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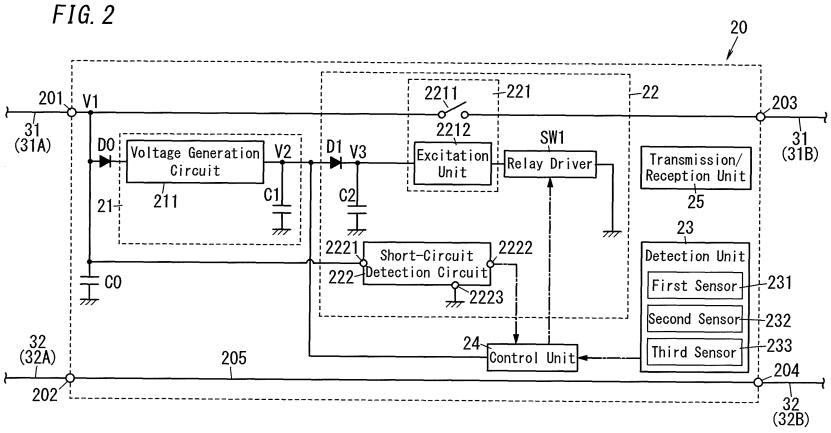
(54) DETECTOR, ISOLATOR, WARNING SYSTEM AND CONTROL METHOD

(57) Providing a detector, an isolator, an alarm system, and a control method capable of operating with a capacitor having comparatively small capacitance. A detector (20) includes a short-circuit detection circuit (222), a relay (221), and a control unit (24). The relay (221) is disposed in an electric wire (31 or 32). The control unit (24) operates with the electric energy stored in a capacitive device. The control unit (24) is configured to repeat a steady-state operation for detecting an occurrence of a specified event, and further configured to open the contact device (2211) of the relay (221) in response to a detection of the occurrence of the short circuit by the short-circuit detection circuit (222). The relay (221) operates with the electric energy stored in the capacitive device to consume the electric energy while the short circuit occurs between the electric wires (31, 32). The control unit (24) is configured to, when the short-circuit detection circuit (222) detects the occurrence of the short circuit, open the contact device (2211) of the relay (221) prior to a first steady-state operation which is a first one of the steady-state operation after a detection of the occurrence of the short circuit.

FIG. 2



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Description

Technical Field

[0001] The present disclosure relates to a detector, an isolator, an alarm system and a control method.

Background Art

[0002] It has been known an alarm system in which two or more detector lines are connected to a master device and an isolator and multiple detectors are provided in each of the detector lines (see, for example, Patent Literature 1).

[0003] The alarm system of Patent Literature 1 is configured such that, when a short circuit occurs in any one of the detector lines, all of the isolators operates their own switching circuits (relays) to break corresponding detector lines, respectively. Each isolator includes a power supply circuit having a capacitor (capacitive device) and the like, and thus can operate its own switching circuit in a short time even when supply power is cut due to a short circuit occurred in a corresponding detector line for example.

[0004] Incidentally, assuming that an isolator is provided in a detector, another elements (such as a control unit for detecting fire) other than the isolator of the detector also should be powered. Thus, the power supply circuit of the detector is required to include a capacitor (capacitive device) having comparatively large capacity in order to ensure an operation voltage of a relay of the isolator.

Citation List

Patent Literature

[0005] Patent Literature 1: JPH9-62975A

Summary of Invention

[0006] The present disclosure is achieved in view of the foregoing grounds, and is aimed to provide a detector capable of operating an isolator with a capacitive device having a comparatively small capacity, the isolator equipped in the detector, and an alarm system including the detector.

[0007] An detector according to an aspect of the disclosure includes first to fourth terminals, a relay, a connection part, a voltage generation circuit, a capacitive device, a short-circuit detection circuit, and a control unit. The first terminal and the second terminal are configured to be electrically connected to a pair of first electric wires to receive an application voltage applied between the pair of first electric wires. The third terminal and the fourth terminal are configured to be electrically connected to a pair of second electric wires. The relay includes a contact device electrically connected between the first terminal and the third terminal and is configured to open and close an electric circuit between the first terminal and the third terminal. The connection part electrically interconnects the second terminal and the fourth terminal. The voltage generation circuit is configured to generate an operation voltage from the application voltage. The capacitive device is electrically connected to the voltage generation circuit and configured to be charged by the operation voltage. The short-circuit detection circuit is configured to detect an occurrence of short circuit between the pair of second electric wires. The control unit operates with electric energy stored in the capacitive device. The control unit is configured to repeat a steady-state operation for detecting an occurrence of a specified event, and further configured to open the contact device of the relay in response to a detection of the occurrence of the short circuit by the short-circuit detection circuit. The relay operates with the electric energy stored in the capacitive device to consume the electric energy while the short circuit occurs. The control unit is configured to, when the short-circuit detection circuit detects the occurrence of the short circuit, open the contact device of the relay prior to a first steady-state operation which is a first one of the steady-state operation after a detection of the occurrence of the short circuit.

[0008] An isolator according to an aspect of the present disclosure is configured to be equipped in the detector. The isolator includes at least the relay and the short-circuit detection circuit.

[0009] An alarm system according to an aspect of the present disclosure includes a plurality of the detectors and a master device. The plurality of detectors are electrically connected in series such that third and fourth terminals of one of adjacent two detectors of the plurality of detectors are connected to a pair of second electric wires to be connected to a pair of first electric wires connected to first and second terminals of another one of the adjacent two detectors. The master device includes an application unit. The application unit is electrically connected to a pair of first electric wires electrically connected to first and second terminals of a detector located at a first end of the plurality of detectors connected in series. The application unit is configured to apply the application voltage between the pair of first electric wires.

