a can transmit a signal including predetermined information (hereinafter, also referred to as "communication signal") in a downlink communication time slot other than the downlink communication time slot in which the beacon signal should be transmitted. In the downlink communication time slot, the first fire alarm 100a through the third fire alarm 100c operate to receive the communication signal from the first relay device 200a.

[0026] The first fire alarm 100a has the uplink communication time slot "2" assigned thereto and can transmit a communication signal in the assigned uplink communication time slot. The second fire alarm 100b has the uplink communication time slot "3" assigned thereto and can transmit a communication signal in the assigned uplink communication time slot. The third fire alarm 100c has the uplink communication time slot "m" assigned thereto and can transmit a communication signal in the

assigned uplink communication time slot. In the uplink communication time slots "2" through "m", the first relay device 200a operate to receive a communication signal from the first fire alarm 100a through the third fire alarm 100c.

[0027] When the fire detection sensor 150 of the first fire alarm 100a detects an outbreak of a fire, for example, the first fire alarm 100a transmits a result of detection to the first relay device 200a wirelessly. The detection result includes identification information on the first fire alarm 100a that transmitted the result. Upon receiving the result of detection from the first fire alarm 100a, the first relay device 200a transmits the result of detection to the management device 300. Upon receiving the result of detection, the management device 300 identifies the fire alarm 100 that should sound an alarm, based on the identification information included in the result of detection. The correspondence between the identification information and the information on the fire alarm 100 that should sound an alarm is stored in the management device 300 in advance. The management device 300 transmits an instruction to sound an alarm to the first relay device 200a or the second relay device 200b, designating the identified fire alarm 100 as the ultimate destination. The first relay device 200a or the second relay device 200b transmits the instruction to sound an alarm to the fire alarm 100 designated by the management device 300. Upon receiving the instruction to sound an alarm, the fire alarm 100 causes the buzzer 152 to sound an alarm. The relay device 200 may include a light-emitting apparatus, and the light-emitting apparatus may be caused to blink. The result of detection and the instruction to sound an alarm are examples of a communication signal.

[0028] The alarm system 1000 defines a plurality of channels that can be used for communication between the fire alarm 100 and the relay device 200. The relay device 200 selects one channel from the plurality of channels and communicates with the plurality of fire alarms 100 by using the selected channel. Also, the first relay device 200a and the second relay device 200b select mutually different channels to reduce interference. When the alarm system 1000 defines five channels "1ch" through "5ch", for example, the first relay device 200a selects "1ch", and the second relay device 200b selects "5ch".

[0029] In such a situation, the relay device 200 switches the channel when it cannot communicate with one of the fire alarms 100. Use of a plurality of channels for communication resulting from channel switching makes channel management complicated. It is therefore desired to facilitate channel management even channel switching could occur. To this end, the alarm system 1000 according to the embodiment performs the following process.

[0030] Fig. 4 shows an outline of a channel determination process for determination of a channel between the fire alarm 100 and the relay device 200. The horizontal axis represents time. One super frame includes "n"

frames, and one frame includes "m" slots. It is assumed that the first relay device 200a uses "1ch", but the channel used in the first relay device 200a is not limited to "1ch". The first relay device 200a transmits a beacon signal to the fire alarms 100 in the downlink communication time slot "1" on "1ch". For transmission of a beacon signal, broadcast transmission is used, for example.

[0031] The first fire alarm 100a through the third fire alarm 100c receive the beacon signal in the downlink communication time slot "1" on "1ch". In response, the first fire alarm 100a transmits an ACK signal to the first relay device 200a in the uplink communication time slot "2" on "1ch". The first relay device 200a receives the ACK signal from the first fire alarm 100a in the uplink communication time slot "2" on "1ch". The second fire alarm 100b transmits an ACK signal to the first relay device 200a in the uplink communication time slot "3" on "1ch". The first relay device 200a receives the ACK signal from the second fire alarm 100b in the uplink communication time slot "3" on "1ch". The third fire alarm 100c transmits an ACK signal to the first relay device 200a in the uplink communication time slot "m" on "1ch". The first relay device 200a receives the ACK signal from the third fire alarm 100c in the uplink communication time slot "m" on "1ch".

[0032] Upon receiving the ACK signal from all registered fire alarms 100 on "1ch", the control unit 224 of the first relay device 200a recognizes that it is possible to communicate with all fire alarms 100 on "1ch". The control unit 224 determines to continue to use "1ch" used hitherto. Such a process may be performed in each frame or performed in the leading frame of each super frame. Fig. 4 can be said to show an operation performed in a normal condition in which it is confirmed that communication with all fire alarms 100 is possible.

[0033] Fig. 5 shows an outline of a further channel determination process for determination of a channel between the fire alarm 100 and the relay device 200. The outline is as similarly shown in Fig. 4. As in Fig. 4, the first relay device 200a transmits a beacon signal to the fire alarms 100 in the downlink communication time slot "1" on "1ch".

[0034] The first fire alarm 100a and the third fire alarm 100c receive the beacon signal in the downlink communication time slot "1" on "1ch". In response, the first fire alarm 100a transmits an ACK signal to the first relay device 200a in the uplink communication time slot "2" on "1ch". The first relay device 200a receives the ACK signal from the first fire alarm 100a in the uplink communication time slot "2" on "1ch". The third fire alarm 100c transmits an ACK signal to the first relay device 200a in the uplink communication time slot "m" on "1ch". The first relay device 200a receives the ACK signal from the third fire alarm 100c in the uplink communication time slot "m" on "1ch". However, the second fire alarm 100b cannot receive the beacon signal in the downlink communication time slot "1" on "1ch" and so does not transmit an ACK signal in the uplink communication time slot "3" on "1ch". The first relay device 200a does not receive an ACK signal from

the second fire alarm 100b in the uplink communication time slot "3" on "1ch".

[0035] When the ACK signal is not received on "1ch" from at least one of the registered fire alarms 100, the control unit 224 of the first relay device 200a recognizes that it is not possible to communicate with at least one fire alarm 100 on "1ch". The control unit 224 determines to switch from "1ch" to another channel (e.g., "2ch"). Before switching to "2ch", the first relay device 200a transmits a channel change request to the fire alarms 100 in the downlink communication time slot "1" of the next frame on "1ch". The channel change request is a signal to request changing the channel. Changing the channel is inclusive of changing the channel for each frame.

[0036] The first fire alarm 100a transmits an ACK signal to the first relay device 200a in the uplink communication time slot "2" on "1ch". The first relay device 200a receives the ACK signal from the first fire alarm 100a in the uplink communication time slot "2" on "1ch". The third fire alarm 100c transmits an ACK signal to the first relay device 200a in the uplink communication time slot "m" on "1ch". The first relay device 200a receives the ACK signal from the third fire alarm 100c in the uplink communication time slot "m" on "1ch".

[0037] The control unit 224 of the first relay device 200a switches the channel from "1ch" to "2ch" in the next frame. The first relay device 200a transmits a beacon signal to the fire alarms 100 in the downlink communication time slot "1" on "2ch".

[0038] The first fire alarm 100a and the third fire alarm 100c receive the beacon signal in the downlink communication time slot "1" on "2ch". In response, the first fire alarm 100a transmits an ACK signal to the first relay device 200a in the uplink communication time slot "2" on "2ch". The first relay device 200a receives the ACK signal from the first fire alarm 100a in the uplink communication time slot "2" on "2ch". The third fire alarm 100c transmits an ACK signal to the first relay device 200a in the uplink communication time slot "m" on "2ch". The first relay device 200a receives the ACK signal from the third fire alarm 100c in the uplink communication time slot "m" on "2ch".

[0039] The second fire alarm 100b has not received the channel change request so that the control unit 124 of the second fire alarm 100b does not recognize that the beacon signal is transmitted on a channel other than "1ch". When the beacon signal cannot be received in the downlink communication time slot "1" on "1ch", the control unit 124 causes the communication unit 120 to perform high-speed intermittent reception.

