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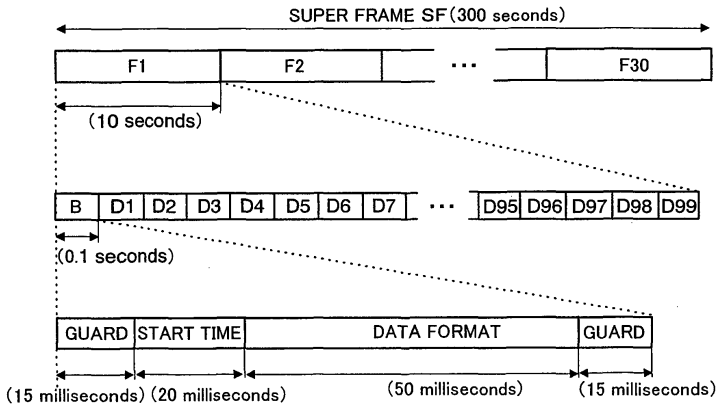
(54) FIRE ALARM SYSTEM

(57) The fire alarm system of the present invention comprises one receiver and a plurality of fire detectors. Each of the fire detectors and the receiver perform radio communication with each other by using a super frame SF comprising a plurality of frames F1 to F30 each of which includes one down-time slot B for transmission from a receiver side to a fire detector side and a plurality of up-time slots D1 to D99 for transmission from the fire detector side to the receiver side, and the fire detectors are assigned respectively to different ones of the up-time slots for transmission of the radio signal.

FIG. 5



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Description

TECHNICAL FIELD

[0001] The present invention relates to a fire alarm system comprising a plurality of fire detectors for detecting a fire, and a receiver which sounds an alarm on receiving a signal from each fire detector, and, more particularly, to a fire alarm system in which each fire detector and the receiver communicate by radio with each other.

BACKGROUND ART

[0002] Japanese Patent No. 3029716 discloses a fire alarm system which comprises a plurality of fire detectors for detecting fire and a receiver which sounds an alarm on receiving a signal from each fire detector, and in which each fire detector and the receiver communicate by radio with each other.

[0003] In this fire alarm system, in order to check that each fire detector works normally, periodical communication is performed at a predetermined time interval. That is, the receiver sends a reply request message to each fire detector once every several hours, and each fire detector sends back a reply message which indicates its own operating condition, such as battery information, to the receiver on receiving the reply request message. The receiver judges whether a failure, e.g. battery exhaustion, occurs or not in each fire detector based on the received replay message.

[0004] In recent years, it is required that the periodical communication is performed more frequently in order to increase the reliability of the fire alarm system. For example, in the Proposal of European Standard (Pr_EN54-25), the periodical communication is due to be required to be performed once within 300 seconds.

[0005] If the periodical communication is performed frequently, transmission timing of the fire detectors may overlap one another, whereby a probability of occurrence of a collision of communication becomes high. In the above fire alarm system, in order to avoid the collision of the communication, a CSMA method (Carrier Sense Multiple Access method), in which data is transmitted after a frequency to be used is checked is adopted. However, in the CSMA method, because switching action from reception operation to transmission operation of the radio circuit requires a certain period of time and it is not possible to detect the transmission of data by other fire detectors, during the switching action from the reception operation to the transmission operation, there is a problem that it is not possible to entirely avoid the collision.

[0006] As to other collision-avoidance methods other than the CSMA method, a polling method, in which the receiver transmits a request message to each fire detector in turn, an ARQ method (Automatic Repeat reQuest method), in which the receiver transmits a receipt acknowledgement (ACK) to the fire detector which sent the reply message and each fire detector sends the reply message repeatedly until it receives the receipt acknowledgement, a token-ring method (registered trademark), in which a token is circulated among the fire detectors, and so on, can be considered.

[0007] However, in the polling method and the ARQ method, transmission frequency of the receiver increases in proportion to the number of the fire detectors. In general, the fire alarm system uses a frequency which does not require a license, but in such a frequency which do no require a license, there is a rigid restriction on a transmission time duty, that is, an allowable transmission time per unit of time (namely, per one hour). For example, in the EU (European Union), the above duty has to be less than 0.1 % in the frequency for an alarm used in the fire alarm system. Therefore, in the polling method and the ARQ method, because the duty will go beyond the limit when the number of the fire detectors increases, the number of the fire detectors cannot be increased very much.

[0008] Furthermore, in the token-ring method, when one fire detector breaks down, the token will disappear and all the fire detectors may not be able to transmit data.

DISCLOSURE OF THE INVENTION

[0009] In view of the above problem, the object of the present invention is to provide a fire alarm system which can avoid the collision reliably even if the periodical communication is performed frequently.

[0010] The fire alarm system in accordance with the present invention comprises a plurality of fire detectors and a receiver. Each of the fire detectors has a detection means for detecting a fire, and a radio transmitter and receiver means which transmits and receives a radio signal to and from the receiver, and the radio transmitter and receiver means transmits the radio signal to the receiver when the detection means detects fire and also performs periodical communication with the receiver which informs the receiver of an operating condition of its own fire detector at a predetermined time interval. The receiver has a radio transmitter and receiver means which transmits and receives the radio signal to and from each of the fire detectors, and an informing means which informs an outside about a fire if the received radio signal includes fire detection information. The feature of the present invention resides in that each of the fire detectors and the receiver perform radio communication with each other by using a super frame comprising a plurality of frames each of which includes one down-time slot for transmission from a receiver side to a fire detector side and a plurality of up-time slots for transmission from the fire detector side to the receiver side, and the fire detectors are assigned respectively to different ones of the up-time slots for transmission of the radio signal. Therefore, in the fire alarm system of the present invention, because each fire detector transmits the radio signal in distinct up-time slot, it is possible to avoid the collision reliably even if the periodical communication is performed frequently.

[0011] Preferably, the receiver transmits a synchronizing signal to all the fire detectors in the down-time slot in the first frame in the super frame, and each of the fire detectors determines a starting timing of the up-time slot assigned for its own fire detector based on a point of time when it received the synchronizing signal. In this case, all the fire detectors can operate in synchronization with one another by receiving the synchronizing signal and adjusting the synchronism individually. Furthermore, it is possible to calculate a reception timing of the down-time slot in the next frame from the timing of the reception of the synchronizing signal and the period of the frame, so it is possible for each fire detector to reduce useless power consumption by performing a receiving operation only while it receives the down-time slot.

[0012] As to the method for the periodical communication, it is preferable that the receiver transmits, to all the fire detectors, a reply request message which requests the periodical communication, in the same down-time slot as said synchronizing signal, and each of the fire detectors which received the reply request message transmits, to the receiver, a reply message which informs the receiver of the operating condition of its own fire detector in the up-time slot assigned for its own fire detector. In this case, it is possible to perform the periodical communication without increasing a transmission frequency from the receiver 1 to each fire detector, even when the number of the fire detectors increases.

[0013] Preferably, when the receiver could not receive the reply message in any up-time slot, the receiver retransmits the reply request message to the fire detector which is assigned to the up-time slot in which the receiver could not receive the reply message, in the down-time slot of the next frame, and the fire detector which received the reply request message transmits the reply message to the receiver again in the next up-time slot assigned for its own fire detector. In this case, it is possible to perform the periodical communication reliably.

[0014] Or, when the receiver could not receive the reply message in any up-time slot, the receiver may retransmit the reply request message to the fire detector which is assigned to the up-time slot in which the receiver could not receive the reply message, in the down-time slot of the next frame, and the fire detector which received the reply request message may transmit the reply message to the receiver again in a plurality of arbitrary up-time slots. In this case, by sending back the reply message in a plurality of arbitrary up-time slots, it becomes possible to perform the periodical communication more reliably.

[0015] Or, when the receiver could not receive the reply message in any up-time slot, the receiver may retransmit the reply request message to the fire detector which is assigned to the up-time slot in which the receiver could not receive the reply message while specifying one or more up-time slots in which the receiver could receive the reply message, in the down-time slot of the next frame, and the fire detector which received the reply request message may transmit the reply message to the receiver again in the specified one or more up-time slots. In this case, by sending back the reply message using proven up-time slots, it is possible to perform the periodical communication reliably.

[0016] Or, when the receiver could not receive the reply message in any up-time slot, the receiver may retransmit the reply request message while specifying the up-time slots which are different for each frame, and the fire detector which received the reply request message may transmit the reply message to the receiver again in the specified up-time slots. In this case, by sending back the reply message while changing the up-time slots, it is possible to perform the periodical communication reliably.

[0017] Or, the receiver may calculate an upper limit of the number of times of transmission from each fire detector to the receiver allowed in one super frame by using a transmission time allowed in one super frame, a time necessary for a single up-time slot and a single down-time slot, and the number of the up-time slots in one frame, and the receiver may send the number of times of the transmission which is less than or equal to the upper limit to all the fire detectors together with the reply request message, and each fire detector may transmit the reply message to the receiver in the up-time slots assigned for its own fire detector in one super frame until the number of times of the transmission reaches the transmitted (specified) number of times of the transmission. In this case, it is possible to perform the periodical communication reliably by sending back the reply message repeatedly, while satisfying the restriction on transmission-time necessary for the usage of a frequency which does not require a license.

[0018] In the above case, it is preferable that the receiver has a detection means for detecting signal strength of the received radio signal, and the receiver relatively reduces the number of times of the transmission, to the fire detector which sent the radio signal with relatively high signal strength, and the receiver relatively increases the number of times of the transmission within the upper limit, to the fire detector which sent the radio signal with relatively low signal strength. In this case, it is possible to reduce unnecessary traffic as well as to perform the periodical communication reliably.

[0019] In case of fire, it is preferable that, when the detection means detects fire, each of the fire detectors transmits fire detection information to the receiver in the next up-time slot assigned for its own fire detector. In this case, it is possible to inform the receiver of the fire reliably without a collision between the fire detection information and the radio signal sent by the other fire detectors, such as the reply message and the fire detection information.

[0020] In the above case, it is preferable that, when the receiver receives the fire detection information, it transmits a confirmation message, in the next down-time slot, to the fire detector which sent the fire detection information, and the fire detector which sent the fire detec-

tion message transmits the fire detection information to the receiver in the up-time slots assigned for its own fire detector until it receives the confirmation message. In this case, it is possible to transmit the fire detection information to the receiver reliably even when the receiver could not receive the fire detection information normally due to noise, interfering wave, and so on.

[0021] Preferably, each of the fire detectors has a unique address, and a lower address of the unique address corresponds to a position of the up-time slot assigned for its own fire detector. In this case, it is not necessary to store the position of the up-time slot in each fire detector in addition to the unique address of the fire detector.

[0022] In the above case, when each fire detector transmits the radio signal to the receiver, it may transmit an upper address derived from the unique address by loss of the lower address as information indicating an originating fire detector. Because the receiver can know the lower address of the fire detector from the position of the up-time slot, each fire detector has only to send the upper address derived from the unique address by loss of the lower address, whereby it is possible to reduce the transmission time and to reduce the power consumption.