[0010] A control method according to an aspect of the present disclosure is for controlling a contact device of a detector according to an occurrence of a specified event. The detector includes a first terminal, a second terminal, a third terminal, a fourth terminal, a relay including the contact device, a connection part, a voltage generation circuit, a capacitive device, and a short-circuit detection circuit. The first terminal and the second terminal are configured to be electrically connected to a pair of first electric wires to receive an application voltage applied between the pair of first electric wires. The third terminal and the fourth terminal are configured to be electrically connected to a pair of second electric wires. The contact device of the relay is electrically connected between the first terminal and the third terminal. The relay is configured to

open and close an electric circuit between the first terminal and the third terminal. The relay operates with electric energy stored in the capacitive device to consume the electric energy, while the short circuit occurs. The connection part electrically interconnects the second terminal and the fourth terminal. The voltage generation circuit is configured to generate an operation voltage from the application voltage. The capacitive device is electrically connected to the voltage generation circuit and is configured to be charged by the operation voltage. The short-circuit detection circuit is configured to detect an occurrence of short circuit between the pair of second electric wires. The control method includes: receiving power from the electric energy stored in the capacitive device; repeating a steady-state operation for detecting an occurrence of the specified event with the power received from the electric energy; and in response to a detection of the occurrence of the short circuit by the short-circuit detection circuit, opening, with the power received from the electric energy, the contact device of the relay prior to a first steady-state operation which is a first one of the steady-state operation after a detection of the occurrence of the short circuit.

Brief Description of Drawings

[0011]

Fig. 1 is a block diagram illustrating an alarm system according to an embodiment of the disclosure.

Fig. 2 is a block diagram illustrating a detector employed for the alarm system.

Fig. 3 is a circuit diagram illustrating a first specific example of a short-circuit detection circuit for the detector.

Fig. 4 is a circuit diagram illustrating a second specific example of a short-circuit detection circuit for the detector.

Fig. 5 is a waveform diagram illustrating an operation of the detector.

Fig. 6 is a flowchart diagram illustrating the operation of the detector.

Description of Embodiments

(1) Embodiment

[0012] An alarm system 100, a detector 20, and an isolator 22 according to the present embodiment will be described with reference to Fig. 1 to Fig. 6. The detector 20 of the embodiment is a detector for detecting an occurrence of a specified event, and more particularly a detector for detecting the outbreak of fire.

[0013] As shown in Fig. 1, the alarm system 100 according to the present embodiment includes one master device 10, and a plurality of (three, in the illustrated example) detectors 20 (20A, 20B, 20C).

[0014] The alarm system 100 of the present embodiment has a basic configuration same as that of a general automatic fire alarm system. According to the alarm system 100, when any of the detectors 20 detects the outbreak of fire, this detector 20 notifies the master device 10 of the outbreak of fire (fire notification). That is, the master device 10 serves as an alarm control unit configured to receive warning information (fire notification) from the detectors 20. When receiving the fire notification from any of the detectors 20, the master device 10 operates notification appliances (sounds alarm) to warn the outbreak of fire, for example.

[0015] As shown in Fig. 1, each of the plurality of detectors 20 includes a first terminal 201 to a fourth terminal 204, a relay 221, and a connection part 205. The relay 221 is electrically connected between the first terminal 201 and the third terminal 203, and is configured to open and close (make and break) an electric circuit between the first terminal 201 and the third terminal 203. The connection part 205 interconnects the second terminal 202 and the fourth terminal 204 directly. The connection part 205 is an electric wire, for example.

[0016] The plurality of detectors 20 are electrically connected in series via electric wires 31 and 32 (a high potential side electric wire 31 and a low potential side electric wire 32). The high potential side electric wire 31 includes electric wires 311, 312, 313, and 314. The low potential side electric wire 32 includes electric wires 321, 322, 323 and 324. The detector 20A has its first and second terminals 201 and 202 electrically connected to the master device 10 via the electric wires 311 and 321, respectively. The detector 20B has its first and second terminals 201 and 202 electrically connected to third and fourth terminals 203 and 204 of the detector 20A via the electric wires 312 and 322, respectively. The detector 20C has its first and second terminals 201 and 202 electrically connected to third and fourth terminals 203 and 204 of the detector 20B via the electric wires 313 and 323, respectively. The detector 20C has its third and fourth terminals 203 and 204 electrically connected to the electric wires 311 and 314 via the electric wires 314 and 324, respectively. The low potential side electric wire 32 is electrically connected to the ground (circuit ground) serving as a reference potential of the alarm system 100.

[0017] The master device 10 includes an application unit 11 configured to apply a voltage Vi between the electric wires 31(311) and 32(321). The voltage Vi applied by the application unit 11 between the electric wires 31 and 32 may be, although not limiting, DC 24V for example.

[0018] The master device 10 may use, as its main power supply, a utility power supply, a non-utility generation facility, or the like. The master device 10 is configured to apply the voltage Vi between the electric wires 31 and

32 to serve as a power source for powering the entire alarm system 100 including the detectors 20 connected to the master device 10 via the electric wires 31, 32.

[0019] The detector 20 can transmit a fire notification to the master device 10 with any method, which is not particularly limited. The detector 20 may be configured to vary the voltage between the electric wires 31 and 32 by pulling in a current flowing through the electric wire 31, 32 to transmit the fire notification to the master device 10. Alternatively or additionally, the detector 20 may be configured to transmit the fire notification with a wireless signal.

[0020] As shown in FIG. 2, each of the detectors 20 further includes a capacitor C0, a diode D0, a power supply circuit 21, the isolator 22, a detection unit 23, a control unit 24, and a transmission/reception unit 25.

[0021] The first and second terminals 201 and 202 are electrically connected to a pair of first electric wires 31A and 32A (a first high potential side electric wire 31A and a first low potential side electric wire 32A), respectively. The first and second terminals 201 and 202 receive an application voltage (the voltage Vi from the application unit 11) between the pair of first electric wires 31A and 32A. The third and fourth terminals 203 and 204 are electrically connected to a pair of second electric wires 31B and 32B (a second high potential side electric wire 31B and a second low potential side electric wire 32B), respectively.

[0022] The capacitor C0 is electrically connected between the first terminal 201 and the ground (the second terminal 202). The capacitor C0 is configured to be charged by the application voltage between the first and second terminals 201 and 202. Hereinafter, the electric potential of the first terminal 201 with reference to the ground (the second terminal 202) (namely, the voltage across the capacitor C0) is referred to as a "first voltage V1".