[0040] Fig. 6 shows an outline of a high-speed intermittent reception process in the fire alarm 100. The horizontal axis represents time. The beacon signal has a certain duration. In the high-speed intermittent reception process, the channel in which the communication unit 120 stands by is switched in a short period of time. Referring to Fig. 6, switching from "1ch reception" to "5ch reception" is performed sequentially in the period for the beacon signal. Even when the fire alarm 100 does not

know the channel in which the beacon signal is received due to the failure to receive the channel change request, a portion of the beacon signal is received in one of the channels by performing a high-speed intermittent reception process. Reference is made back to Fig. 5.

[0041] The second fire alarm 100b cannot receive the beacon signal in the downlink communication time slot "1" on "2ch" and so does not transmit an ACK signal in the uplink communication time slot "3" on "2ch". The first relay device 200a does not receive an ACK signal from the second fire alarm 100b in the uplink communication time slot "3" on "2ch".

[0042] When the ACK signal is not received on "2ch" from at least one of the registered fire alarms 100, the control unit 224 of the first relay device 200a recognizes that it is not possible to communicate with at least one fire alarm 100 on "2ch". The control unit 224 determines to switch from "2ch" to another channel (e.g., "3ch"). Before switching to "3ch", the first relay device 200a does not transmit a channel change request on "2ch". The control unit 224 of the first relay device 200a switches the channel from "2ch" to "3ch" in the next frame. The first relay device 200a transmits a beacon signal to the fire alarms 100 in the downlink communication time slot "1" on "3ch".

[0043] The first fire alarm 100a through the third fire alarm 100c receive the beacon signal in the downlink communication time slot "1" on "3ch". In response, the first fire alarm 100a transmits an ACK signal to the first relay device 200a in the uplink communication time slot "2" on "3ch". The first relay device 200a receives the ACK signal from the first fire alarm 100a in the uplink communication time slot "2" on "3ch". The second fire alarm 100b transmits an ACK signal to the first relay device 200a in the uplink communication time slot "3" on "3ch". The first relay device 200a receives the ACK signal from the second fire alarm 100b in the uplink communication time slot "3" on "3ch". The third fire alarm 100c transmits an ACK signal to the first relay device 200a in the uplink communication time slot "m" on "3ch". The first relay device 200a receives the ACK signal from the third fire alarm 100c in the uplink communication time slot "m" on "3ch".

[0044] Upon receiving the ACK signal from all registered fire alarms 100 on "3ch", the control unit 224 of the first relay device 200a recognizes that it is possible to communicate with all fire alarms 100 on "3ch". The control unit 224 determines to use "3ch". When the control unit 224 of the first relay device 200a determines to use "3ch", the first relay device 200a transmits a channel finalization request to the fire alarms 100 in the downlink communication time slot "1" of the next frame on "4ch". The channel finalization request is a signal for causing the fire alarm 100 to stop switching the channel and has, for example, a pattern different from the beacon signal.

[0045] When the first fire alarm 100a and the third fire alarm 100c that had received the channel change request receive the channel finalization request on "4ch", the control unit 224 of these fire alarms determines to use "3ch".

When the second fire alarm 100b that had not received the channel change request receives the channel finalization request on "4ch", on the other hand, the control unit 224 determines to use "3ch". Subsequently, the first relay device 200a and the first fire alarm 100a through the third fire alarm 100c use "3ch" to perform the process as shown in Fig. 3.

[0046] Upon receiving the ACK signal from all registered fire alarms 100 on "2ch", the control unit 224 of the first relay device 200a recognizes that it is possible to communicate with all fire alarms 100 on "2ch". The control unit 224 determines to use "2ch". The process following this is as already described, and a description thereof is omitted. Fig. 5 can be said to show an operation performed when the channel is switched in response to an outbreak of an abnormality in communication with at least one fire alarm 100.

[0047] The apparatus, the system, or the entity that executes the method according to the disclosure is provided with a computer. By causing the computer to run a program, the function of the apparatus, the system, or the entity that executes the method according to the disclosure is realized. The computer is comprised of a processor that operates in accordance with the program as a main hardware feature. The disclosure is non-limiting as to the type of the processor so long as the function is realized by running the program. The processor is comprised of one or a plurality of electronic circuits including a semiconductor integrated circuit (IC) or a large-scale integration (LSI). The plurality of electronic circuits may be integrated in one chip or provided in a plurality of chips. The plurality of chips may be aggregated in one apparatus or provided in a plurality of apparatuses. The program is recorded in a non-transitory recording medium such as a computer-readable ROM, optical disk, and hard disk drive. The program may be stored in a recording medium in advance or supplied to a recording medium via wide area communication network including the Internet.

[0048] A description will be given of the operation of the alarm system 1000 having the configuration described above. Fig. 7 is a flowchart showing a sequence of steps performed by the relay device 200 to determine a channel. The communication unit 220 transmits a beacon signal (S10). When an ACK signal is not received from all fire alarms 100 (N in S12), the communication unit 220 transmits a channel change request (S14). The control unit 224 switches the channel (S16), and the communication unit 220 transmits a beacon signal (S18). When an ACK signal is not received from all fire alarms 100 (N in S20), control is returned to step 16 provided that a channel to switch to is available (Y in S22). When an ACK signal is received from all fire alarms 100 (Y in S20), or when no channels to switch to are available (N in S22), the control unit 224 determines a channel to use (S24). The communication unit 220 transmits a channel finalization request (S26). When an ACK signal is received from all fire alarms 100 (Y in S12), the process is terminated.

[0049] When there is a fire alarm 100 from which an ACK signal responsive to a beacon signal is not received, the embodiment ensures that a beacon signal is transmitted by changing the channel until an ACK signal is received from all fire alarms 100. Therefore, an optimum channel is detected. Further, when there are no fire alarms 100 from which an ACK signal responsive to a beacon signal is not received, it is determined to use the channel then in use so that channel management is facilitated even channel switching could occur. Further, the channel is changed for each frame after a channel change request to request changing the channel is transmitted. Therefore, the channel is changed automatically. Further, since the channel is changed automatically, a drop in the use efficiency of the frames is suppressed. Further, a channel finalization request is transmitted when the channel is determined so that the channel that should be used is made known.

[0050] One embodiment of the present disclosure is summarized below. An alarm system (1000) according to an embodiment of the present disclosure includes: a relay device (200); and a first alarm (100) and a second alarm (100) that can communicate with the relay device (200). The relay device (200) transmits a beacon signal to the first alarm (100) and the second alarm (100) on a first channel, when the first alarm (100) and the second alarm (100) receive the beacon signal on the first channel, the first alarm (100) and the second alarm (100) transmit a response signal to the relay device (200) on the first channel, when the relay device (200) receives the response signal from the first alarm (100) and the second alarm (100) on the first channel, the relay device (200) determines to use the first channel in the alarm system (1000), when the relay device (200) does not receive the response signal from at least one of the first alarm (100) or the second fire alarm (100) on the first channel, the relay device (200) transmits the beacon signal to the first alarm (100) and the second alarm (100) on a second channel different from the first channel, when the first alarm (100) and the second alarm (100) receive the beacon signal on the second channel, the first alarm (100) and the second alarm (100) transmit the response signal to the relay device (200) on the second channel, and, when the relay device (200) receives the response signal from the first alarm (100) and the second alarm (100) on the second channel, the relay device (200) determines to use the second channel in the alarm system (1000).

[0051] When the relay device (200) does not receive the response signal from at least one of the first alarm (100) or the second alarm (100) on the second channel, the relay device (200) transmits the beacon signal to the first alarm (100) and the second alarm (100) on a third channel different from the first channel and the second channel, when the first alarm (100) and the second alarm (100) receive the beacon signal on the third channel, the first alarm (100) and the second alarm (100) transmit the response signal to the relay device (200) on the third

channel, when the relay device (200) receives the response signal from the first alarm (100) and the second alarm (100) on the third channel, the relay device (200) determines to use the third channel in the alarm system (1000).

[0052] The relay device (200) transmits a channel change request to request changing a channel on the first channel and then changes the first channel to the second channel, and the relay device (200) changes the second channel to the third channel without transmitting the channel change request on the second channel.

[0053] When the relay device (200) determines to use the second channel, the relay device (200) transmits a channel finalization request to make the channel determined to be used known, and, when the relay device (200) determines to use the third channel, the relay device (200) transmits the channel finalization request.