[0023] Preferably, each of the fire detectors has a timer which counts a time from an end of the reception of the time slot including the synchronizing signal to a beginning of the reception of the time slot including the synchronizing signal in the next super frame, and each of the fire detectors calculates an error between the time counted by the timer and an actual timing at which it actually receives the time slot including the synchronizing signal, and it corrects the time counted by the timer from then on by using the error. In this case, it is possible to correct the error between the operation clock of the receiver and the operation clock of each fire detector, whereby it is possible to synchronize the receiver and each fire detector with each other reliably.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024]

FIG. 1 is a view of a fire alarm system in accordance with an embodiment of the present invention.
FIG. 2 is a block diagram of each fire detector of the fire alarm system of FIG. 1.
FIG. 3 is a block diagram of a receiver of the fire alarm system of FIG. 1.
FIG. 4 is a view for explaining a data format used in the fire alarm system of FIG. 1.
FIG. 5 is a view for explaining a configuration of a super frame used in the fire alarm system of FIG. 1.
FIG. 6 is a flow chart for explaining an operation of each fire detector of the fire alarm system of FIG. 1.
FIG. 7 is a view for explaining a timer used in the fire detector of the fire alarm system of FIG. 1.
FIG. 8 is a view for explaining an operation of the fire alarm system of FIG. 1.
FIG. 9 is a flow chart for explaining the operation of the fire detector of the fire alarm system of FIG. 1.
FIG. 10 is a view for explaining the operation of the fire alarm system of FIG. 1.
FIG. 11 is a view for explaining another operation of the fire alarm system of FIG. 1.
FIG. 12 is a flow chart for explaining another operation of the fire alarm system of FIG. 1.
FIG. 13 is a flow chart for explaining another operation of the fire alarm system of FIG. 1.
FIG. 14 is a view for explaining another operation of the fire alarm system of FIG. 1.
FIG. 15 is a view for explaining another operation of the fire alarm system of FIG. 1.

BEST MODE FOR CARRYING OUT THE INVENTION

[0025] Hereinafter, the present invention will be described in more detail with reference to the accompanying drawings. FIG. 1 is a configuration diagram of a fire alarm system in accordance with an embodiment of the present invention. This fire alarm system comprises a single receiver 1 and six fire detectors 10_1 to 10_6.

[0026] Each of the fire detectors 10_1 to 10_6 is installed in, for example, a ceiling of a facility, and, as shown in FIG. 2, it has a detector 11 which detects a fire by detecting temperature change and/or smoke generated by fire, a radio transmitter and receiver part 12 which modulates and demodulates between an after-mentioned data format and a carrier of a predetermined frequency, and transmits and receives a radio signal to and from the receiver 1, a battery power source 14 for supplying power to each part from batteries, a switch 16 which opens and closes between the battery power source 14 and the radio transmitter and receiver part 12, a controller 13 for controlling the radio transmitter and receiver part 12 and the switch 16, and an antenna 15 for transmitting and receiving the radio signal. The controller 13 mainly comprises a microcomputer and nonvolatile memory such as EEPROM, and programs for performing various processes are stored in the nonvolatile memory. The radio transmitter and receiver part 12 transmits the radio signal to the receiver 1 when the detector 11 detects a fire, and also it performs periodical communication with the receiver 1 which informs the receiver 1 of an operating condition of its own fire detector at a predetermined time interval. An after-mentioned unique IP address is provided to each fire detector during manufacturing or during construction, and it is stored in the nonvolatile memory of the controller 13.

[0027] On the other hand, the receiver 1 is installed in, for example, a management room of a building, and, as shown in FIGS. 1 and 3, it has a radio transmitter and receiver part 2 which modulates and demodulates between an after-mentioned data format and a carrier of a predetermined frequency, and transmits and receives

the radio signal to and from each detectors 10_1 to 10_6, operation switches 3a for configuring various setting, an informing part 3 including a liquid crystal display 3b for displaying various information, such as fire alert, and a speaker 3c for generating an audible alarm, an alarm message, and so on, a controller 4 for controlling the radio transmitter and receiver part 2 and the informing part 3, a power source 5 for supplying power to each part from commercial power supply, and an antenna 6 for transmitting and receiving the radio signal. The controller 4 mainly comprises a microcomputer and nonvolatile memory such as EEPROM, and programs for performing various processes are stored in the nonvolatile memory. A unique IP address which is different from that of the fire detectors 10 is provided to the receiver 1 during manufacturing or during construction, and it is stored in the nonvolatile memory of the controller 4.

[0028] The receiver 1 and each of the fire detectors 10_1 to 10_6 perform radio communication with each other by using a frequency which does not require a license. Therefore, they have to meet radio characteristics which conforms to, for example, low-power security or specified low power radio standard in Japan, FCC Regulations Part15 Subpart C in the United States, and Short Range Device in Europe.

[0029] FIG. 4 shows a data format of the data which is transmitted and received between the receiver 1 and each of the fire detectors 10_1 to 10_6. This data format includes a 32-bit preamble (PR) in which "1" and "0" alternate (bit synchronization pattern), a 16-bit unique word (UW) of a prescribed bit string (frame synchronization pattern), a 32-bit unique system ID (sysID) assigned to the fire alarm system, a 8-bit unique detector ID (NodeID) assigned to each fire detector 10, a 16-bit message (Msg), and a 16-bit error-detecting code (CRC). That is, the unique address of each fire detector is the system ID plus the detector ID (namely, the system ID + the detector ID), and the unique address of the receiver 1 is the system ID.

[0030] When the receiver 1 transmits a message to a specific fire detector, the receiver 1 specifies the detector ID of the fire detector 10 in the detector ID (NodeID) of the data format, and when the receiver 1 transmits a message to all the fire detectors 10, it specifies "0" (zero) in the detector ID of the data format. When each fire detector sends a replay to the receiver 1, it specifies the detector ID of its own fire detector in the detector ID of the data format. The receiver 1 and each fire detector which received the radio signal amplify the received signal by the radio transmitter and receiver parts 12 and 2, and demodulate the data format, and output it to the controllers 13 and 4, respectively. The controllers 13 and 4 sample the data demodulated by the radio transmitter and receiver part 12 and 2 by a digital input port of the microcomputer, and extract the bit timing during the reception of the preamble (PR), and then they detect the unique word by shifting the consecutive 16 bits of the received bits until they correspond with the prescribed unique word. Then, the controllers 13 and 4 check the received system ID and the detector ID against the unique address stored in the nonvolatile memory, and if they correspond with each other and the bit error is not detected, these controllers accept the message (Msg) and perform a predetermined process programmed beforehand.

[0031] As to the message (Msg), a reply request message in which the receiver 10 requests the periodical communication to the fire detectors 10, a reply message to the reply request message, fire detection information for informing the receiver 1 of occurrence of a fire, and so on, are included.

[0032] The receiver 1 inserts a synchronizing signal in the message (Msg), and it transmits the message (Msg) including the synchronizing signal to the fire detectors 10. The fire detector 10 which received the synchronizing signal determines a starting timing of the up-time slot assigned for its own fire detector and a time at which the fire detector begins to receive the time slot including the synchronizing signal in the next super frame, based on the point of time when it received the synchronizing signal.

[0033] In this embodiment, the radio communication between the receiver 1 and each fire detector 10_1 to 10_6 is performed in the form of a time division multiplexing access (TDMA). FIG. 5 shows a configuration of the super frame used in the radio communication of this embodiment. This super frame SF includes 30 frames F1 to F30, and each frame includes one down-time slot B for downward transmission (namely, from the receiver side to the fire detector side) and 99 up-time slots D1 to D99 for upward transmission (namely, from the fire detector side to the receiver side). The time distance of each time slot B and D1 to D99 is 0.1 seconds, and the time distance of each frame is 10 seconds, and the period of the super frame is 300 seconds. Each time slots B and D1 to D99 further includes 50-millisecond data format shown in the above-mentioned FIG. 4, 20-millisecond start time for activating the radio transmitter and receiver parts 12 and 2 of the receiver 1 and the fire detector 10 and transmitting data at stable carrier frequency, and 15-millisecond guard times provided at both ends of each time slot. The guard time is an empty time for absorbing a timing difference caused by an error between operation clock frequencies of the fire detector 10 and the receiver 1 (in other words, between operation clock frequencies of the microcomputers which makes up the controllers 13 and 4).

[0034] The fire detectors 10_1 to 10_6 are assigned respectively to different ones of the up-time slots D1 to D99 for transmission of the radio signal. Therefore, even if the periodical communication is performed frequently, it is possible to avoid the collision between the transmissions from the fire detectors reliably.

[0035] As to the method for assigning each fire detector 10_1 to 10_6 to one of the up-time slots D1 to D99, a method in which each fire detector is assigned by a DIP switch provided each fire detector 10_1 to 10_6, a method

in which the slot number is stored in the nonvolatile memory of the controller 13 during manufacturing, a method in which the receiver 1 assigns each fire detector in turn by using a radio communication during construction and each fire detector stores the assignment in the nonvolatile memory of the controller 13, and so on, can be considered. In this embodiment, the detector ID, namely, a lower address out of the unique address of each fire detector is made to correspond to the slot number in a one-to-one relationship. That is, the controller 13 of each fire detector determines the up-time slot number of its own fire detector from the lower address of the unique address stored in the nonvolatile memory. In this case, it is possible to save the trouble of storing the slot number in addition to the unique address or setting the slot number separately.

[0036] Next, the operation of the fire alarm system of this embodiment will be described below. First, the operation for the periodical communication will be explained. In the periodical communication, the receiver 1 transmits the reply request message to each fire detector, and each fire detector which received the reply request message sends back the reply message to the receiver 1. The content of the replay message includes the presence or absence of an abnormality in the fire detector (for example, the battery voltage came down below a threshold, or a defective operation was occurred in the detector 11, and so on). If the reply message includes the content of such an abnormality, the receiver 1 informs a system administrator of occurrence of the abnormality by, for example, displaying the detector ID of the fire detector which sent the reply message on the informing part 3.

[0037] First, when the receiver 1 is turned on, the controller 4 of the receiver 1 specifies "0" in the detector ID of the data format in the down-time slot B of the first frame F1 of the super frame SF, and transmits the reply request message including the synchronizing signal to all the fire detectors 10, as the message (Msg).

[0038] On the other hand, as shown in FIG. 6, in each fire detector 10, the controller 13 closes the switch 16 immediately after the fire detector is turned on to supply the power to the radio transmitter and receiver part 12, and it continues a receiving operation until it receives the reply request message including the synchronizing signal (Steps S1 and S2 of FIG. 6).

[0039] When each fire detector 10 receives the reply request message including the synchronizing signal, it opens the switch 16 by the controller 13 to stop supplying power to the radio transmitter and receiver part 12, and it stops the receiving operation (Step S3 of FIG. 6). Then, each fire detector 10 activates a first timer, a second timer, and a third timer, built in the microcomputer of the controller 13, at the same time (Step S4 of FIG. 6).

[0040] As shown in FIG. 7, the first timer counts a time from the end of the reception of the down-time slot B including the synchronizing signal in the first frame F1 of the super frame SF to the beginning of the reception of the down-time slot B including the synchronizing signal in the next super frame. That is, by the first timer, each fire detector can determine the starting timing of the reception of the down-time slot B in the next super frame. In this embodiment, because the period of the super frame SF is 300 seconds and the period of each down-time slot is 0.1 seconds, the first timer counts 300-0.1 =299.9 seconds.