[0023] The diode D0 is electrically connected between the first terminal 201 and the power supply circuit 21. The diode D0 is configured to prevent a current from flowing in a reverse direction. The diode D0 has an anode electrically connected to the first terminal 201 and a cathode electrically connected to an input terminal of the power supply circuit 21.

[0024] As shown in FIG. 2, the power supply circuit 21 includes a voltage generation circuit 211 and a capacitor C1. The capacitor C1 serves as a first capacitive device. The first capacitive device is not limited to a capacitor, but may be another capacitive device such as an inductor.

[0025] The voltage generation circuit 211 includes a constant voltage circuit in the present embodiment, and may include a three-terminal regulator for example. The voltage generation circuit 211 has an input terminal (the input terminal of the power supply circuit 21) electrically connected to the cathode of the diode D0. The voltage generation circuit 211 is configured to convert the application voltage between the first terminal 201 and the second terminal 202 (the ground) into an operation voltage of a DC voltage.

[0026] The capacitor C1 is electrically connected between an output terminal of the voltage generation circuit 211 and the ground. The capacitor C1 is charged by the operation voltage output from the voltage generation circuit 211. A voltage across the capacitor C1 serves as an output voltage of the power supply circuit 21. Hereinafter, the electric potential of the output terminal of the voltage generation circuit 211 with reference to the ground (namely, the voltage across the capacitor C1) is referred to as a "second voltage V2".

[0027] As shown in FIG. 2, the isolator 22 includes a diode D1, a capacitor C2, the relay 221, a relay driver SW1, and a short-circuit detection circuit 222. The capacitor C2 serves as a second capacitive device. The first capacitive device is not limited to a capacitor, but may be another capacitive device such as an inductor.

[0028] A series circuit of the diode D1 and the capacitor C2 is connected between the output terminal of the voltage generation circuit 211 and the ground. The diode D1 is configured to prevent a current from flowing in a reverse direction. The diode D1 has an anode electrically connected to the output terminal of the voltage generation circuit 211 and a cathode electrically connected to an input terminal of the relay 221 (specifically, an input terminal of an excitation unit 2212 described later). The capacitor C2 is electrically connected between: a connection point of the cathode of the diode D1 and the input terminal of the excitation unit 2212; and the ground. The capacitor C2 is configured to be charged by the electric energy stored in the capacitor C1.

[0029] The relay 221 includes a double coil latching relay including a set coil and a reset coil, for example. The relay 221 includes a contact device 2211 and the excitation unit 2212. The contact device 2211 is electrically connected between the first terminal 201 and the third terminal 203, and is configured to open and close the electric circuit between the first terminal 201 and the third terminal 203. The excitation unit 2212 is configured to switch a state of the contact device 2211 between an opened state and a closed state in response to a current supplied from an outside. The input terminal of the excitation unit 2212 is electrically connected to a connection point of the cathode of the diode D1 and the capacitor C2. Hereinafter, the electric potential of the input terminal of the excitation unit 2212 with reference to the ground (namely, the voltage across the capacitor C2) is referred to as a "third voltage V3".

[0030] The relay driver SW1 is electrically connected between the excitation unit 2212 and the ground. For example, the relay driver SW1 includes a set switch and a reset switch. A series circuit of the set coil and the set switch is electrically connected between: a connection point of the cathode of the diode D1 and the capacitor C2; and the ground. A series circuit of the reset coil and the reset switch is electrically connected between: the connection point of the cathode of the diode D1 and the

capacitor C2; and the ground. The set switch and the reset switch each are configured to be switched between an ON state and an OFF state under the control of the control unit 24.

[0031] In the present embodiment, when the control unit 24 drives the relay driver SW1 to cause a current to flow from a circuit including the capacitors C1 and C2 to the set coil, the set coil generates an electromagnetic field to make the contact device 2211 be closed. Even when the current is interrupted from flowing through the set coil while the contact device 2211 is closed, the contact device 2211 is kept closed. When the control unit 24 drives the relay driver SW1 to cause a current to flow from the circuit including the capacitors C1 and C2 to the reset coil, the reset coil generates an electromagnetic field to make the contact device 2211 be opened. Even when the current is interrupted from flowing through the reset coil while the contact device 2211 is opened, the contact device 2211 is kept opened.

[0032] The isolator 22 is configured such that, when the relay driver SW1 operates under the control of the control unit 24, the contact device 2211 of the relay 221 is closed in response to a current flowing through the set coil, derived from the electric energy stored in the capacitor C2. Also, the isolator 22 is configured such that, when the relay driver SW1 operates under the control of the control unit 24, the contact device 2211 of the relay 221 is opened in response to a current flowing through the reset coil, derived from the electric energy stored in the capacitor C2. That is, the relay 221 is configured to operate with the electric energy stored in the capacitor C2 to consume the electric energy.

[0033] As described above, the capacitor C2 is charged by the electric energy stored in the capacitor C1. Therefore, the relay 221 operates with the electric energy stored in the capacitors C1 and C2 to consume the electric energy.

[0034] The short-circuit detection circuit 222 is electrically connected between the first terminal 201 and the ground (the second terminal 202). That is, the short-circuit detection circuit 222 is electrically connected across the capacitor C0. The short-circuit detection circuit 222 is configured to compare the voltage across the capacitor C0 (i.e., the first voltage VI) with a predetermined threshold voltage Vth to detect an occurrence of short circuit between the electric wires 31 and 32. The short-circuit detection circuit 222 is configured to, when detecting that the voltage across the capacitor C0 is smaller than the threshold voltage (i.e., when detecting the occurrence of the short circuit), transmit, to the control unit 24, a signal indicative of the occurrence of the short circuit. Note that the voltage between the pair of first electric wires 31A and 32A and the voltage between the pair of second electric wires 31B and 32B should be equal to each other while the contact device 2211 of the relay 221 is closed (i.e., in the ON state). Therefore, the short-circuit detection circuit 222 is configured to further detect the occurrence of the short circuit between the pair of second electric wires 31B and 32B in addition to detecting the short circuit between the pair of first electric wires 31A and 32A.