[0054] Another embodiment of the present disclosure relates to a relay device (200). The device includes: a communication unit (220) that can communicate with a first alarm (100) and a second alarm (200); and a control unit (224) that controls the communication unit (220). The communication unit (220) transmits a beacon signal to the first alarm (100) and the second alarm (100) on a first channel, when the first alarm (100) and the second alarm (100) receive the beacon signal on the first channel, the first alarm (100) and the second alarm (100) transmit a response signal on the first channel, and, when the communication unit (220) receives the response signal from the first alarm (100) and the second alarm (100) on the first channel, the control unit (224) determines to use the first channel in an alarm system (1000), when the communication unit (220) does not receive the response signal from at least one of the first alarm (100) or the second alarm (100) on the first channel, the communication unit (220) transmits the beacon signal to the first alarm (100) and the second alarm (200) on a second channel different from the first channel, and, when the first alarm (100) and the second alarm (100) receive the beacon signal on the second channel, the first alarm (100) and the second alarm (100) transmit the response signal on the second channel, and, when the communication unit (220) receives the response signal from the first alarm (100) and the second alarm (100) on the second channel, the control unit (224) determines to use the second channel in the alarm system (1000).

[0055] Still another embodiment of the present disclosure relates to a channel determination method. The method including transmitting a beacon signal to the first alarm (100) and the second alarm (100) on a first channel, wherein, when the first alarm (100) and the second alarm (100) receive the beacon signal on the first channel, the first alarm (100) and the second alarm (100) transmit a response signal on the first channel, the method including, when the response signal from the first alarm (100) and the second alarm (100) is received on the first channel, determining to use the first channel in an alarm system (1000), the method including, when the response

signal from at least one of the first alarm (100) or the second alarm (100) is not received, transmitting the beacon signal to the first alarm (100) and the second alarm (200) on a second channel different from the first channel, wherein, when the first alarm (100) and the second alarm (100) receive the beacon signal on the second channel, the first alarm (100) and the second alarm (100) transmit the response signal on the second channel, the method including, when the response signal from the first alarm (100) and the second alarm (100) is received on the second channel, determining to use the second channel in the alarm system (1000).

(Embodiment 2)

[0056] A description will now be given of embodiment 2. Like embodiment 1, embodiment 2 relates to an alarm system that includes a relay device and a plurality of fire alarms. Embodiments 1, 2 relate to switching the channel by the relay device when there is a fire alarm that cannot communicate with the relay device. The fire alarm of embodiment 1 switches the channel for each frame automatically, when it receives a channel change request from the relay device. Meanwhile, the fire alarm of embodiment 2 switches the channel every time a channel change request from the relay device is received. The alarm system 1000, the fire alarm 100, the relay device 200 according to embodiment 2 are of the same type as those of Fig. 1, Fig. 2. The description below highlights a difference from embodiment 1.

[0057] Fig. 8 shows an outline of a channel determination process for determination of a channel between the fire alarm 100 and the relay device 200. The outline is as similarly shown in Fig. 5. The first relay device 200a transmits a beacon signal to the fire alarms 100 in the downlink communication time slot "1" on "1ch".

[0058] The first fire alarm 100a and the third fire alarm 100c receive the beacon signal in the downlink communication time slot "1" on "1ch". In response, the first fire alarm 100a transmits an ACK signal to the first relay device 200a in the uplink communication time slot "2" on "1ch". The first relay device 200a receives the ACK signal from the first fire alarm 100a in the uplink communication time slot "2" on "1ch". The third fire alarm 100c transmits an ACK signal to the first relay device 200a in the uplink communication time slot "m" on "1ch". The first relay device 200a receives the ACK signal from the third fire alarm 100c in the uplink communication time slot "m" on "1ch". However, the second fire alarm 100b cannot receive the beacon signal in the downlink communication time slot "1" on "1ch" and so does not transmit an ACK signal in the uplink communication time slot "3" on "1ch". The first relay device 200a does not receive an ACK signal from the second fire alarm 100b in the uplink communication time slot "3" on "1ch".

[0059] When the ACK signal is not received on "1ch" from at least one of the registered fire alarms 100, the control unit 224 of the first relay device 200a recognizes

that it is not possible to communicate with at least one fire alarm 100 on "1ch". The control unit 224 determines to switch from "1ch" to another channel (e.g., "2ch"). Before switching to "2ch", the first relay device 200a transmits a channel change request to the fire alarms 100 in the downlink communication time slot "1" of the next frame on "1ch". The channel change request is a signal to request changing the channel and includes information on the channel to switch to. In this case, the channel change request indicates "2ch" to switch to.

[0060] The first fire alarm 100a transmits an ACK signal to the first relay device 200a in the uplink communication time slot "2" on "1ch". The first relay device 200a receives the ACK signal from the first fire alarm 100a in the uplink communication time slot "2" on "1ch". The third fire alarm 100c transmits an ACK signal to the first relay device 200a in the uplink communication time slot "m" on "1ch". The first relay device 200a receives the ACK signal from the third fire alarm 100c in the uplink communication time slot "m" on "1ch".

[0061] The control unit 224 of the first relay device 200a switches the channel from "1ch" to "2ch" in the next frame. The first relay device 200a transmits a beacon signal to the fire alarms 100 in the downlink communication time slot "1" on "2ch".

[0062] The first fire alarm 100a and the third fire alarm 100c receive the beacon signal in the downlink communication time slot "1" on "2ch". In response, the first fire alarm 100a transmits an ACK signal to the first relay device 200a in the uplink communication time slot "2" on "2ch". The first relay device 200a receives the ACK signal from the first fire alarm 100a in the uplink communication time slot "2" on "2ch". The third fire alarm 100c transmits an ACK signal to the first relay device 200a in the uplink communication time slot "m" on "2ch". The first relay device 200a receives the ACK signal from the third fire alarm 100c in the uplink communication time slot "m" on "2ch".

[0063] The second fire alarm 100b has not received the channel change request so that the control unit 124 of the second fire alarm 100b does not recognize that the beacon signal is transmitted on a channel other than "1ch". When the beacon signal cannot be received in the downlink communication time slot "1" on "1ch", therefore, the control unit 124 causes the communication unit 120 to perform high-speed intermittent reception. The second fire alarm 100b cannot receive the beacon signal in the downlink communication time slot "1" on "2ch" and so does not transmit an ACK signal in the uplink communication time slot "3" on "2ch". The first relay device 200a does not receive an ACK signal from the second fire alarm 100b in the uplink communication time slot "3" on "2ch".

[0064] When the ACK signal is not received on "2ch" from at least one of the registered fire alarms 100, the control unit 224 of the first relay device 200a recognizes that it is not possible to communicate with at least one fire alarm 100 on "2ch". The control unit 224 determines to switch from "2ch" to another channel (e.g., "3ch"). Be-

fore switching to "3ch", the first relay device 200a transmits a channel change request to the fire alarms 100 in the downlink communication time slot "1" of the next frame on "2ch". The channel change request indicates "3ch" to switch to.

[0065] The first fire alarm 100a transmits an ACK signal to the first relay device 200a in the uplink communication time slot "2" on "2ch". The first relay device 200a receives the ACK signal from the first fire alarm 100a in the uplink communication time slot "2" on "2ch". The third fire alarm 100c transmits an ACK signal to the first relay device 200a in the uplink communication time slot "m" on "2ch". The first relay device 200a receives the ACK signal from the third fire alarm 100c in the uplink communication time slot "m" on "2ch".

[0066] The control unit 224 of the first relay device 200a switches the channel from "2ch" to "3ch" in the next frame. The first relay device 200a transmits a beacon signal to the fire alarms 100 in the downlink communication time slot "1" on "3ch".