[0041] The second timer counts a time from the end of the down-time slot B in the first frame F1 of the super frame SF to the beginning of the up-time slot D_i (i=1 to 99) assigned individually for each fire detector 10. That is, by the second timer, each fire detector can determine the starting timing of the up-time slot D_i assigned for its own fire detector in the frame F1. In this embodiment, because the period of the up-time slot is 0.1 seconds, the second timer counts 0.1 $\times${(the number of the up-time slots Di)-1}.

[0042] The third timer counts a time from the end of the down-time slot B to the beginning of the reception of the down-time slot B in the next frame. In this embodiment, because the period of each frame is 10 seconds and the period of the down-time slot B is 0.1 seconds, the third timer counts 10-0.1=9.9 seconds.

[0043] When the count of the second timer reaches its end, that is, in the up-time slot D_i assigned for its own fire detector, the controller 13 of each fire detector 10 transmits the reply message through the radio transmitter and receiver part 12, and after the transmission, each fire detector activates the fourth timer built in the microcomputer (Steps S5 and S6 of FIG. 6).

[0044] The fourth timer counts a time from the end of the up-time slot D_i assigned for its own fire detector to the beginning of the up-time slot D_i assigned for its own fire detector in the next frame. That is, by the fourth timer, each fire detector can determine the starting timing of the up-time slot D_i assigned for its own fire detector in the next frame. In this embodiment, the fourth timer counts 10-0.1=9.9 seconds from the end of the up-time slot D_i.

[0045] Then, each fire detector waits until the third timer expires and the message (Msg) is transmitted from the receiver 1 in the down-time slot B of the next frame (Step S7 of FIG. 6).

[0046] On the other hand, in the receiver 1, the controller 4 receives the reply message sent back from each fire detector 10 while the third timer is activated, that is, during the up-time slots D1 to D99. If the controller 4 receives the reply message from all the fire detectors, it sends a reception confirmation message for informing each fire detector of normal reception, as the message (Msg), to all the fire detectors 10 simultaneously (that is, in the multicasting).

[0047] When the third timer expires, the controller 13 of each fire detector 10 closes the switch 16 again to activate the radio transmitter and receiver part 12, and it receives the down-time slot B from the receiver 1. After the controller 13 received the down-time slot B, it acti-

vates the third timer again (Step S8 of FIG. 6).

[0048] At that time, if the message (Msg) of the received down-time slot B is the reception confirmation message (Step S9 of FIG. 6), the controller 13 of each fire detector opens the switch 16 to halt the radio transmitter and receiver part 12 until the first timer expires (Step S10 of FIG. 6), and when the first timer expires and the next super frame SF begins, the controller 13 closes the switch 16 again to receive the down-time slot B (Step S11 of FIG. 6), and repeats the above operation from Step S4.

[0049] By the way, even when the fire detector is normal, the receiver 1 may not be able to receive the reply message from the fire detectors normally due to noise, interfering wave, and so on. In such a case, the receiver 1 specifies the detector ID of the fire detector from which the receiver 1 could not receive the reply message in the detector ID of the data format of FIG. 4, and the receiver sends the reply request message, as a substitute for the reception confirmation message, again, to the fire detector in the down-time slot B of the next frame F2. For example, as shown in FIG. 8, if the receiver 1 could not receive the reply message from the fire detector 10_3, the receiver 1 specifies the ID of the fire detector 10_3 in the detector ID, and it sends the reply request message again in the down-time slot B of the next frame F2. In FIG. 8, "T" indicates a transmission state, and "R" indicates a reception state.

[0050] In the Step S8 of FIG. 6, although each fire detector receives the down-time slot B in the next frame F2, the fire detectors except for the fire detector 10_3 discard the transmitted data because the detector ID in the data format of the transmitted data does not correspond with each of their own IDs (Step S9 and S12 of FIG. 6), and they open the switch 16 to halt the radio transmitter and receiver part 12 until the third timer expires, and they repeat the Steps S7, S8, S9, and S12 until they receive the reception confirmation message.

[0051] On the other hand, the controller 13 of the fire detector 10_3 accepts the reply request message because the detector ID of the data format received in the down-time slot B of the second frame F2 corresponds with the detector ID of its own fire detector, and it sends back the reply message again at the point of time when the fourth timer expires, that is, in the up-time slot D3 assigned for its own fire detector in the second frame F2 (Steps S13 and S6).

[0052] When the receiver receives the reply message from the fire detector 10_3 normally, it specifies "0" in the detector ID and sends the reception confirmation message as the message (Msg) to all the fire detectors simultaneously. If the receiver could not receive the reply message from the fire detector 10_3, it sends the reply request message to the fire detector 10_3 again, and repeats the above operations.

[0053] If there are two or more fire detectors from which the receiver could not receive the reply message, the receiver 1 may sends the reply request message to each fire detector in the second and subsequent frames F2, F3, ..., within the upper limit of the number of times of the transmission.

[0054] As mentioned above, each fire detector determines the starting timing of the up-time slot assigned for its own fire detector by using the second and fourth timers based on the point of time when it received the synchronizing signal. That is, all the fire detectors can operate in synchronism with one another by receiving the synchronizing signal and adjusting the synchronism individually. Furthermore, because each fire detector performs the transmitting operation only while it receives the down-time slot B by using the third timer, it is possible to reduce useless power consumption. Furthermore, because each fire detector which finished the periodical communication halts the operation of the radio transmitter and receiver part 12 until it receives the synchronizing signal in the next super frame by using the first timer, it is possible to further reduce the useless power consumption. Still furthermore, because the receiver 1 transmits the reply request message to all the fire detectors in the same down-time slot B as the synchronizing signal, it is possible to perform the periodical communication without increasing the transmission frequency from the receiver 1 to each fire detector even when the number of the fire detectors increases.

[0055] In a case where all the reply messages to the reply request message could be received normally in the first frame F1, the transmission time duty becomes 0.1 (sec) $\times$ 2/300 (sec) $\times$ 100$\fallingdotseq$0.067%, because the receiver 1 transmits the reply request message in the down-time slot B of the first frame F1 and it transmits the reception confirmation message in the time slot B of the second frame F2, in the super frame SF of 300 seconds. As mentioned above, for example in Europe, when the radio communication is performed by using the frequency which does not require the license, it is necessary to meet not only the Proposal of European Standard (Pr_EN54-25) but also the European Radio Law. Because the limit value of the transmission time duty at the frequency for an alarm in the European Radio Law is less than 0.1 %, the fire alarm system of this embodiment meets this limitation.

[0056] If all the reply messages to the reply request message could not be received normally in the first frame F1, the upper limit L1 of the number of times of the transmission from the receiver 1 to the fire detector is limited by the limit value of the transmission time duty. For example, in the above European Radio Law, because the limit value of the transmission time duty at the frequency for an alarm is less than 0.1 %, the upper limit L1 of a transmission time per one hour is;

$$L1 = 3600\ (\text{sec}) \times 0.1\ (\%) = 3.6\ (\text{sec})$$

[0057] In this embodiment, because the time T_B of the

down-time slot is 0.1 seconds, the upper limit of the number of times of the transmission from the receiver 1 to the fire detector is 3.6 (sec) / 0.1 (sec) = 36 times per one hour. As long as the limit, namely 36 times per one hour, is complied with, it is possible that, when the receiver 1 could not receive the reply message normally, the receiver 1 transmits the down-time slots B collectively in successive frames and prohibits the transmission of the down-time slot B in the frames after the completion of the process. The upper limit of the number of times of the transmission may be stored in the nonvolatile memory of the controller 4. For reference, it is only necessary that the upper limit of the number of times of the transmission, such as 36 times per one hour, should be established between the receiver 1 and each fire detector 10_1 to 10_6, and it is not necessary that such a restriction should be established in the whole system comprising the receiver 1 and the fire detectors 10_1 to 10_6.

[0058] Next, the operation of this system performed when any fire detector detects a fire will be described below. The following process of the controller 13 of each fire detector 10 is an interrupt processing which interrupts the operation for the above-mentioned periodical communication.

[0059] When a certain fire detector 10 detects a fire by the detector 11, it judges whether the second timer is in the counting operation or not (Step S1 of FIG. 9). If the second timer is in the counting operation, the fire detector transmits a fire detection information for informing the receiver 1 of detection of a fire, as a substitute for the reply message of the periodical communication, to the receiver 1 as the message (Msg) at the time when the second timer expires, that is, in the up-time slot Di assigned for its own fire detector in the frame F1, and after that, it activates the fourth timer (Steps S2 and S3 of FIG. 9). If the second timer is not in the counting operation (in other words, if the second timer has already expired), the fire detector transmits the fire detection information to the receiver 1 at the time when the fourth timer expires, that is, in the up-time slot Di assigned for its own fire detector in the frame, and after that, it activates the fourth timer (Steps S7 and S3 of FIG. 9).

[0060] The receiver 1 which received the fire detection information transmits the reception confirmation message of the fire detection information to the fire detector which transmitted the fire detection information, in the next down-time slot B. Then, the receiver 1 informs the system administrator of the fire by using the liquid crystal display 3b and the speaker 3c of the receiver 1.

[0061] When the third timer expires (Step S4 of FIG. 9), the fire detector which sent the fire detection information closes the switch 16 to receive the next down-time slot B, and after the reception, it activates the third timer again (Step S5 of FIG. 9). If the content of the message (Msg) of the down-time slot B is the reception confirmation message of the fire detection information, the fire detector which sent the fire detection information returns to the main routine (that is, the flow chart of FIG. 6) (Step S6 of FIG. 9).

[0062] If the fire detector does not receive the reception confirmation message of the fire detection information, there is a possibility that the receiver 1 does not receive the fire detection information normally, so the fire detector retransmits the fire detection information at a point of time when the fourth timer expires (Steps S8 and S3 of FIG. 9). And then, the fire detector repeats from the Step S3 to the Steps S6 and S8 of FIG. 9 until it receivers the reception confirmation message from the receiver 1 so as to inform the receiver 1 of the occurrence of the fire reliably.

[0063] Concretely speaking, as shown in FIG. 10 for example, consider that two fire detectors 10_2 and 10_3 detect a fire in the first frame F1 after the up-time slot D2 of the fire detector 10_2 expires and before the up-time slot D3 of the fire detector 10_3 expires. Because the second timer of the fire detector 10_2 had already expired at the time when the fire detector 10_2 detected the fire, the fire detector 10_2 waits until the fourth time expires and transmits the fire detection information to the receiver 1 in the up-time slot D2 of the next frame F2. On the other hand, because the second timer of the fire detector 10_3 had not expired yet at the time when the fire detector 10_3 detected the fire, it transmits the fire detection information to the receiver 1 in the up-time slot D3 of the frame F1 after the second timer expires.

[0064] The receiver 1 transmits the reception confirmation message of the fire detection information to the fire detector 10_3 in the down-time slot B of the second frame F2. When the fire detector 10_3 receives the reception confirmation message of the fire detection information in the down-time slot B of the second frame F2, it returns to the main routine. If the fire detector 10_3 does not receive the reception confirmation message of the fire detection information, it retransmits the fire detection information after the expiration of the fourth timer.

[0065] And, the receiver 1 also transmits the reception confirmation message of the fire detection information to the fire detector 10_2 in the down-time slot B of the third frame F3. When the fire detector 10_2 receives the reception confirmation message for the fire detection information in the down-time slot B of the third frame F3, it returns to the main routine. If the fire detector 10_2 does not receive the reception confirmation message for the fire detection information, it retransmits the fire detection information after the expiration of the fourth timer.