[0035] The short-circuit detection circuit 222 has an input terminal 2221, an output terminal 2222, and an earth terminal 2223. The input terminal 2221 is electrically connected to the first terminal 201. The earth terminal 2223 is electrically connected to the second terminal 202 (the ground).

[0036] FIG. 3 illustrates a first specific example of the short-circuit detection circuit 222.

[0037] The short-circuit detection circuit 222 of the first specific example includes resistors R11, R12 and R13, a transistor TR1, a constant voltage source VS1, and a voltage monitoring circuit (reset IC) RC1. A series circuit of the resistors R11 and R12 (voltage divider circuit) is electrically connected between the input terminal 2221 and the earth terminal 2223 of the short-circuit detection circuit 222. The transistor TR1 has a base electrically connected to a connection point of the resistors R11 and R12. The transistor TR1 has a collector electrically connected to the constant voltage source VS1, and an emitter electrically connected to the earth terminal 2223 via the resistor R13. The emitter of the transistor TR1 is electrically connected to an input terminal of the voltage monitoring circuit RC1. The voltage monitoring circuit RC1 has an output terminal electrically connected to the output terminal 2222 of the short-circuit detection circuit 222.

[0038] While the voltage across the capacitor C0 is equal to or larger than the threshold voltage Vth, the transistor TR1 is in the ON state to allow a voltage across the resistor R13 to be applied to the input terminal of the voltage monitoring circuit RC1 (an input voltage of the input terminal of the voltage monitoring circuit RC1 is in a high level). The voltage monitoring circuit RC1 keeps a voltage level of the output terminal at a low level, and the short-circuit detection circuit 222 outputs a signal of a low level from the output terminal 2222. When a short circuit occurs between the electric wires 31 and 32, the voltage across the capacitor C0 decreases to cause the transistor TR1 to be turned off, and as a result the input voltage of the input terminal of the voltage monitoring circuit RC1 is turned to a low level. As a result, the voltage monitoring circuit RC1 turns the voltage level of the output terminal to be a high level, and the short-circuit detection circuit 222 outputs a signal of a high level from the output terminal 2222. The control unit 24 is configured to determine that a short circuit occurs between the electric wires 31 and 32 when receiving a signal of a high level from the short-circuit detection circuit 222.

[0039] Note that the voltage monitoring circuit RC1 is an optional device and can be omitted. Alternatively, the emitter of the transistor TR1 may be electrically connected directly to the output terminal 2222 of the short-circuit detection circuit 222. In this case, the voltage across the resistor R13 is applied to the output terminal 2222. In this case, the control unit 24 may be configured to determine that a short circuit occurs between the electric wires 31 and 32 when receiving a signal of a low level from the

short-circuit detection circuit 222.

[0040] FIG. 4 illustrates a second specific example of the short-circuit detection circuit 222.

[0041] The short-circuit detection circuit 222 of the second specific example includes resistors R21, R22, R23, R24 and R25, a capacitor C10, an operational amplifier OP1, and a constant voltage source VS2. A series circuit of the resistors R21 and R22 (voltage divider circuit) is electrically connected between the input terminal 2221 and the earth terminal 2223 of the short-circuit detection circuit 222. The capacitor C10 is electrically connected across the resistor R22. The operational amplifier OP1 has an inverting input terminal connected to a connection point of the resistors R21 and R22. The operational amplifier OP1 has a non-inverting input terminal electrically connected to the constant voltage source VS2 via the resistor R25. The non-inverting input terminal of the operational amplifier OP1 is electrically connected to the earth terminal 2223 via a series circuit of the resistors R23 and R24. The operational amplifier OP1 has an output terminal electrically connected to the output terminal 2222 of the short-circuit detection circuit 222.

[0042] While the voltage across the capacitor C0 is equal to or larger than the threshold voltage Vth, the inverting input terminal of the operational amplifier OP1 has an voltage level of an input voltage higher than a voltage level of an input voltage of the non-inverting input terminal. This causes the voltage of the output terminal of the operational amplifier to have a voltage level of a low level, so that the short-circuit detection circuit 222 outputs a signal of a low level from the output terminal 2222. When a short circuit occurs between the electric wires 31 and 32, the voltage across the capacitor C0 decreases to make the voltage level of the inverting input terminal of the operational amplifier OP1 be lower than the voltage level of the non-inverting input terminal. This causes the voltage level of the output terminal of the operational amplifier OP1 to be a high level, so that the short-circuit detection circuit 222 outputs a signal of a high level from the output terminal 2222. The control unit 24 determines that a short circuit occurs between the electric wires 31 and 32 when receiving a signal of a high level from the short-circuit detection circuit 222.

[0043] As shown in FIG. 4, a capacitor C20 may be connected to the output terminal 2222 of the short-circuit detection circuit 222 in order to cut a noise and to prevent an erroneous operation.

[0044] The short-circuit detection circuit 222 is not limited to have the above circuit configurations. The short-circuit detection circuit 222 is not particularly limited as long as it can transmit a signal indicative of the occurrence of the short circuit when the input voltage of the input terminal 2221 (the voltage across the capacitor C0) becomes smaller than the threshold voltage Vth.

[0045] As shown in FIG. 2, the detection unit 23 includes at least one sensor. In the present embodiment, the detection unit 23 includes a first sensor 231, a second sensor 232, and a third sensor 233. Each of the first sensor 231 to the third sensor 233 is configured to sense a sensing target.

[0046] The first sensor 231 may be a temperature sensor. That is, the sensing target of the first sensor 231 is a temperature. The first sensor 231 includes a thermistor, for example. The first sensor 231 is configured to send data about a measured ambient temperature when receiving an instruction from the control unit 24.