[0067] The first fire alarm 100a through the third fire alarm 100c receive the beacon signal in the downlink communication time slot "1" on "3ch". In response, the first fire alarm 100a transmits an ACK signal to the first relay device 200a in the uplink communication time slot "2" on "3ch". The first relay device 200a receives the ACK signal from the first fire alarm 100a in the uplink communication time slot "2" on "3ch". The second fire alarm 100b transmits an ACK signal to the first relay device 200a in the uplink communication time slot "3" on "3ch". The first relay device 200a receives the ACK signal from the second fire alarm 100b in the uplink communication time slot "3" on "3ch". The third fire alarm 100c transmits an ACK signal to the first relay device 200a in the uplink communication time slot "m" on "3ch". The first relay device 200a receives the ACK signal from the third fire alarm 100c in the uplink communication time slot "m" on "3ch".

[0068] Upon receiving the ACK signal from all registered fire alarms 100 on "3ch", the control unit 224 of the first relay device 200a recognizes that it is possible to communicate with all fire alarms 100 on "3ch". The control unit 224 determines to use "3ch". Subsequently, the first relay device 200a and the first fire alarm 100a through the third fire alarm 100c use "3ch" to perform the process as shown in Fig. 3.

[0069] Upon receiving the ACK signal from all registered fire alarms 100 on "2ch", the control unit 224 of the first relay device 200a recognizes that it is possible to communicate with all fire alarms 100 on "2ch". The control unit 224 determines to use "2ch". The process following this is as already described, and a description thereof is omitted.

[0070] A description will be given of the operation of the alarm system 1000 having the configuration described above. Fig. 9 is a flowchart showing a sequence of steps performed by the relay device 200 to determine a channel. The communication unit 220 transmits a beacon signal (S50). When an ACK signal is not received

from all fire alarms 100 (N in S52), the communication unit 220 transmits a channel change request (S54). The control unit 224 switches the channel (S56), and the communication unit 220 transmits a beacon signal (S58). When an ACK signal is not received from all fire alarms 100 (N in S60), control is returned to step 54 provided that a channel to switch to is available. When an ACK signal is received from all fire alarms 100 (Y in S60), or when no channels to switch to are available (N in S62), the control unit 224 determines a channel to use (S64). When an ACK signal is received from all fire alarms 100 (Y in S52), the process is terminated.

[0071] According to the embodiment, the channel is switched after a channel change request is transmitted. Therefore, it is possible to change the channel properly. Further, the channel change request includes information on a channel to switch to so that the channel to switch to can be made known properly.

[0072] One embodiment of the present disclosure is summarized below. The relay device (200) transmits a channel change request to request changing a channel on the first channel and then changes the first channel to the second channel, and the relay device (200) transmits the channel change request on the second channel and then changes the second channel to the third channel.

[0073] The channel change request includes information on a channel to switch to.

[0074] Described above is an explanation based on an exemplary embodiment. The embodiment is intended to be illustrative only and it will be understood by those skilled in the art that various modifications to constituting elements and processes could be developed and that such modifications are also within the scope of the present invention.

[0075] In the embodiment, the relay device 200 connects the fire alarms 100 each provided with the function of detecting a fire and the function of outputting an alarm sound. Alternatively, however, the fire alarm 100 may only be provided with the function of detecting a fire. Instead of the fire alarm 100 for detecting a fire, sensors for detecting flood damage, earthquakes, gas leakage, or generation of CO (carbon monoxide) due to imperfect combustion may be provided. According to this variation, the flexibility in the configuration is improved.

[REFERENCE SIGNS LIST]

[0076] 100 fire alarm, 120 communication unit, 122 processing unit, 124 control unit, 150 fire detection sensor, 152 buzzer, 200 relay device, 220 communication unit, 222 processing unit, 224 control unit, 300 management device, 1000 alarm system

Claims

1. An alarm system (1000) comprising:

a relay device (200); and
a first alarm (100) and a second alarm (100) that can communicate with the relay device (200), wherein

the relay device (200) transmits a beacon signal to the first alarm (100) and the second alarm (100) on a first channel,
when the first alarm (100) and the second alarm (100) receive the beacon signal on the first channel, the first alarm (100) and the second alarm (100) transmit a response signal to the relay device (200) on the first channel,
when the relay device (200) receives the response signal from the first alarm (100) and the second alarm (100) on the first channel, the relay device (200) determines to use the first channel in the alarm system (1000),
when the relay device (200) does not receive the response signal from at least one of the first alarm (100) or the second fire alarm (100) on the first channel, the relay device (200) transmits the beacon signal to the first alarm (100) and the second alarm (100) on a second channel different from the first channel,
when the first alarm (100) and the second alarm (100) receive the beacon signal on the second channel, the first alarm (100) and the second alarm (100) transmit the response signal to the relay device (200) on the second channel, and
when the relay device (200) receives the response signal from the first alarm (100) and the second alarm (100) on the second channel, the relay device (200) determines to use the second channel in the alarm system (1000).

2. The alarm system (1000) according to claim 1, wherein

when the relay device (200) does not receive the response signal from at least one of the first alarm (100) or the second alarm (100) on the second channel, the relay device (200) transmits the beacon signal to the first alarm (100) and the second alarm (100) on a third channel different from the first channel and the second channel,
when the first alarm (100) and the second alarm (100) receive the beacon signal on the third channel, the first alarm (100) and the second alarm (100) transmit the response signal to the relay device (200) on the third channel,
when the relay device (200) receives the response signal from the first alarm (100) and the second alarm (100) on the third channel, the relay device (200) determines to use the third channel in the alarm system (1000).

3. The alarm system (1000) according to claim 2,

wherein

the relay device (200) transmits a channel change request to request changing a channel on the first channel and then changes the first channel to the second channel, and
the relay device (200) changes the second channel to the third channel without transmitting the channel change request on the second channel.

4. The alarm system (1000) according to claim 2, wherein

the relay device (200) transmits a channel change request to request changing a channel on the first channel and then changes the first channel to the second channel, and
the relay device (200) transmits the channel change request on the second channel and then changes the second channel to the third channel.

5. The alarm system (1000) according to claim 3 or 4, wherein
the channel change request includes information on a channel to switch to.

6. The alarm system (1000) according to any one of claims 3 through 5, wherein

when the relay device (200) determines to use the second channel, the relay device (200) transmits a channel finalization request to make the channel determined to be used known, and
when the relay device (200) determines to use the third channel, the relay device (200) transmits the channel finalization request.

7. A relay device (200) comprising:

a communication unit (220) that can communicate with a first alarm (100) and a second alarm (200); and
a control unit (224) that controls the communication unit (220), wherein
the communication unit (220) transmits a beacon signal to the first alarm (100) and the second alarm (100) on a first channel,
when the first alarm (100) and the second alarm (100) receive the beacon signal on the first channel, the first alarm (100) and the second alarm (100) transmit a response signal on the first channel, and, when the communication unit (220) receives the response signal from the first alarm (100) and the second alarm (100) on the first channel, the control unit (224) determines to use the first channel in an alarm system (1000),

when the communication unit (220) does not receive the response signal from at least one of the first alarm (100) or the second alarm (100) on the first channel, the communication unit (220) transmits the beacon signal to the first alarm (100) and the second alarm (200) on a second channel different from the first channel, and

when the first alarm (100) and the second alarm (100) receive the beacon signal on the second channel, the first alarm (100) and the second alarm (100) transmit the response signal on the second channel, and, when the communication unit (220) receives the response signal from the first alarm (100) and the second alarm (100) on the second channel, the control unit (224) determines to use the second channel in the alarm system (1000).

8. A channel determination method comprising:

transmitting a beacon signal to the first alarm (100) and the second alarm (100) on a first channel,

wherein, when the first alarm (100) and the second alarm (100) receive the beacon signal on the first channel, the first alarm (100) and the second alarm (100) transmit a response signal on the first channel, the method comprising, when the response signal from the first alarm (100) and the second alarm (100) is received on the first channel, determining to use the first channel in an alarm system (1000),

the method comprising, when the response signal from at least one of the first alarm (100) or the second alarm (100) is not received, transmitting the beacon signal to the first alarm (100) and the second alarm (200) on a second channel different from the first channel,

wherein, when the first alarm (100) and the second alarm (100) receive the beacon signal on the second channel, the first alarm (100) and the second alarm (100) transmit the response signal on the second channel, the method comprising, when the response signal from the first alarm (100) and the second alarm (100) is received on the second channel, determining to use the second channel in the alarm system (1000).