[0066] After that, the fire detectors 10_3 and 10_2 send the fire detection information in a row until they receive the reception confirmation message of the fire detection information. The upper limit of the number of times of the transmission in the super frame SF is set so that the transmission time duty does not exceed the limit value.

[0067] As mentioned above, because the fire detector 10 which detected the fire transmits the fire detection information to the receiver 1 in the next frame F(k+1), at the latest, of the frame F(k) in which the fire was detected, it is possible to transmit the fire detection information to

the receiver 1 within 10 seconds, which is the period of the frame, after the fire detector detects the fire. In the European EN Standard (EN54-25), it is stipulated to transmit the information within 10 seconds after the detection, so the fire alarm system of this embodiment meets this standard.

[0068] In this embodiment, in the case where the receiver 1 could not receive the reply message from each of the fire detectors 10_1 to 10_6 normally and retransmitted the reply request message, the fire detector which received the reply request message sends the reply message again in the same up-time slot (see FIG. 8). But, the fire detector which received the reply request message may send the reply message in a plurality of arbitrary up-time slots.

[0069] For example, as shown in FIG. 11, when the receiver 1 could not receive the reply message normally from the fire detector 10_3 assigned to the up-time slot D3 in the frame F1, the fire detector 10_3 resends the reply message in the two up-time slots D3 and D4 in the next frame F2. By sending the reply message in a plurality of up-time slots, it is possible to transmit the reply message to the receiver 1 more reliably. The plurality of the up-time slots may be decided by using random number generated by the controller 13, or, the up-time slots having earlier numbers may be used.

[0070] The operation for the periodical communication in this case will be explained below with reference to the flow chart of FIG. 12. The steps S1 to S11 of FIG. 12 are identical to FIG. 6 of the embodiment, so no duplicate explanation is made here.

[0071] When the receiver 1 could not receive the reply message normally and retransmitted the reply request message, each fire detector checks whether the detector ID of the transmitted data format corresponds with its own ID, and if the detector ID does not correspond, the fire detector discards the data (Step S12 of FIG. 12) and repeats the Steps S7, S8, S9 and S12 until it receives the reception confirmation message. The fire detector whose ID corresponds with the detector ID of the transmitted data format accepts the reply request message, and it determines a plurality of up-time slot numbers by random numbers and so on. And, the fire detector sets a plurality of timers to the beginning of each of the determined up-time slots, and when each timer expires, the fire detector operates the radio transmitter and receiver part 12 and transmits the reply message again (Step S13 of FIG. 12).

[0072] Although FIG. 12 is a flow chart showing the operation for the periodical communication, it is preferable that each fire detector retransmits the fire detection information in a plurality of arbitrary up-time slots of the next frame even when the receiver 1 could not receive the fire detection information, as shown in the Step S8 of the FIG. 13. Because the Steps S1 to S7 of FIG. 13 are identical to the Steps S1 to S7 of FIG. 9, so no duplicate explanation is made here.

[0073] As a substitute for using a plurality of arbitrary up-time slots, the receiver 1 may retransmit the reply request message while specifying one or more up-time slots in which the receiver could receive the message, and the fire detector which received the reply request message may resend the reply message to the receiver 1 in the specified one or more up-time slots.

[0074] For example, as shown in FIG. 14, when the receiver could not receive the reply message from the fire detector 10_2 assigned to the up-time slot D2 in the frame F1, the receiver 1 selects one or more up-time slots, for example, two up-time slots D1 and D3, out of the up-time slots in which the receiver 1 could receive the reply message normally in the frame F1, and it transmits the reply request message again to the fire detector 10_2 while specifying the selected up-time slots D1 and D3. The fire detector 10_2 resends the reply message in the specified up-time slots D1 and D3 in the second frame F2.

[0075] As above, by sending back the reply message using proven up-time slots, it is possible to transmit the reply message to the receiver 1 more reliably.

[0076] In order to receive the reply message rapidly, the receiver 1 may select the up-time slot having the lowest number out of the proven up-time slots Di when it selects the up-time slot Di. The number of the up-time slots Di to be selected may be three or more as long as it is within the limit value of the transmission time duty.

[0077] Or, the receiver 1 may transmit the reply request message again while specifying the up-time slots which are different for each frame. For example, as shown in FIG. 15, when the receiver 1 could not receive the reply message normally from the fire detector 10_2 assigned to the up-time slot D2 in the frame F1, the receiver 1 retransmits the reply request message while specifying the up-time slot D1 in the next frame F2, and retransmits the reply request message while specifying the up-time slot D3 which is different from the up-time slot D1 in the next frame F3. The fire detector 10_2 resends the reply message in each of the specified up-time slots.

[0078] As above, by transmitting the reply message in the up-time slots which are different for each frame, it is possible to transmit the reply message to the receiver 1 more reliably even when periodical noise having a period near the time period of the frame F exists.

[0079] As above, in this embodiment, each fire detector sends the reply message once in response to the reply request message sent from the receiver 1, and only the fire detector to which the reply request message was individually sent sends the reply message several times. But, in order to send the reply message to the receiver 1 more reliably, each fire detector may send the reply message several times within the limit value of the transmission time duty. That is, the receiver 1 may calculate the upper limit of the number of times of the transmission from each fire detector to the receiver 1 allowed in one super frame by using the transmission time allowed in the one super frame SF, the time necessary for a single up-time slot and a single down-time slot, and the number

of the up-time slots in one frame, and the receiver 1 may send the number of times of the transmission, which is less than or equal to the upper limit, to all the fire detectors together with the reply request message, and each fire detector may send the reply message to the receiver 1 in the up-time slots assigned for its own fire detector in one super frame until the number of times of the transmission reaches the transmitted (specified) number of times of the transmission.

[0080] That is, when the time of the super frame SF is represented by "T_{SF}", the time of the up-time slot is represented by "T_D", and the limit value of the transmission time duty is represented by "Z%", the upper limit L2 of the number of times of the transmission of each fire detector in one super frame SF arising from the limit value of the transmission time duty is:

$$L2 = (T_{SF} \times Z/100) / T_D$$

[0081] On the other hand, when the number of up-time slots in one frame is represented by "i", the time of the down-time slot is represented by "T_B", and the time of the up-time slot is represented by "T_D", the time width T_F of the one frame F is:

$$T_F = T_B + (T_D \times i)$$

[0082] Because the number of the up-time slots of each fire detector is one in each frame, the number of times of the transmission of each fire detector in one super frame SF has to be less than or equal to a maximum repeat count y ($y = T_{SF} \div T_F$) of the frame F included in the super frame SF. So, if $y \leqq L2$, the upper limit of the number of times of the transmission from each fire detector to the receiver 1 allowed in one super frame is "y", and if $L2 \leqq y$, it is "L2".

[0083] For example, in this embodiment, because T_{SF}=300 seconds, Z=0.1 %, $T_B=T_D$=0.1 seconds, and the number of up-time slots is 99, L2 becomes 3 (namely, L2 = 3 times) and y becomes 30 (namely, y=30 times), so the upper limit of the number of times of the transmission from each fire detector to the receiver 1 allowed in one super frame is 3 times (= L2).

[0084] When the upper limit is 3 times, the receiver 1 sends the reply request message to all the fire detectors while specifying the number of times of transmission which is less than or equal to 3 times, for example, twice, and each fire detector sends the reply message to the receiver 1 twice in one super frame. In this case, it is possible to increase the possibility that the receiver 1 receives the reply message.

[0085] For reference, conditions for calculating the above-mentioned upper limit, such as the time width T_{SF} of the super frame SF and the limit value Z% of the transmission time duty, are inputted by a contractor by operating the operation switches 3a of the informing part 3 during construction, and the process to calculate the above-mentioned upper limit is performed by the controller 4 of the receiver 1.

[0086] In the above case, it is preferable that the receiver 1 has a sensor (namely, a detection means. Not shown.) for detecting signal strength of the received radio signal, and the receiver 1 relatively reduces the number of times of the transmission, to the fire detector which sent the radio signal with relatively high signal strength, and the receiver 1 relatively increases the number of times of the transmission within the upper limit, to the fire detector which sent the radio signal with relatively low signal strength. For example, when the signal strength of the fire detector 10_1 is relatively high, the receiver 1 instructs the fire detector 10_1 to send the reply message only once, and when the signal strength of the fire detector 10_2 is relatively low, the receiver 1 instructs the fire detector 10_2 to send the reply message three times, which is the upper limit. In this case, because the possibility that the radio signal with low signal strength can be received normally is low, it is possible to increase the possibility that the radio signal with low signal strength is received normally by increasing the number of times of transmission, and because the possibility that the radio signal with high signal strength can be received normally is high, it is possible to reduce unnecessary traffic by reducing the number of times of transmission.

[0087] As above, in this embodiment, when each fire detector transmits data to the receiver 1, it specifies its own detector ID in the detector ID (NodeID) of the data format shown in FIG. 4 and transmits the data. However, when the lower address (namely, the detector ID) of the unique address of each fire detector corresponds to the slot number in a one-to-one relationship, the receiver 1 can identify the detector ID of the fire detector which sent the data from the slot number. Therefore, it is preferable that each fire detector sends only the upper address (that is, the system ID (SysID)) derived from the unique address by loss of the lower address. In this case, it is possible to reduce the transmission time, whereby it is possible to reduce the power consumption.

[0088] Furthermore, in this embodiment, the starting timing of the reception of the time slot including the synchronizing signal in the next super frame SF is estimated by the first timer. However, the time that the first timer counts may have an error because of an error between the operation clock of the microcomputer which makes up the controller 13 and the operation clock of the microcomputer which makes up the controller 4 of the receiver 1. In this embodiment, as shown in FIG. 5, the guard times of 15 milliseconds are provided at both ends of the up-time slot B and the down-time slot Di. However, when the guard time is 15 milliseconds, only relative error of 50 ppm (15 msec / 299.9 sec = 50 ppm) can be allowed. That is, the absolute error allowed for each of the microcomputers of the controller 13 of the each fire detector

and the controller 4 of the receiver 1 is ±25 ppm, so even when a crystal oscillator is used for the clock of the microcomputer, the cost may increase substantially in order to satisfy the above absolute error.

[0089] So, it is preferable that the controller 13 of the fire detector 10 calculates an error between the time from the end of the reception of the time slot including the synchronizing signal to the beginning of the reception of the time slot including the synchronizing signal in the next super frame, counted by the first timer, and an timing at which the fire detector actually receives the time slot including the synchronizing signal, and the controller 13 corrects the time counted by the timer from then on by using the calculated error. In this case, it is possible to ease the permissible error of the operation clock of the microcomputer, whereby it is possible to reduce the cost.

[0090] Although the synchronizing signal is inserted only in the message (Msg) of the first frame of the super frame SF in this embodiment, the synchronizing signal may be inserted in the message (Msg) of the frames other than the first frame.

[0091] Furthermore, although the informing part 3 of this embodiment comprises the liquid crystal display 3b and the speaker 3c, a plurality of receivers 1 may be connected to a central supervisory board through wires, and when the receiver 1 receives the fire detection information, the informing part 3 may transmit the fire detection information to the central supervisory board, and the central supervisory board may take necessary measures (for example, it may sound the fire alarm or it may alert the fire department).