[0047] The second sensor 232 may be a smoke sensor. That is, the sensing target of the second sensor 232 is concentration of the smoke in the air. The second sensor 232 may include a light emitting device such as an LED, and a light receiving device such as a photo diode, for example. The light emitting device and the light receiving device are positioned such that a light receiving surface of the light receiving device is off an optical axis of the light emitting device. Provided that no smoke exist in a space in which the second sensor 232 is placed, little or no light beam emitted from the light emitting device reaches the light receiving surface of the light receiving device. When the smoke enters the space in which the second sensor 232 is placed, the light beam emitted from the light emitting device is scattered by particles of the smoke and the scattered light partially reaches the light receiving device. The second sensor 232 is configured to send data about the amount of the light received with the light receiving device when receiving an instruction from the control unit 24.

[0048] The third sensor 233 may be a carbon monoxide sensor. That is, the sensing target of the third sensor 233 is concentration of the carbon monoxide in the air. The third sensor 233 may include an electrochemical sensor, for example. The electrochemical sensor includes a catalyst containing detection electrode, an opposed electrode facing the detection electrode, and an ion conductor between the detection electrode and the opposed electrode. This sensor is configured to facilitate the carbon monoxide reacting with the moisture in the air with the catalyst of the detection electrode to transfer the electric charge between the detection electrode and the opposed electrode. The third sensor 233 is configured to send data about the transferred amount of the electric charge between the detection electrode and the opposed electrode when receiving an instruction from the control unit 24.

[0049] The control unit 24 includes a microcomputer, and performs various functions by the microcomputer executing a computer program stored in a memory, for example. The computer program may be written in the memory in advance, may be provided by being stored on some storage medium such as a memory card, or may be downloaded through a telecommunications line such as the Internet.

[0050] The control unit 24 is connected to the capacitor C1, and is configured to operate with the electric energy stored in the capacitor C1. For example, the control unit 24 is configured to operate with the voltage across the capacitor C1. That is, the control unit 24 is powered by

the electric energy stored in the capacitor C1. The control unit 24 is configured to repeat a steady-state operation for detecting an occurrence of a specified event. The steady-state operation includes a detection operation for determining whether the specified event has occurred based on the sensing target sensed by the first sensor 231 to the third sensor 233. In the present embodiment, the specified event includes fire. That is, the control unit 24 is configured to repeat the detection operation for detecting the outbreak of fire. The control unit 24 is configured to transmit an instruction to the detection unit 23, and to determine the outbreak of fire based on the information (about temperature, amount of light, and transferred amount of electric charge) received from the detection unit 23 as a response.

[0051] The control unit 24 is configured to perform at least one of a temperature detection operation, a smoke detection operation, and a carbon monoxide detection operation during the steady-state operation. For example, the control unit 24 may be configured to perform the temperature detection operation and the smoke detection operation sequentially during the steady-state operation.

[0052] During the temperature detection operation, the control unit 24 transmits an instruction to the first sensor (temperature sensor) 231, receives data on a temperature from the first sensor 231, and compares the received temperature with predetermined threshold.

[0053] During the smoke detection operation, the control unit 24 transmits an instruction to the second sensor (smoke sensor) 232, receives data on an amount of light from the second sensor 232, and compares the received amount of light with predetermined threshold.

[0054] During the carbon monoxide detection operation, the control unit 24 transmits an instruction to the third sensor (carbon monoxide sensor) 233, receives data on an amount of transferred electric charge from the third sensor 233, and compares the received amount of transferred electric charge with predetermined threshold.

[0055] The control unit 24 is configured to determine that the fire has occurred when a quantity received from any of the first to third sensors 231 to 233 is greater than a corresponding threshold during the steady-state operation. Alternatively, the control unit 24 may be configured to determine the outbreak of fire based on a combination of quantities received from two or more sensors. The control unit 24 may be configured to compare a value (average value, median value, or the like) obtained from two or more sequential values measured by a sensor, with a corresponding threshold.

[0056] The control unit 24 is configured to, when determining that the fire has occurred, light a warning unit provided in advance (such as a light emitting diode(s)) to warn of the outbreak of fire. The control unit 24 is further configured to, when determining that the fire has occurred, provide the fire notification to the master device 10 through the transmission/reception unit 25. The transmission/reception unit 25 is not limited in its configuration, and may be configured to transmit the fire notification by changing the current flowing through the electric wires 31 and 32 or by transmitting a wireless signal.

[0057] The control unit 24 is further configured to operate the relay driver SW1 to open the contact device 2211 of the relay 221 when receiving, from the short-circuit detection circuit 222, a signal indicative of the occurrence of the short circuit. The control unit 24 is further configured to operate the relay driver SW1 to close contact device 2211 of the relay 221 when receiving, from the master device 10, an instruction instructing that the contact device 2211 be closed.

[0058] Hereafter, it is explained an operation of the alarm system 100 when the short circuit occurs between the electric wires 312 and 322 connecting between the detectors 20A and 20B, with reference to FIG. 1 and FIG. 5. FIG. 5 illustrates variations with time of the first voltage V1, the second voltage V2, and the third voltage V3 of the detector 20A.

[0059] In a normal operation while no short circuit occurs, the respective contact devices 2211 of the relays 221 of the detectors 20A, 20B, and 20C are closed, and the voltage Vi (DC 24V) is applied between the electric wires 31 and 32 from the application unit 11.

[0060] For example, when a short circuit occurs between the electric wires 312 and 322 (t0), the voltage between the electric wires 31 and 32 decreases and as a result the voltage across the capacitor C0 (the first voltage V1) of each of the detectors 20A, 20B, and 20C decreases as well. Upon detecting that the voltage across the capacitor C0 decreases to reach the threshold voltage Vth (t1), each of the detectors 20A, 20B, and 20C opens its contact device 2211 of the relay 221. In each of the detectors 20, the relay 221 operates with the electric energy stored in the capacitors C1 and C2 to consume the electric energy, so that the second voltage V2 and the third voltage V3 decreases. Then, the master device 10 detects the decreased voltage between the electric wires 31 and 32, and stops the application of the voltage Vi from the application unit 11. In each of the detectors 20, the electric energy stored in the capacitor C1 decreases due to the operation of the control unit 24, so that the second voltage V2 gradually decreases (t1~t2).