9. A program comprising computer-implemented modules comprising:

a module that transmits a beacon signal to the first alarm (100) and the second alarm (100) on a first channel,

wherein, when the first alarm (100) and the second alarm (100) receive the beacon signal on

the first channel, the first alarm (100) and the second alarm (100) transmit a response signal on the first channel, the modules comprising a module that, when the response signal from the first alarm (100) and the second alarm (100) is received on the first channel, determines to use the first channel in an alarm system (1000), the modules comprising a module that, when the response signal from at least one of the first alarm (100) or the second alarm (100) is not received, transmits the beacon signal to the first alarm (100) and the second alarm (200) on a second channel different from the first channel, wherein, when the first alarm (100) and the second alarm (100) receive the beacon signal on the second channel, the first alarm (100) and the second alarm (100) transmit the response signal on the second channel, the modules comprising a module that, when the response signal from the first alarm (100) and the second alarm (100) is received on the second channel, determines to use the second channel in the alarm system (1000).

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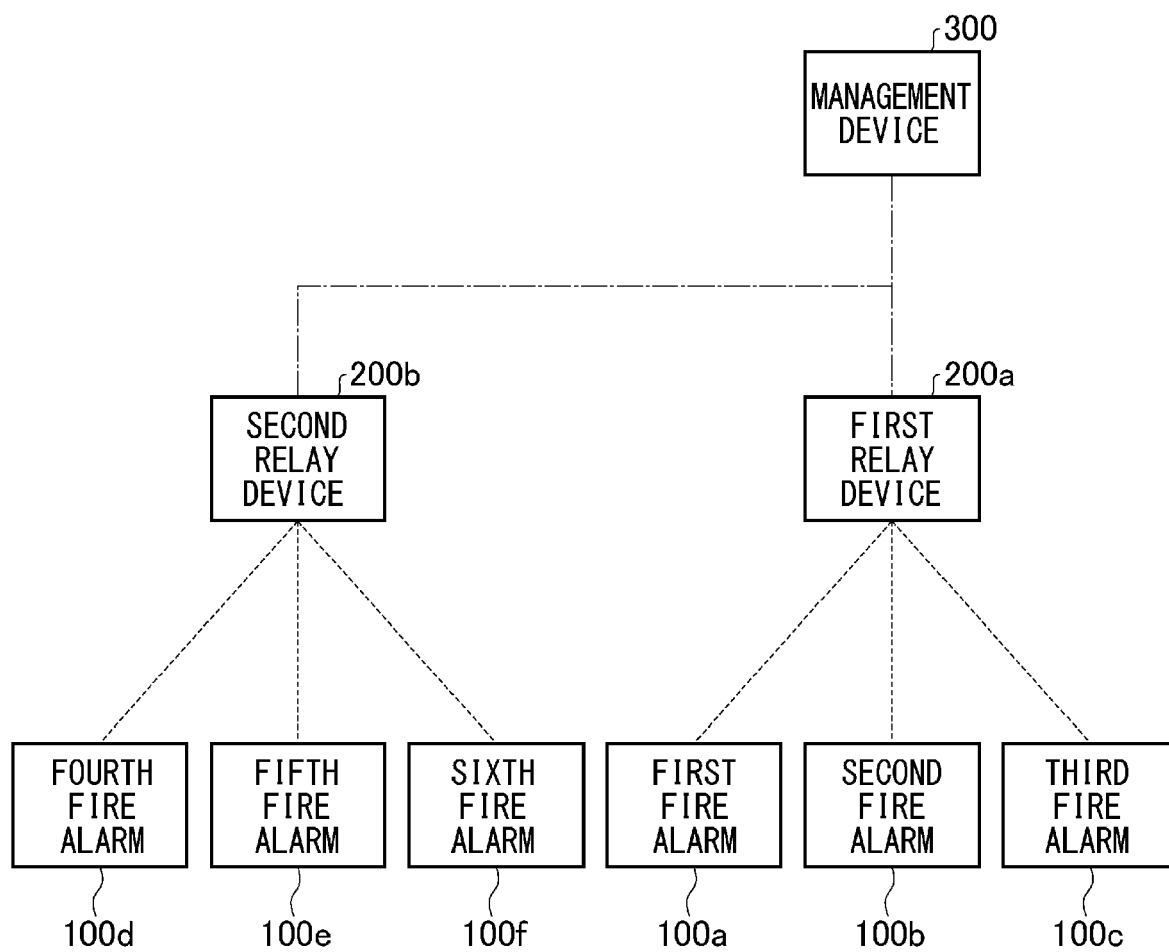
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FIG. 1