[0092] As mentioned above, as many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments thereof except as defined in the appended claims.

[0093] Especially, the duration time of the frame which constitutes the super frame and the duration time of the time slot are not limited to the above numeric value, and of course, they should be changed as appropriate according to the fire alarm system based on the number of fire detectors and other various factors.

Claims

1. A fire alarm system comprising:

a plurality of fire detectors, and
a receiver,

wherein
each of said fire detectors has a detection means for detecting a fire, and a radio transmitter and receiver means which transmits and receives a radio signal to and from said receiver, said radio transmitter and receiver means transmitting the radio signal to said receiver when said detection means detects a fire and also performing periodical communication with said receiver which informs said receiver of an operating condition of its own fire detector at a predetermined time interval,
said receiver having a radio transmitter and receiver means which transmits and receives the radio signal to and from each of said fire detectors, and an informing means which informs an outside about the fire when the received radio signal includes fire detection information,
wherein
each of said fire detectors and said receiver perform radio communication with each other by using a super frame comprising a plurality of frames each of which includes one down-time slot for transmission from a receiver side to a fire detector side and a plurality of up-time slots for transmission from the fire detector side to the receiver side,
said fire detectors being assigned respectively to different ones of said up-time slots for transmission of said radio signal.

2. The fire alarm system as set forth in claim 1, wherein said receiver transmits a synchronizing signal to all the fire detectors in the down-time slot in a first frame in said super frame,
each of said fire detectors determining a starting timing of the up-time slot assigned for its own fire detector based on a point of time when it received the synchronizing signal.

3. The fire alarm system as set forth in claim 2, wherein said receiver transmits, to all the fire detectors, a reply request message which requests the periodical communication, in the same down-time slot as said synchronizing signal,
each of said fire detectors which received said reply request message transmitting, to said receiver, a reply message which informs said receiver of the operating condition of its own fire detector in the up-time slot assigned for its own fire detector.

4. The fire alarm system as set forth in claim 3, wherein said receiver retransmits said reply request message to the fire detector which is assigned to the up-time slot in which the receiver could not receive the reply message, in the down-time slot of the next frame, when the receiver could not receive the reply message,
the fire detector which received the reply request message transmitting the reply message to the receiver again in the next up-time slot assigned for its own fire detector.

5. The fire alarm system as set forth in claim 3, wherein said receiver retransmits said reply request message to the fire detector which is assigned to the up-

time slot in which the receiver could not receive the reply message, in the down-time slot of the next frame, when the receiver could not receive the reply message,
the fire detector which received the reply request message transmitting the reply message to the receiver again in a plurality of arbitrary up-time slots.

6. The fire alarm system as set forth in claim 3, wherein said receiver retransmits said reply request message to the fire detector which is assigned to the up-time slot in which the receiver could not receive the reply message while specifying one or more up-time slots in which the receiver could receive the reply message, in the down-time slot of the next frame, when the receiver could not receive the reply message,
said fire detector which received the reply request message transmitting the reply message to the receiver again in the specified one or more up-time slots.

7. The fire alarm system as set forth in claim 3, wherein said receiver retransmits said reply request message while specifying the up-time slots which are different for each frame when the receiver could not receive the reply message in any up-time slot,
said fire detector which received the reply request message transmitting the reply message to the receiver again in the specified up-time slots.

8. The fire alarm system as set forth in claim 3, wherein said receiver calculates an upper limit of the number of times of transmission from each fire detector to the receiver allowed in one super frame by using a transmission time allowed in one super frame, a time necessary for a single up-time slot and a single down-time slot, and the number of the up-time slots in one frame, and said receiver sends the number of times of the transmission which is less than or equal to the upper limit to all the fire detectors together with the reply request message,
each fire detector transmitting the reply message to said receiver in the up-time slots assigned for its own fire detector in one super frame until the number of times of the transmission reaches the transmitted number of times of the transmission.

9. The fire alarm system as set forth in claim 8, wherein said receiver has a detection means for detecting signal strength of the received radio signal,
said receiver relatively reducing the number of times of the transmission, to the fire detector which sent the radio signal with relatively high signal strength, and said receiver relatively increasing the number of times of the transmission within the upper limit, to the fire detector which sent the radio signal with relatively low signal strength.

10. The fire alarm system as set forth in claim 1, wherein each of said fire detectors transmits fire detection information to said receiver in the next up-time slot assigned for its own fire detector when said detection means detects a fire.

11. The fire alarm system as set forth in claim 10, wherein
said receiver transmits a confirmation message, in the next down-time slot, to the fire detector which sent the fire detection information when it receives the fire detection information,
said fire detector which sent the fire detection message transmitting the fire detection information to said receiver in the up-time slots assigned for its own fire detector until it receives the confirmation message.

12. The fire alarm system as set forth in claim 1, wherein each of said fire detectors has a unique address,
a lower address of the unique address corresponding to a position of the up-time slot assigned for its own fire detector.

13. The fire alarm system as set forth in claim 12, wherein
each of said fire detectors transmits an upper address derived from the unique address by loss of the lower address as information indicating an originating fire detector, when it transmits the radio signal to the receiver.

14. The fire alarm system as set forth in claim 2, wherein each of said fire detectors has a timer which counts a time from an end of the reception of the time slot including the synchronizing signal to a beginning of the reception of the time slot including the synchronizing signal in the next super frame,
each of said fire detectors calculating an error between the time counted by said timer and an actual timing at which it receives the time slot including the synchronizing signal, and it correcting the time counted by the timer from then on by using the error.

FIG. 1

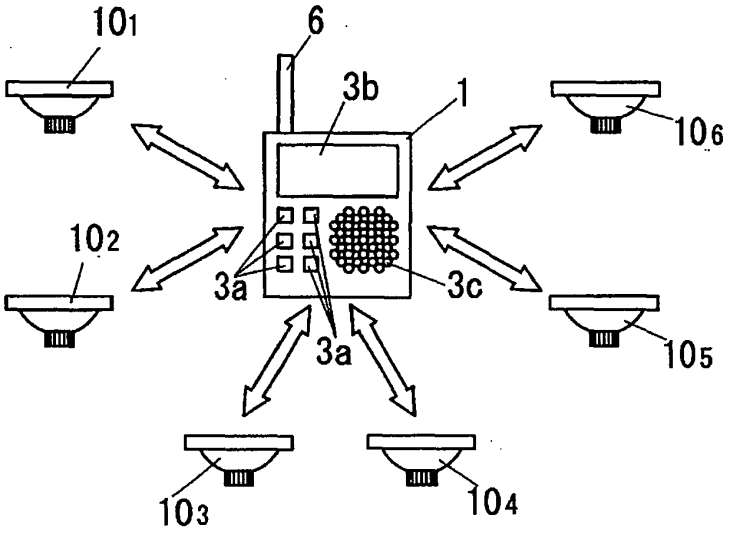


FIG. 2

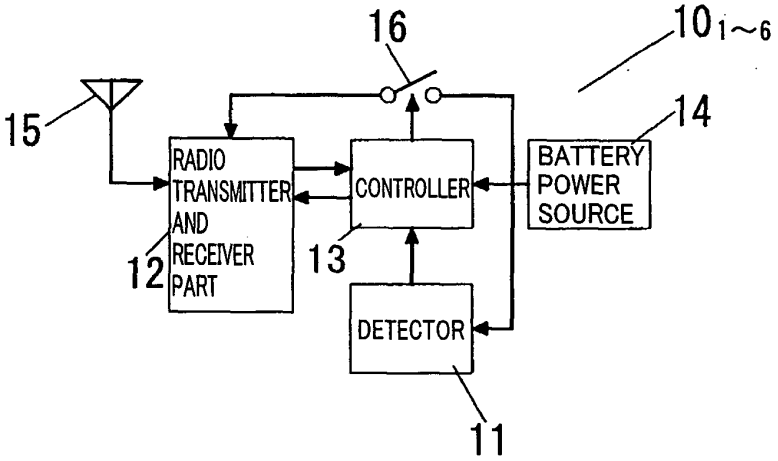


FIG. 3

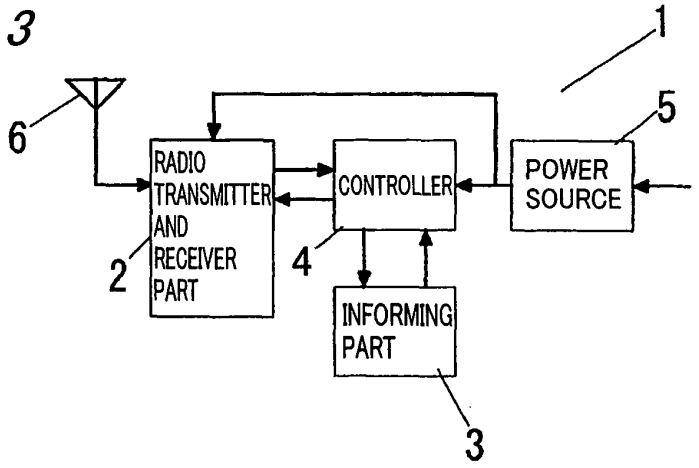


FIG. 4

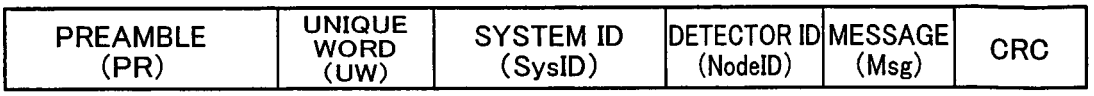

PREAMBLE (PR)
UNIQUE WORD (UW)
SYSTEM ID (SysID)
DETECTOR ID (NodeID)
MESSAGE (Msg)
CRC

FIG. 5

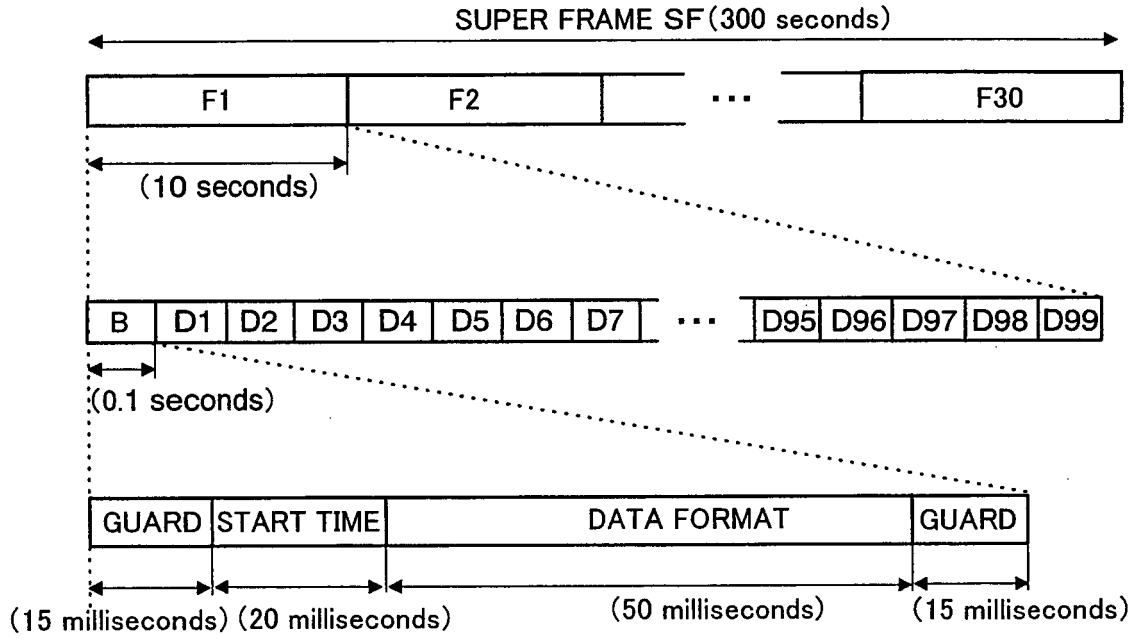

SUPER FRAME SF (300 seconds)
F1
F2
F30
(10 seconds)
B
D1
D2
D3
D4
D5
D6
D7
D95
D96
D97
D98
D99
(0.1 seconds)
GUARD
START TIME
DATA FORMAT
GUARD
(15 milliseconds)
(20 milliseconds)
(50 milliseconds)
(15 milliseconds)