[0061] Subsequently, the master device 10 restarts the application of the voltage Vi from the application unit 11 in order to determine a place where the short circuit has occurred. As a result, the capacitors C0, C1, and C2 of the detector 20A are charged up, so that the first to third voltages V1 to V3 increase (t2). Note that, since the contact device 2211 of the relay 221 of the detector 20A is kept opened, the capacitors C0, C1, and C2 of the detectors 20B and 20C are not charged.

[0062] The master device 10 then transmits an instruction for instructing the detector 20A to close the contact device 2211 of the relay 221. In response to the instruction, the detector 20A closes the contact device 2211 of its relay 221 (t11). In this instance, the electric energy stored in the capacitors C1 and C2 are consumed due

to the operation of the relay 221, so that the second voltage V2 and the third voltage V3 decrease.

[0063] When the contact device 2211 of the relay 221 of the detector 20A is closed in this situation, the high potential side electric wire 31 and the low potential side electric wire 32 are electrically connected to each other since the short circuited has occurred between the electric wires 312 and 322, so that the voltage between the electric wires 31 and 32 decreases. The master device 10 therefore can specify that the short circuit has occurred between the electric wires 311 and 321 that connect the detector 20A and the detector 20B.

[0064] While the contact device 2211 of the relay 221 of the detector 20A is closed, the high potential side electric wire 31 and the low potential side electric wire 32 are electrically connected to each other, so that the voltage across the capacitor C0 of the detector 20A (the first voltage VI) decreases. In the detector 20A, the electric energy stored in the capacitor C1 decreases due to the operation of the control unit 24 (t11~t12).

[0065] When finding that the voltage across the capacitor C0 (the first voltage V1) decreases to reach the threshold voltage Vth, the detector 20A determines that the short circuit has occurred between the electric wires 31 and 32, and opens the contact device 2211 of its relay 221 (t12). In this instance, the electric energy stored in the capacitors C1 and C2 would be consumed due to the operation of the relay 221, so that the second voltage V2 and the third voltage V3 further decrease.

[0066] When the contact device 2211 of the relay 221 of the detector 20A is opened (t13), the electric wires 312 and 322, namely the point at which the short circuit has occurred, is electrically disconnected from the master device 10. Then, the capacitors C0, C1, and C2 of the detector 20A are charged up, so that the first to third voltages V1 to V3 increase. Thereafter, the detector 20A can be operated with the voltage Vi from the master device 10 while the point at which the short circuit has occurred (the electric wires 312 and 322) is disconnected from the master device 10.

[0067] In another case where the short circuit has occurred between the electric wires 313 and 323 that connect the detectors 20B and 20C, the high potential side electric wire 31 and the low potential side electric wire 32 are not electrically connected even when the detector 20A closes the contact device 2211 of its relay 221 in response to an instruction from the master device 10. With this result, the master device 10 can specify that the point at which the short circuit has occurred is not between the electric wires 311 and 321 that connect the detector 20A and the detector 20B. Subsequently, the master device 10 transmits an instruction to the detector 20B for closing the contact device 2211 of the relay 221, while keeping the detector 20A closing the contact device 2211 of the relay 221. When the contact device 2211 of the relay 221 of the detector 20B is closed in this situation, the high potential side electric wire 31 and the low potential side electric wire 32 are electrically connected to each other since short circuit has occurred between the electric wires 313 and 323, so that the voltage between the electric wires 31 and 32 decreases. The master device 10 therefore can specify that the short circuit has occurred between the electric wires 313 and 323 that connect the detector 20B and the detector 20C. Thereafter, the detectors 20A and 20B can be operated with the voltage Vi from the master device 10 while the contact device 2211 of the relay 221 of the detector 20B is kept opened so that the point at which the short circuit has occurred (the electric wires 313 and 323) is disconnected from the master device 10.

[0068] It should be noted that the detector 20 is configured to operate the relay 221 with the electric energy stored in the capacitors C1 and C2 to consume the electric energy, as described above. Further, in a specific case where the multiple detectors 20 are connected in series as in alarm system 100 of the present embodiment, the contact device 2211 of the relay 221 needs to be operated two times (i.e., is closed and then opened) in order to perform a specifying operation for specifying the point at which the short circuit has occurred (t11 and t12 in FIG.. 5). Furthermore, in a case where the short circuit has occurred between the electric wires 31 and 32, the capacitors C1 and C2 cannot be charged by the voltage between the electric wires 31 and 32 since the voltage level thereof is lowered. Therefore, the capacitors C1 and C2 are required to have capacitances for storing the electric energy sufficient to operate the contact device 2211 of the relay 221 two times.

[0069] Furthermore, the control unit 24 operates with and consumes the electric energy stored in the capacitor C1 while a short circuit occurs. Therefore, if the control unit 24 performs the steady-state operation while the short circuit has occurred, the energy stored in the capacitor C1 decreases due to the operation of the control unit 24 to possibly cause the electric energy accumulated in the capacitors C1 and C2 to be insufficient for operating the delay 221 to open the contact device 2211. For example, if the contact device 2211 of the relay 221 is kept closed while the short circuit has occurred, the electric energy stored in the capacitor C1 decreases due to the steady-state operation of the control unit 24 (t22) to be insufficient for the control unit 24 to operate the relay 221 to open the contact device 2211, as depicted by broken lines in FIG. 5. This may be prevented by employing a capacitor C1 having a larger capacitance, but this may increase the total size of the power supply circuit 21.

[0070] In view of the above circumstances, the control unit 24 of the detector 20 of the present embodiment is configured to, when the short-circuit detection circuit 222 detects the occurrence of the short circuit, open (turn off) the contact device 2211 of the relay 221 prior to a first steady-state operation after detection of the occurrence of the short circuit. With this configuration, the contact device 2211 of the relay 221 can be surely opened without the need for increasing the capacitance of the capacitor C1. An operation of the detector 20 according to this

configuration will be explained with reference to FIG. 6.