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FIG. 2

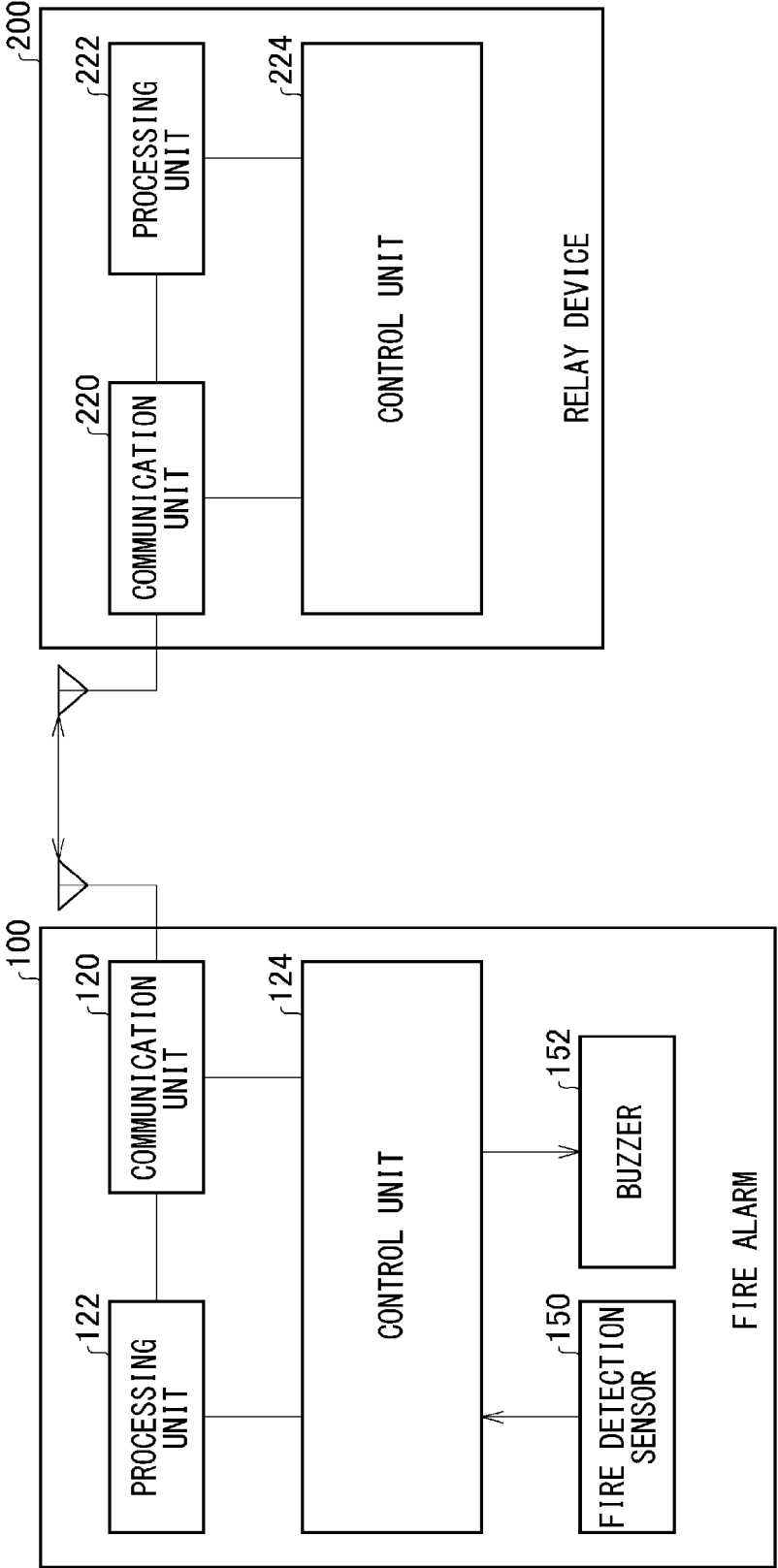


FIG. 3

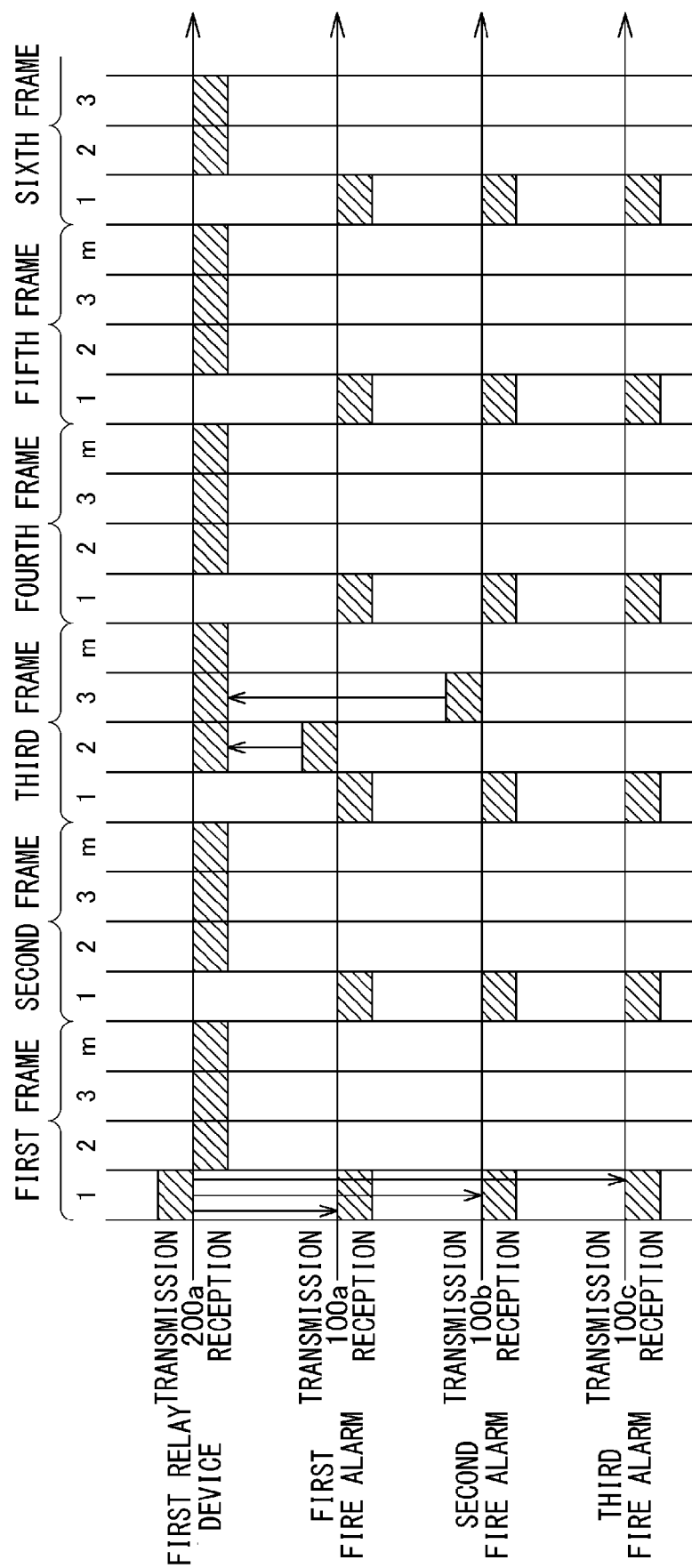


FIG. 4