FIG. 6

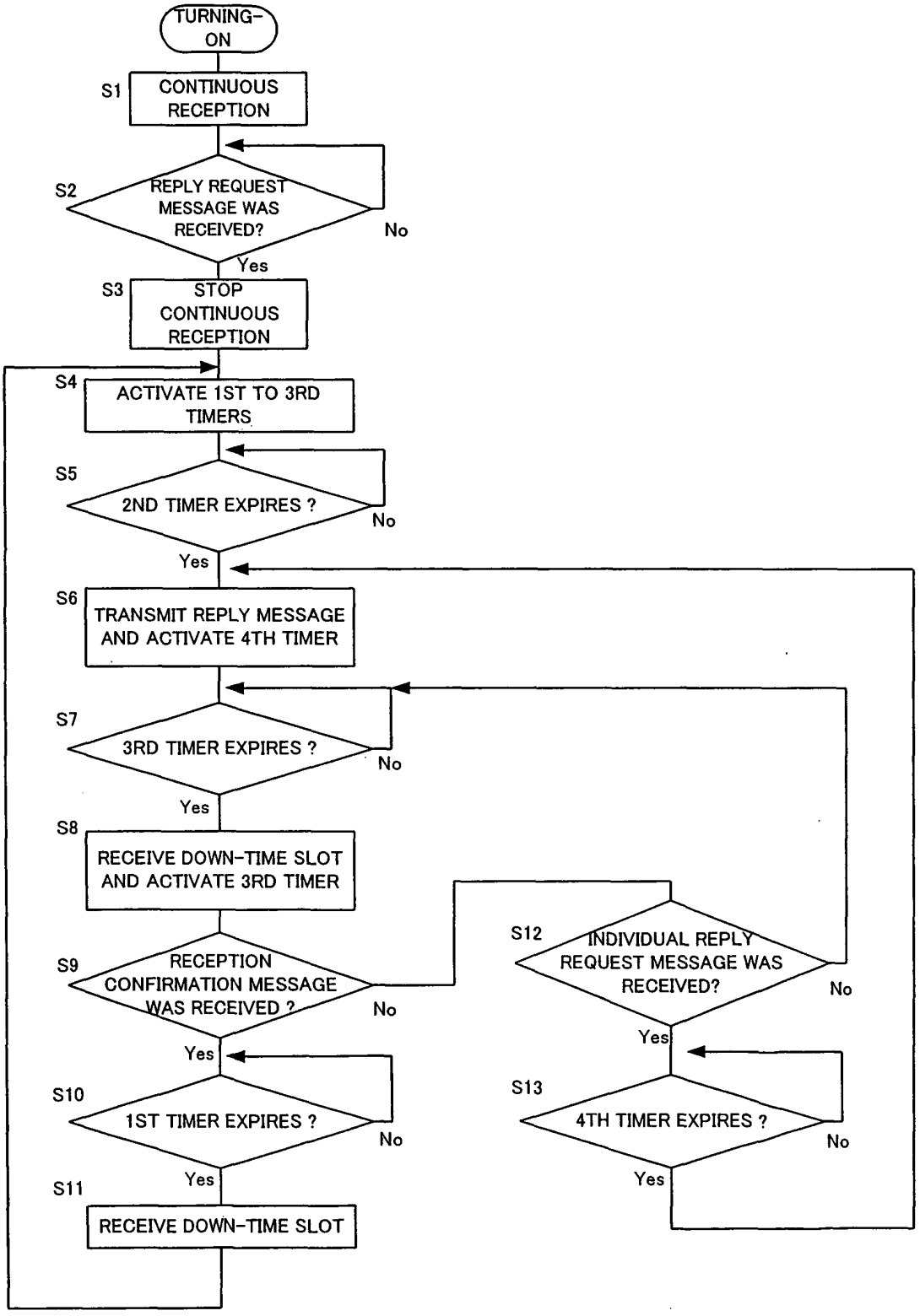

TURNING-ON
S1
CONTINUOUS RECEPTION
S2
REPLY REQUEST MESSAGE WAS RECEIVED?
No
Yes
S3
STOP CONTINUOUS RECEPTION
S4
ACTIVATE 1ST TO 3RD TIMERS
S5
2ND TIMER EXPIRES ?
No
Yes
S6
TRANSMIT REPLY MESSAGE AND ACTIVATE 4TH TIMER
S7
3RD TIMER EXPIRES ?
No
Yes
S8
RECEIVE DOWN-TIME SLOT AND ACTIVATE 3RD TIMER
S9
RECEPTION CONFIRMATION MESSAGE WAS RECEIVED ?
No
Yes
S10
1ST TIMER EXPIRES ?
No
Yes
S11
RECEIVE DOWN-TIME SLOT
S12
INDIVIDUAL REPLY REQUEST MESSAGE WAS RECEIVED?
No
Yes
S13
4TH TIMER EXPIRES ?
No
Yes

FIG. 7

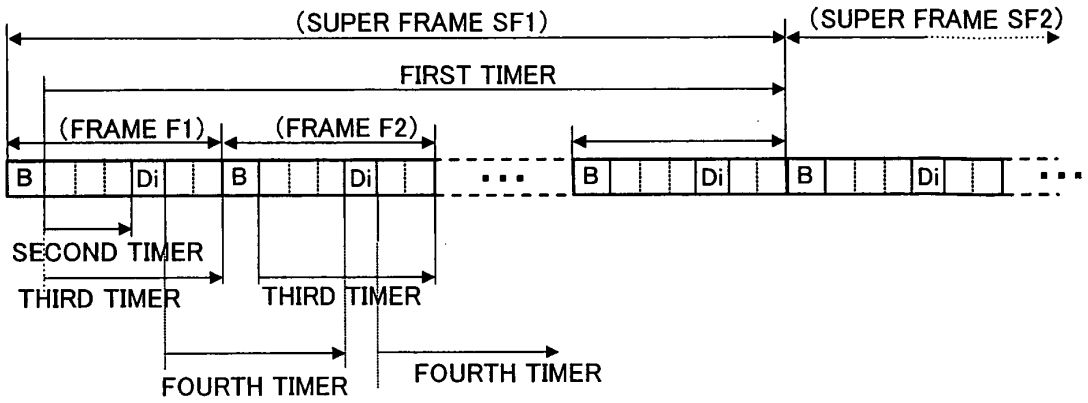

(SUPER FRAME SF1)
(SUPER FRAME SF2)
FIRST TIMER
(FRAME F1)
(FRAME F2)
B
Di
SECOND TIMER
THIRD TIMER
THIRD TIMER
FOURTH TIMER
FOURTH TIMER

FIG. 8

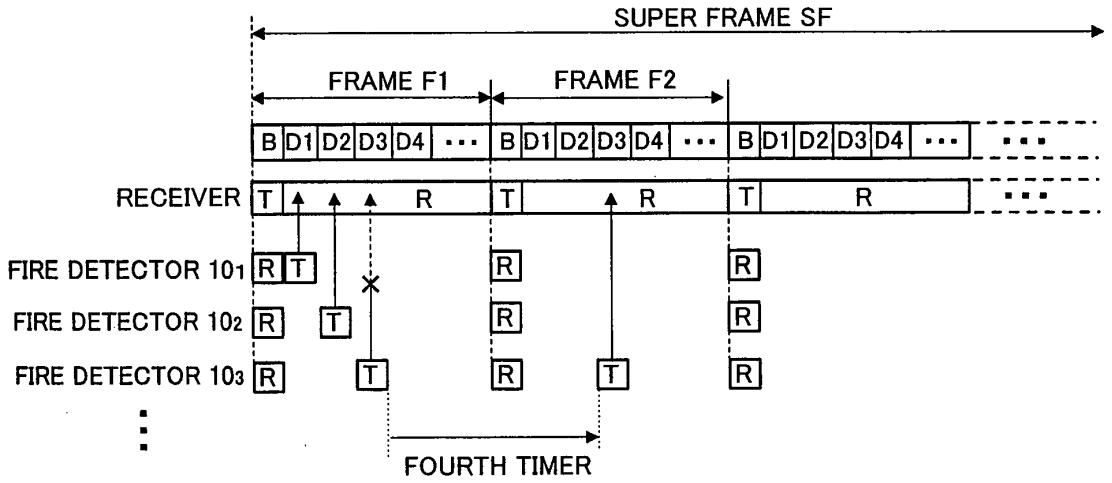

SUPER FRAME SF
FRAME F1
FRAME F2
B D1 D2 D3 D4
RECEIVER
T
R
FIRE DETECTOR 10₁
FIRE DETECTOR 10₂
FIRE DETECTOR 10₃
FOURTH TIMER