[0071] The detector 20 performs a short circuit detection operation of comparing, by the short-circuit detection circuit 222, a voltage across the capacitor C0 with the threshold voltage Vth to determine whether a short circuit has occurred between the electric wires 31 and 32 (S1). If no short circuit is detected (S2; No), the detector 20 performs the steady-state operation for detecting the outbreak of fire (S3). If no fire is detected by the steady-state operation (S4; No), the detector 20 returns to the step S1. The detector 20 usually repeats this cycle during a normal operation.

[0072] If detecting the outbreak of fire (S4; Yes), the detector 20 operates the warning unit (S5) and provides the fire notification to the master device 10 (S6).

[0073] If detecting the occurrence of the short circuit during the short circuit detection operation (S2; Yes), the detector 20 operates the relay driver SW1 to open the contact device 2211 of the relay 221 (S7) without performing a next steady-state operation.

[0074] With this configuration, the contact device 2211 of the relay 221 is opened before electric energy in the capacitors C1 and C2 is consumed by the steady-state operation performed by the control unit 24. It is accordingly possible to reduce a possibility that the contact device 2211 of the relay 221 cannot be opened due to insufficient electric energy in the capacitors C1 and C2. It is further possible to provide the electric energy sufficient for opening the contact device 2211 of the relay 221 without increasing the capacitance of the capacitor C1.

[0075] The detector 20 of the present embodiment includes the capacitor C2 configured to be charged by the electric energy stored in the capacitor C1. The relay 221 operates with the electric energy stored in the capacitors C1 and C2 to consume the electric energy while the short circuit occurs. With this configuration, the capacitor C2 also can provide an operation voltage to the relay 221, further reducing a possibility that the contact device 2211 of the relay 221 cannot be opened due to insufficient electric energy in the capacitors C1 and C2.

(2) Variations

[0076] The embodiment described above is only one of various embodiments of the present disclosure. The above embodiment may be readily modified depending on a design choice or any other factor, without departing from a true spirit and scope of the present disclosure.

[0077] The same function as that of the control unit 24 of the detector 20 may be implemented as a control method, a computer program, or a non-transitory storage medium that stores the computer program thereon, for example. The control unit 24 or an agent that executes the control method includes a computer system. The computer system includes, as principal hardware components, a processor and a memory. The functions of the control unit 24 or the agent that executes the control method are performed by making the processor execute the program stored in the memory of the computer system. The program may be stored in advance in the memory of the computer system. Alternatively, the program may also be downloaded through a telecommunications line or be distributed after having been stored in some computer-readable storage medium. Examples of the computer-readable storage media include a memory card, an optical disc, and a hard disk drive. The processor of the computer system is made up of a single or a plurality of electronic circuits including a semiconductor integrated circuit (IC) or a largescale integrated circuit (LSI). Those electronic circuits may be integrated together on a single chip or distributed on multiple chips without limitation. Those multiple chips may be integrated together in a single device or distributed in multiple devices without limitation.

[0078] The relay 221 is not limited to the dual winding latching relay, but may be a single coil latching relay, a relay with normally open contacts, or the like. The relay with normally open contacts may operate (open or close the contacts) without consuming the electric energy, but consumes energy while keeping the contacts closed. Thus, keeping the relay closed would rapidly decreases the electric energy stored in the capacitor C1 to such an energy level necessary for operating the control unit 24. Therefore, opening the contacts of the relay prior to the steady-state operation can secure the electric energy required for the operation of the control unit 24.

[0079] The contact device 2211 of the relay 221 may be connected between the terminals (between the second terminal 202 and the fourth terminal 204) to be connected to the low potential side electric wire 32, instead of between the terminals (between the first terminal 201 and the third terminal 203) to be connected to the high potential side electric wire 31.

[0080] The capacitor C2 (the second capacitive device) may be an optional device and can be omitted. The relay 221 may be configured to operate directly with and consume the electric energy stored in the capacitor C1.

[0081] The third terminal 203 may be electrically connected to the input terminal of the power supply circuit 21 (a connection point of the power supply circuit 21 and the cathode of the diode D0) via a diode. The diode may have an anode electrically connected to the third terminal 203, and a cathode electrically connected to the input terminal of the power supply circuit 21. With this configuration, when a short circuit occurs between the electric wires 31A and 32A, the master device 10 can apply a voltage to the capacitor C0 of the detectors 20 from a circuit including the third and fourth terminals 203 and 204, for example. Furthermore, the short-circuit detection circuit 222 can operate with a voltage between the first and second terminals 201 and 202 while a short circuit occurs between the electric wires 31B and 32B, and further can operate with a voltage between the third and fourth terminals 203 and 204 while a short circuit occurs between the electric wires 31A and 32A. That is, the short-circuit detection circuit 222 doubles as a first short-

circuit detection circuit for detecting an occurrence of short circuit between the pair of first electric wires 31A and 32A and a second short-circuit detection circuit for detecting an occurrence of short circuit between the pair of second electric wires 31B and 32B, and can operate with the voltage from the electric wires 31 and 32.

(3) Aspects

[0082] A detector (20) according to a first aspect including first to fourth terminals 201 to 204, a relay 221, a connection part 205, a voltage generation circuit 211, a capacitive device (capacitor C1), a short-circuit detection circuit 222, and a control unit 24. The first and second terminals 201, 202 are configured to be electrically connected to a pair of first electric wires 31A, 32A to receive an application voltage applied between the pair of first electric wires 31A, 32A. The third and fourth terminals 201, 204 are configured to be electrically connected to a pair of second electric wires 31B, 32B. The relay 221 includes a contact device 2211 electrically connected between the first terminal 201 and the third terminal 203 and configured to open and close an electric circuit between the first terminal 201 and the third terminal 203. The connection part 205 electrically interconnects the second terminal 202 and the fourth terminal 204. The voltage generation circuit 211 is configured to generate an operation voltage from the application voltage. The capacitive device (capacitor C1) is electrically connected to the voltage generation circuit 211 and is configured to be charged by the operation voltage. The short-circuit detection circuit 222 is configured to detect an occurrence of short circuit between the pair of second electric wires 31B, 32B. The control unit 24 operates with electric energy stored in the capacitive device (capacitor C1). The control unit 24 is configured to repeat a steady-state operation for detecting an occurrence of a specified event, and further configured to open the contact device 2211 of the relay 221 in response to a detection of the occurrence of the short circuit by the short-circuit detection circuit 222. The relay 221 operates, while the short circuit occurs, with the electric energy stored in the capacitive device (capacitor C1). The control unit 24 is configured to, when the short-circuit detection circuit 222 detects the occurrence of the short circuit, open the contact device 2211 of the relay 221 prior to a first steady-state operation which is a first one of the steady-state operation after a detection of the occurrence of the short circuit.