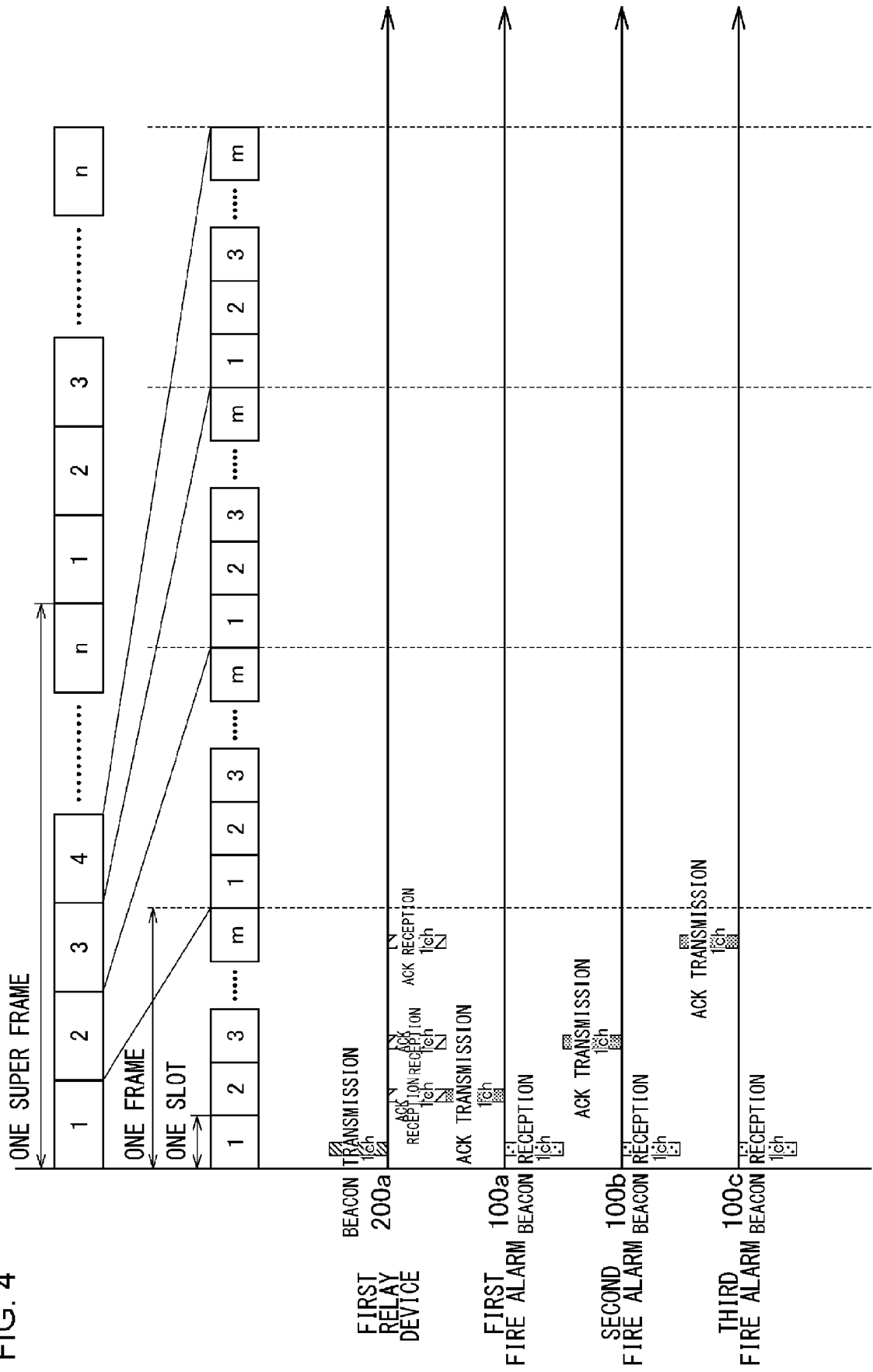


FIG. 5

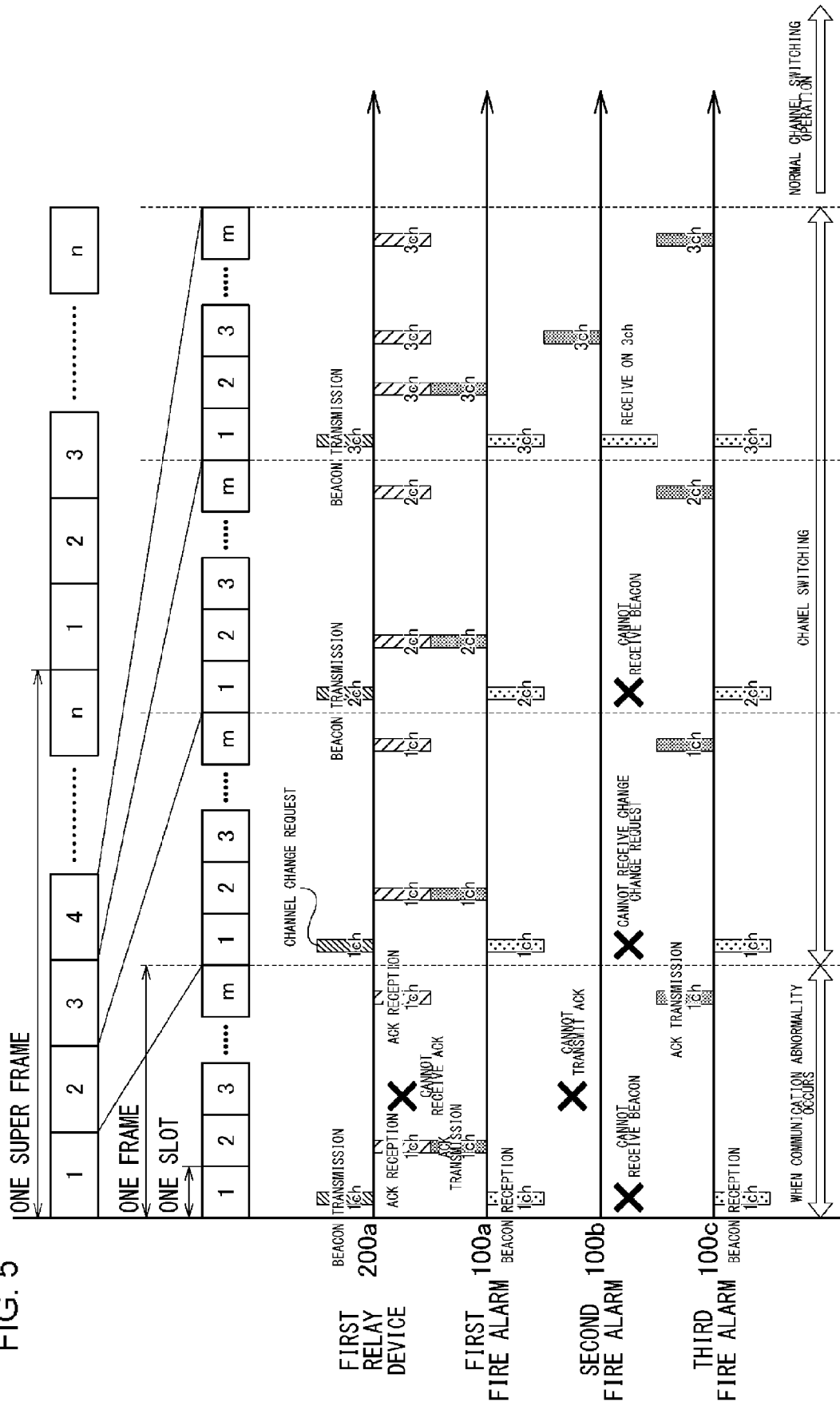


FIG. 6

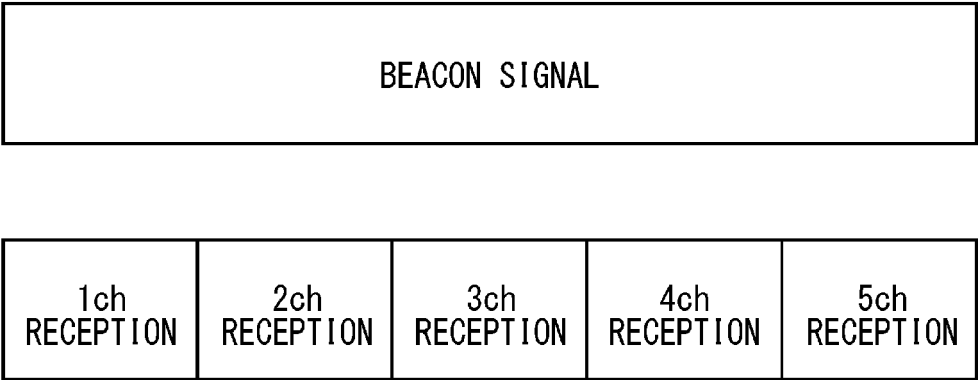
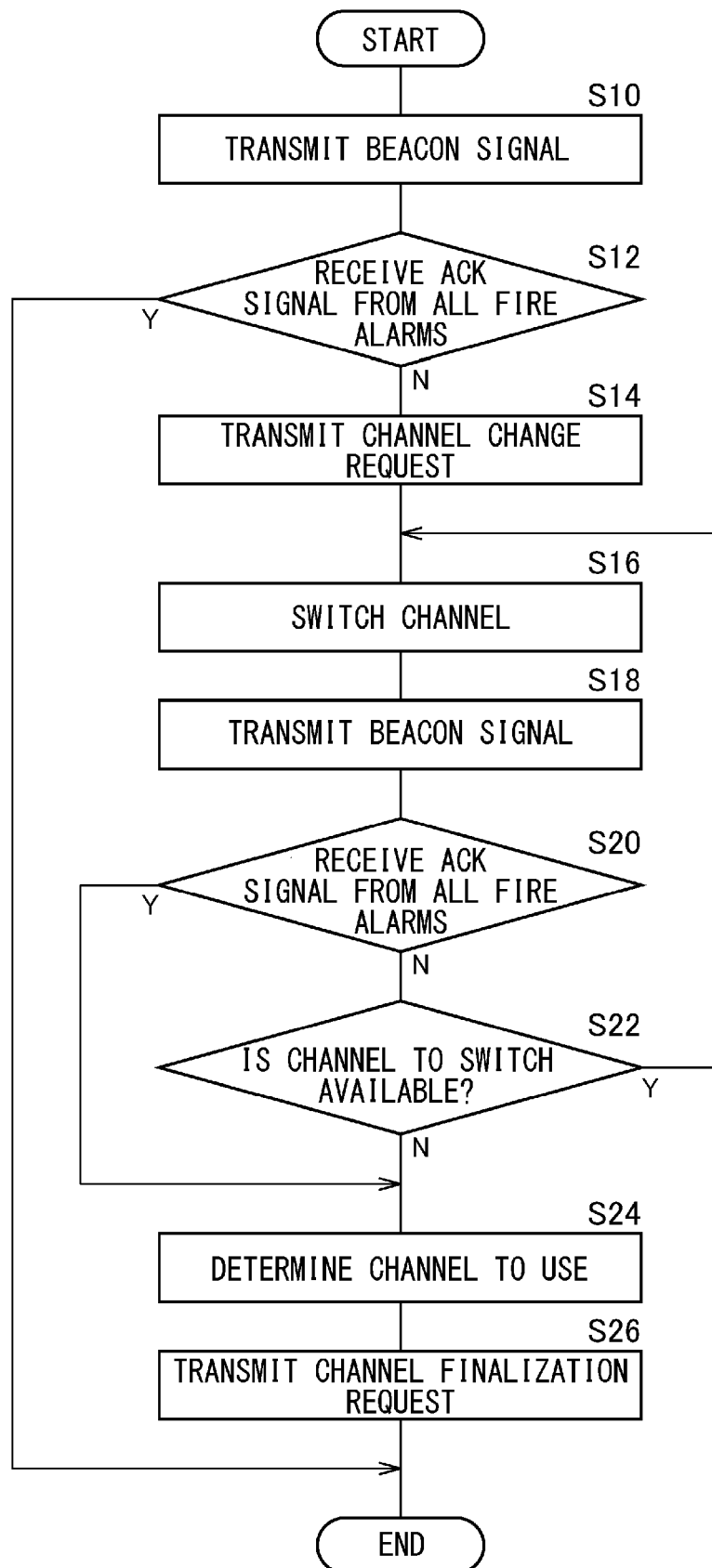