FIG. 9

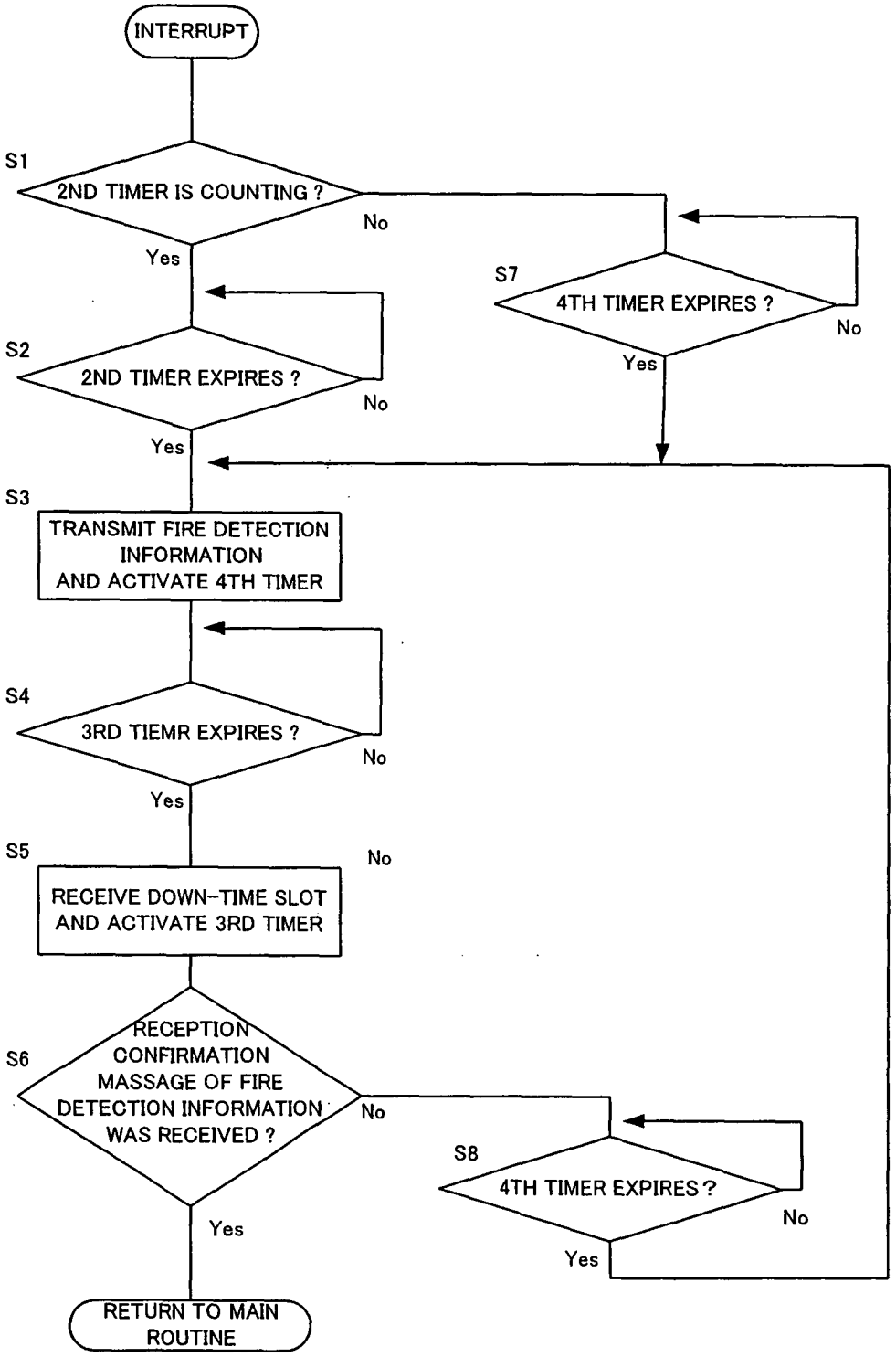

INTERRUPT
S1
2ND TIMER IS COUNTING ?
No
Yes
S2
2ND TIMER EXPIRES ?
No
Yes
S7
4TH TIMER EXPIRES ?
No
Yes
S3
TRANSMIT FIRE DETECTION INFORMATION AND ACTIVATE 4TH TIMER
S4
3RD TIEMR EXPIRES ?
No
Yes
S5
No
RECEIVE DOWN-TIME SLOT AND ACTIVATE 3RD TIMER
S6
RECEPTION CONFIRMATION MASSAGE OF FIRE DETECTION INFORMATION WAS RECEIVED ?
No
Yes
S8
4TH TIMER EXPIRES ?
No
Yes
RETURN TO MAIN ROUTINE

FIG. 10

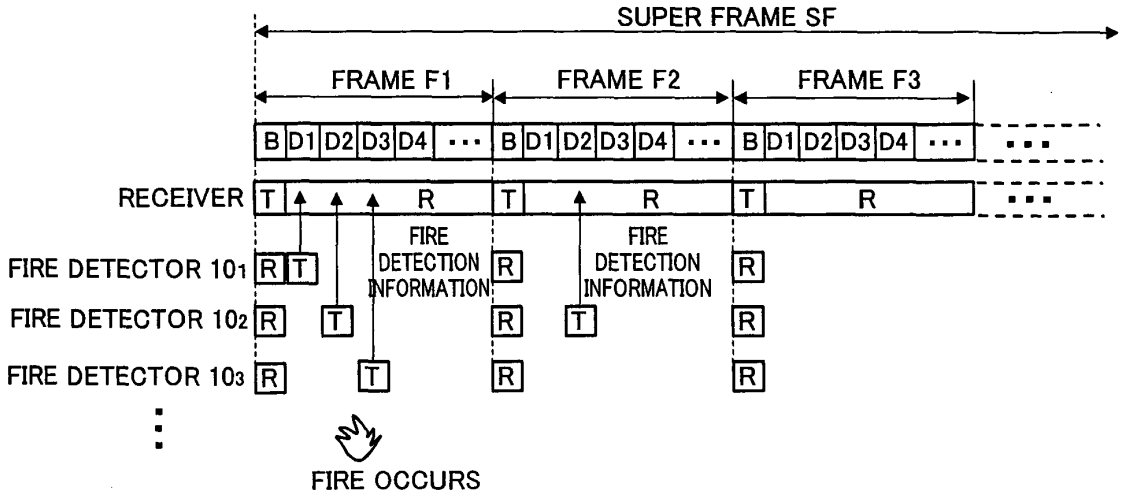

SUPER FRAME SF
FRAME F1
FRAME F2
FRAME F3
B D1 D2 D3 D4 ···
RECEIVER
T R
FIRE DETECTION INFORMATION
FIRE DETECTOR 10₁
FIRE DETECTOR 10₂
FIRE DETECTOR 10₃
FIRE OCCURS

FIG. 11

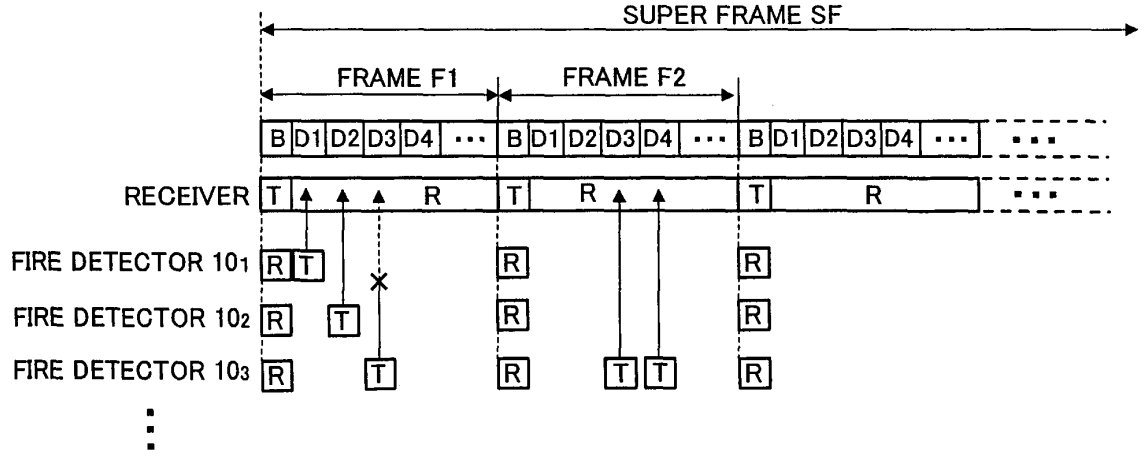

SUPER FRAME SF
FRAME F1
FRAME F2
B D1 D2 D3 D4 ···
RECEIVER
T R
FIRE DETECTOR 10₁
FIRE DETECTOR 10₂
FIRE DETECTOR 10₃

FIG. 12

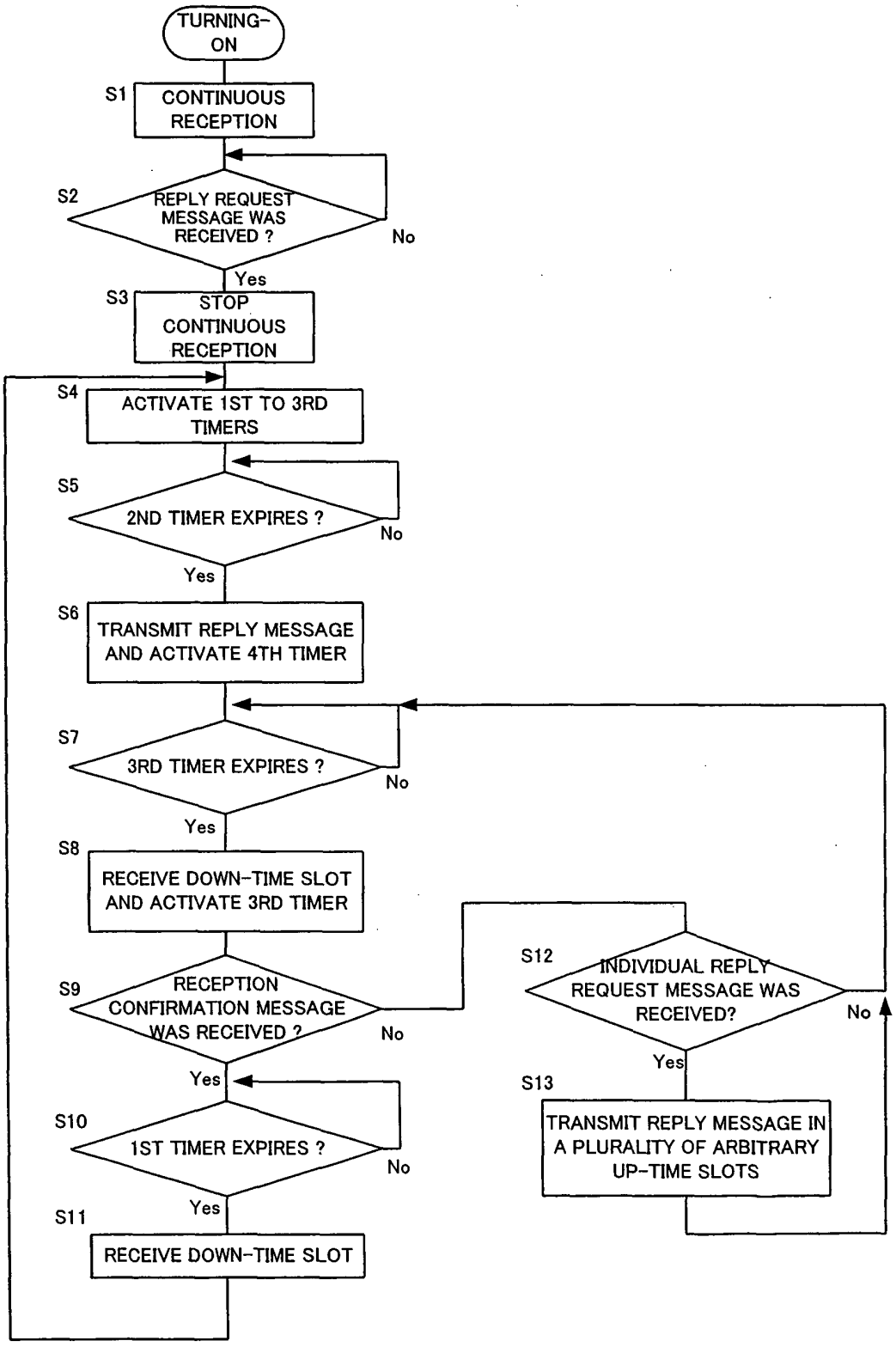

TURNING-ON
S1
CONTINUOUS RECEPTION
S2
REPLY REQUEST MESSAGE WAS RECEIVED ?
No
Yes
S3
STOP CONTINUOUS RECEPTION
S4
ACTIVATE 1ST TO 3RD TIMERS
S5
2ND TIMER EXPIRES ?
No
Yes
S6
TRANSMIT REPLY MESSAGE AND ACTIVATE 4TH TIMER
S7
3RD TIMER EXPIRES ?
No
Yes
S8
RECEIVE DOWN-TIME SLOT AND ACTIVATE 3RD TIMER
S9
RECEPTION CONFIRMATION MESSAGE WAS RECEIVED ?
No
Yes
S10
1ST TIMER EXPIRES ?
No
Yes
S11
RECEIVE DOWN-TIME SLOT
S12
INDIVIDUAL REPLY REQUEST MESSAGE WAS RECEIVED?
No
Yes
S13
TRANSMIT REPLY MESSAGE IN A PLURALITY OF ARBITRARY UP-TIME SLOTS

FIG. 13

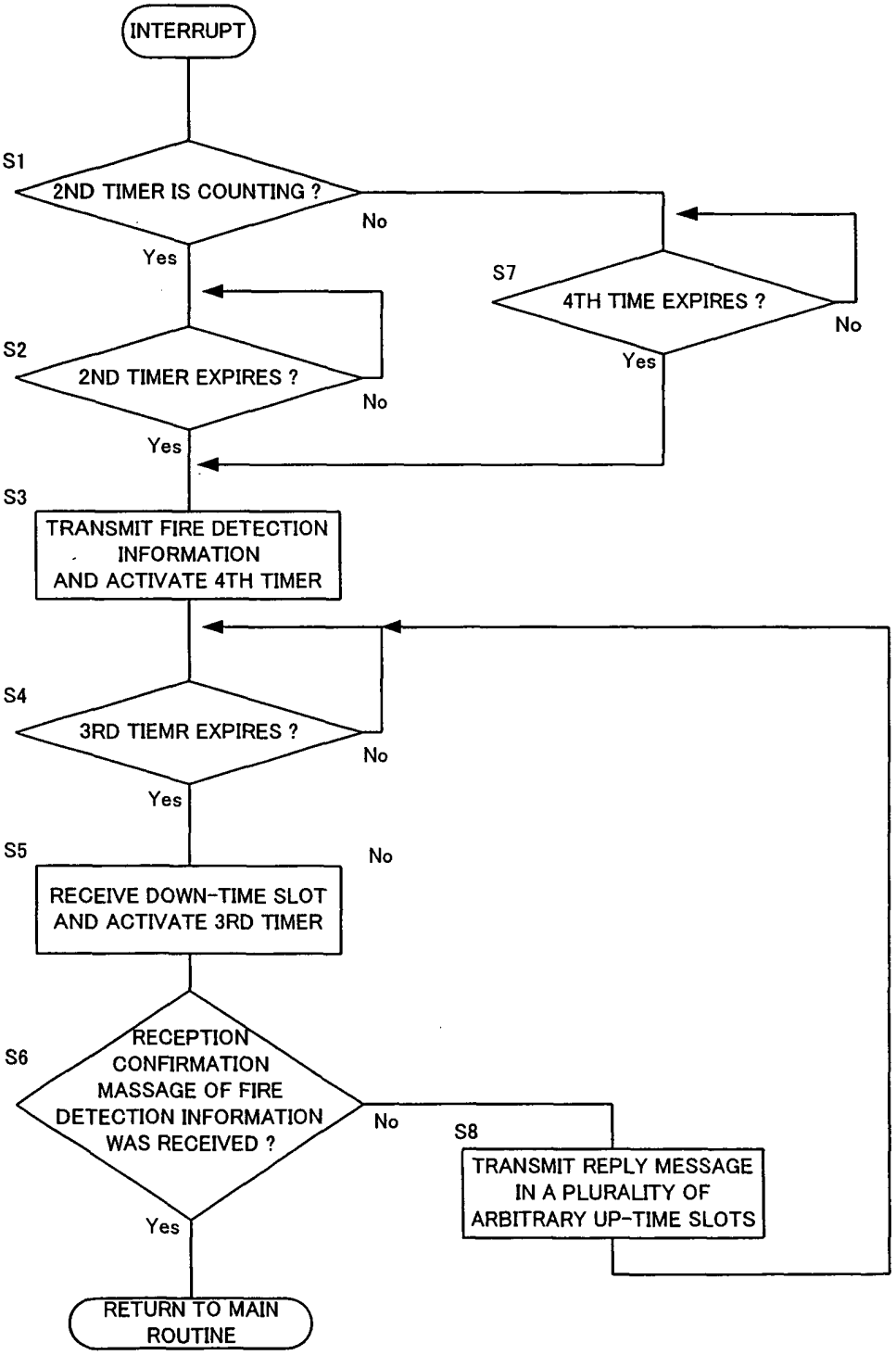

INTERRUPT
S1
2ND TIMER IS COUNTING ?
No
Yes
S7
4TH TIME EXPIRES ?
No
Yes
S2
2ND TIMER EXPIRES ?
No
Yes
S3
TRANSMIT FIRE DETECTION INFORMATION AND ACTIVATE 4TH TIMER
S4
3RD TIEMR EXPIRES ?
No
Yes
S5
No
RECEIVE DOWN-TIME SLOT AND ACTIVATE 3RD TIMER
S6
RECEPTION CONFIRMATION MASSAGE OF FIRE DETECTION INFORMATION WAS RECEIVED ?
No
S8
TRANSMIT REPLY MESSAGE IN A PLURALITY OF ARBITRARY UP-TIME SLOTS
Yes
RETURN TO MAIN ROUTINE

FIG. 14

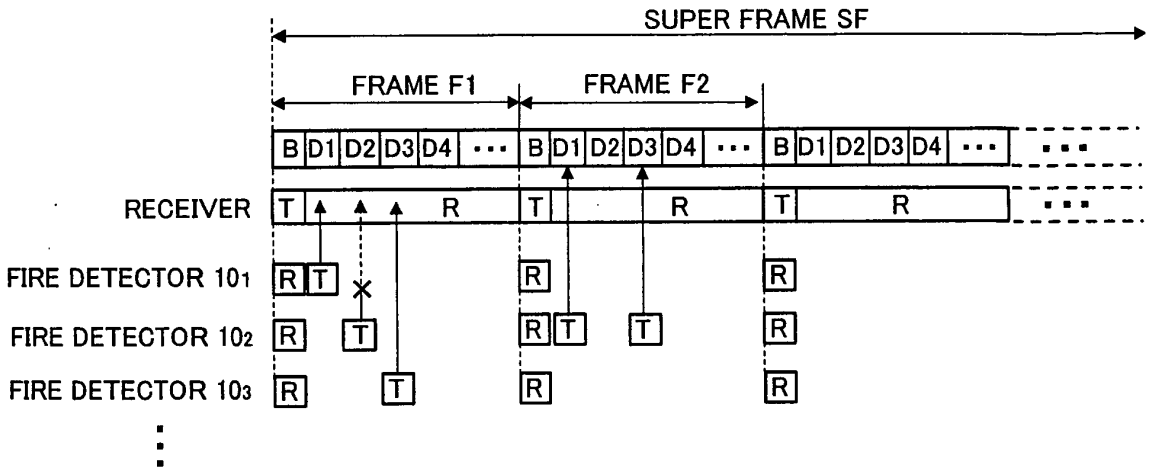
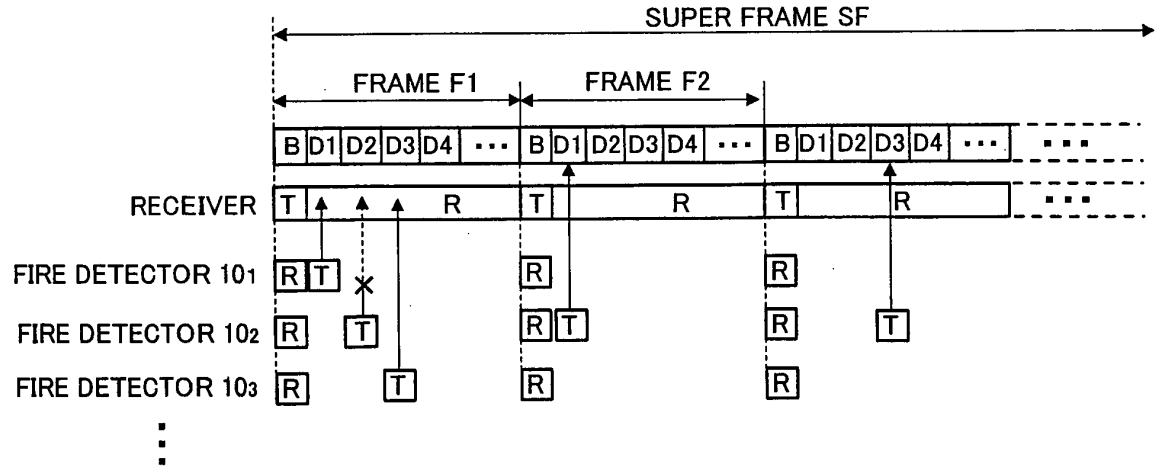

SUPER FRAME SF
FRAME F1
FRAME F2
B D1 D2 D3 D4 ··· B D1 D2 D3 D4 ··· B D1 D2 D3 D4 ···
RECEIVER
T R T R T R
FIRE DETECTOR 10₁
FIRE DETECTOR 10₂
FIRE DETECTOR 10₃

FIG. 15


SUPER FRAME SF
FRAME F1
FRAME F2
B D1 D2 D3 D4 ··· B D1 D2 D3 D4 ··· B D1 D2 D3 D4 ···
RECEIVER
T R T R T R
FIRE DETECTOR 10₁
FIRE DETECTOR 10₂
FIRE DETECTOR 10₃

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2005/016505

A. CLASSIFICATION OF SUBJECT MATTER
G08B25/10(2006.01), ***G08B17/06***(2006.01)

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

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 1996-2005
Kokai Jitsuyo Shinan Koho 1971-2005 Toroku Jitsuyo Shinan Koho 1994-2005

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.
Y	JP 11-259771 A (Atsumi Denki Kabushiki Kaisha), 24 September, 1999 (24.09.99), Par. Nos. [0003] to [0006]; Fig. 10 (Family: none)	1-4,10-13
Y	JP 2005-085131 A (Toshiba Corp.), 31 March, 2005 (31.03.05), Par. Nos. [0023], [0024]; Fig. 11 (Family: none)	1-4,10-13
Y	JP 09-261374 A (Matsushita Electric Works, Ltd.), 03 October, 1997 (03.10.97), Par. Nos. [0035] to [0038]; Fig. 4 (Family: none)	4

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

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Date of the actual completion of the international search	Date of mailing of the international search report
06 October, 2005 (06.10.05)	25 October, 2005 (25.10.05)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2005/016505

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 11-234299 A (Victor Company Of Japan, Ltd.), 27 August, 1999 (27.08.99), Full text; Figs. 5, 6 (Family: none)	1-14
A	JP 2002-544635 A (Honeywell Inc.), 24 December, 2002 (24.12.02), Full text; all drawings & US 006901066 B & EP 001177541 A & WO 00-070572 A & AU 004849300 A & CA 002373254 A	1-14

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Patent documents cited in the description

- JP 3029716 B **[0002]**