FIG. 7



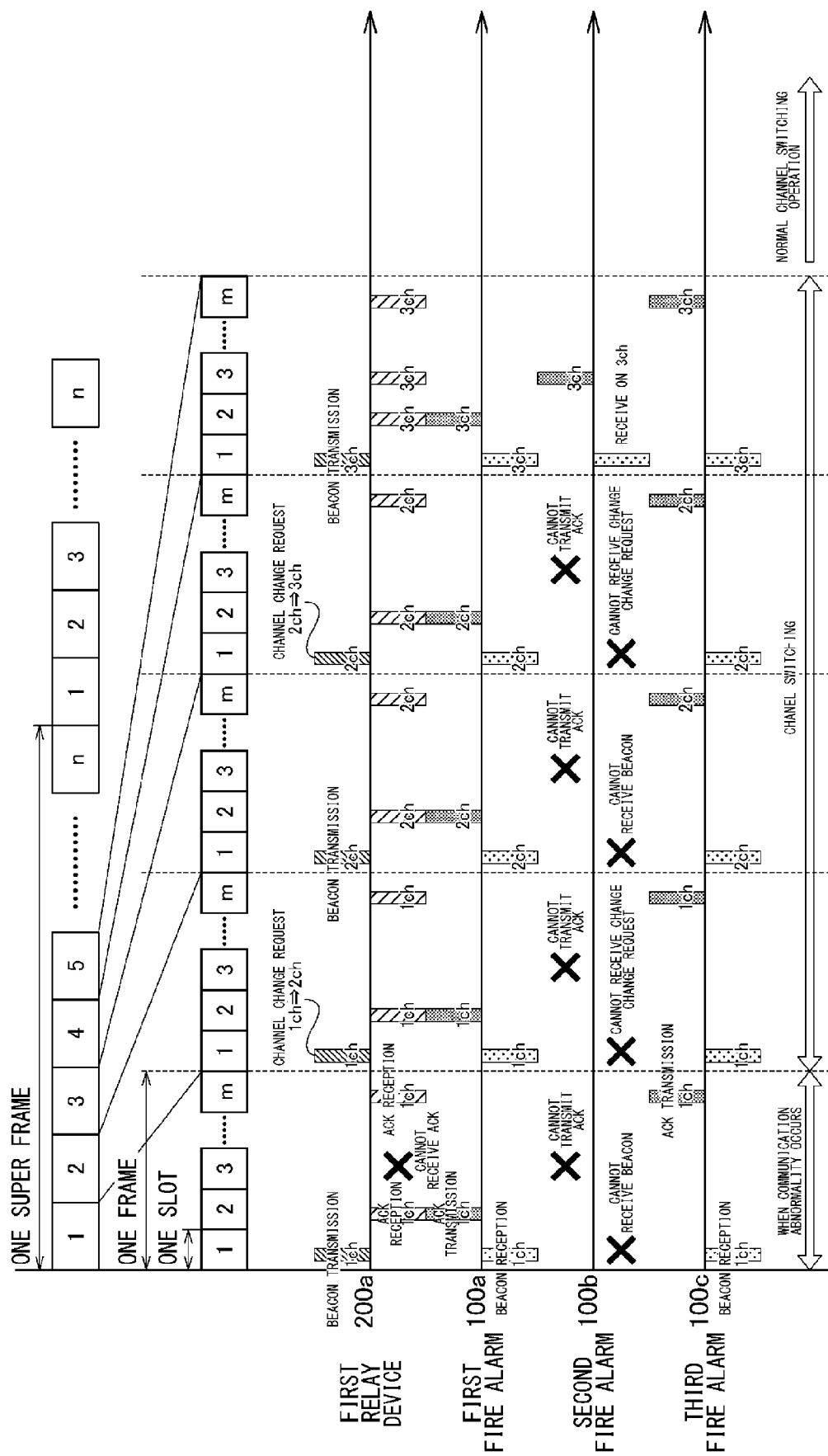
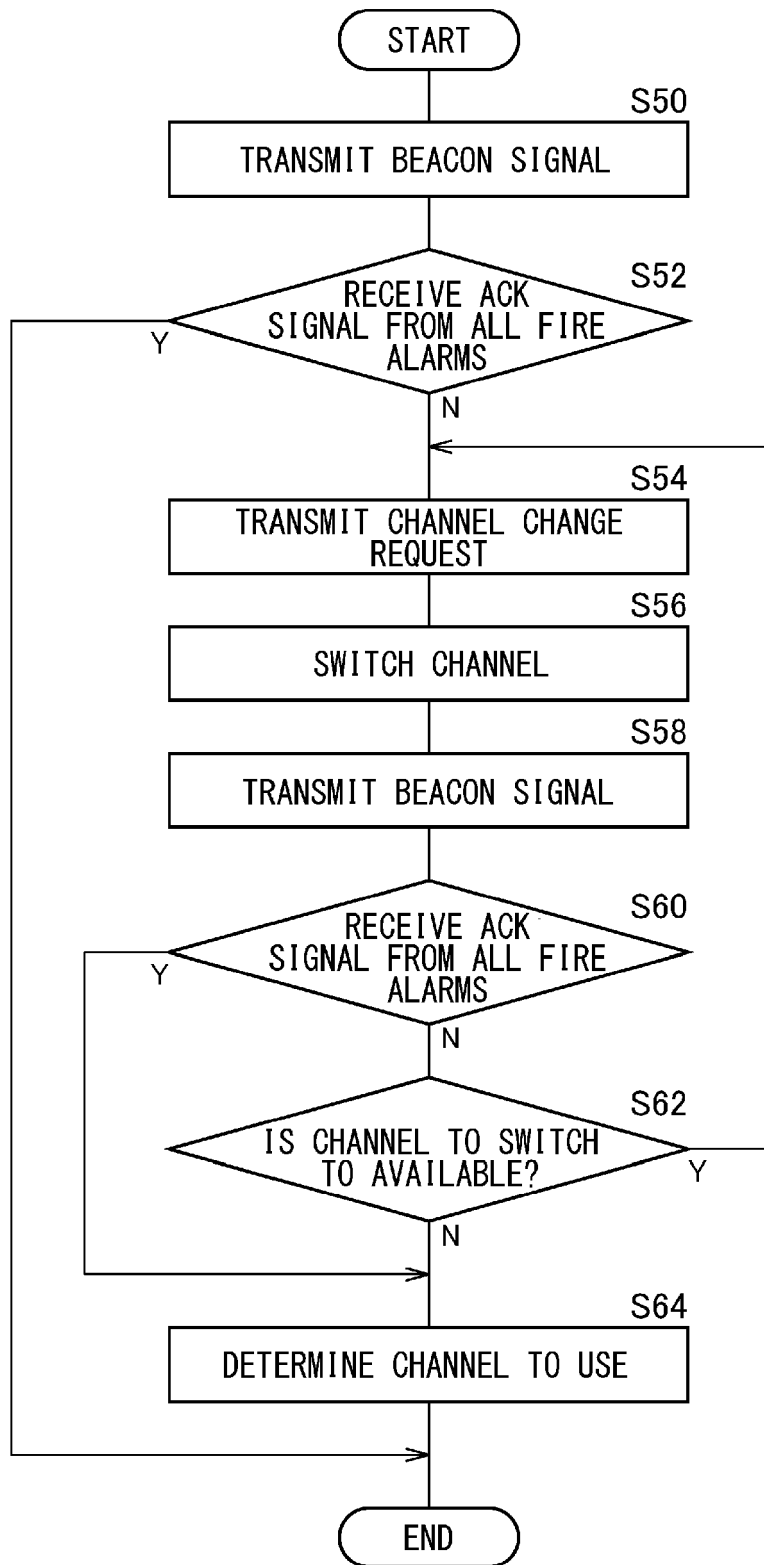
$$\frac{\infty}{F|G}$$


FIG. 9





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Application Number

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