[0083] With this configuration, when the short-circuit detection circuit 222 detects an occurrence of short circuit, the contact device 2211 of the relay 221 is opened before the control unit 24 performs the steady-state operation. This can secure the electric energy for the operation of the relay 221 without increasing the capacitance of the capacitive device (capacitor C1). The capacitive device (capacitor C1) of the power supply circuit 21 can be downsized.

[0084] A detector 20 according to a second aspect, realized in combination with the first aspect, further includes a sensor (first to third sensors 231 to 233) configured to sense a sensing target. The steady-state operation includes a detection operation for determining whether the specified event has occurred based on the sensing target sensed by the sensor.

[0085] With this configuration, when the short-circuit detection circuit 222 detects an occurrence of short circuit, the detector 20 opens the contact device 2211 of the relay 221 before the steady-state operation based on the sensor. This can secure the electric energy for the operation of the relay 221 without the need for increasing the capacitance of the capacitive device (capacitor C1). The capacitive device (capacitor C1) of the power supply circuit 21 can be downsized.

[0086] In a detector 20 according to a third aspect, realized in combination with the second aspect, the specified event is fire. The detection operation includes at least one of a heat detection operation, a smoke detection operation, and a carbon monoxide detection operation. The heat detection operation performed by the detector 20 includes determining whether a temperature sensed by the sensor, serving as a temperature sensor (first sensor 231), exceeds a threshold. The smoke detection operation performed by the detector includes determining whether concentration of smoke in an air sensed by the sensor, serving as a smoke sensor (second sensor 232), exceeds a threshold. The carbon monoxide detection operation performed by the detector 20 includes determining whether concentration of carbon monoxide in the air sensed by the sensor, serving as a carbon monoxide sensor (third sensor 233), exceeds a threshold.

[0087] With this configuration, the detector 20 can detect the outbreak of fire as the specified event.

[0088] A detector 20 according to a fourth aspect, realized in combination with any one of the first to third aspects, further includes a second capacitive device (capacitor C2). The second capacitive device (capacitor C2) is charged by the electric energy stored in the first capacitive device (capacitor C1). The relay 221 operates with and consumes the electric energy stored in the first capacitive device (capacitor C1) and electric energy stored in the second capacitive device (capacitor C2), while the short circuit occurs.

[0089] With this configuration, the second capacitive device can secure the operation voltage of the relay 221 to reduce a possibility that the contact device 2211 of the relay 221 cannot be opened.

[0090] A detector 20 according to a fifth aspect, realized in combination with any one of the first to fourth aspects, the short-circuit detection circuit 222 includes a first short-circuit detection circuit and a second short-circuit detection circuit. The first short-circuit detection circuit is configured to detect an occurrence of short circuit between the pair of first electric wires 31A, 32A. The second short-circuit detection circuit is configured to detect the occurrence of the short circuit between the pair of second electric wires 31B, 32B.

[0091] With this configuration, the short-circuit detection circuit 222 can detect both of short circuits, a shot-circuit between the first and second terminals 201 and 202 and a short circuit between the third and fourth terminals 203 and 204.

[0092] An isolator 22 according to a sixth aspect is equipped in the detector 20 according to any one of the first to fifth aspects. The isolator 22 includes at least the relay 221 and the short-circuit detection circuit 222.

[0093] This configuration can provide an isolator equipped in the detector 20 and operable with a capacitive device having a comparatively small capacitance.

[0094] An alarm system 100 according to a seventh aspect includes a plurality of the detectors 20 (20A, 20B, 20C) of any one of the first to fifth aspects, and a master device 10. The plurality of detectors 20 are electrically connected in series such that third and fourth terminals 203, 204 of one of adjacent two detectors of the plurality of detectors 20 are connected to a pair of second electric wires 31B, 32B to be connected to a pair of first electric wires 31A, 32A connected to first and second terminals 201, 202 of another one of the adjacent two detectors. The master device 10 includes an application unit 11. The application unit 11 is electrically connected to a pair of first electric wires 311, 321 electrically connected to first and second terminals 201, 202 of a detector 20A located at a first end of the plurality of detectors 20 connected in series. The application unit 11 is configured to apply the application voltage between the pair of first electric wires 311, 321.

[0095] This configuration can realize the alarm system 100 including the plurality of detectors 20 connected in series. Even when a short circuit occurs between the electric wires 31 and 32 connecting the plurality of detectors 20, one or more detectors 20 between the master device 10 and a point at which the short circuit has occurred can work as before the short circuit.

[0096] An alarm system 100 according to an eighth aspect, realized in combination with the seventh aspect, the application unit 11 is further electrically connected to a pair of second electric wires 314, 324 electrically connected to third and fourth terminals 203, 204 of a detector 20C located at a second end, which is far away from the first end, of the plurality of detectors 20 connected in series. The application unit 11 is configured to apply the application voltage between the pair of second electric wires 314, 324.

[0097] With this configuration, the application unit 11 of the master device 10 can supply the application voltage from both ends of a set of the plurality of detectors 20 connected in series. Each of the detector 20 may include a diode D0 electrically connected between the first terminal 201 and an input terminal of the voltage generation circuit 211 and allowing a current to flow from the first terminal 201 toward the voltage generation circuit 211. Each of the detector 20 may further include a diode electrically connected between the third terminal 203 and the input terminal of the voltage generation circuit 211 and allowing a current to flow from the third terminal 203 toward the voltage generation circuit 211.

[0098] A control method according to a ninth aspect is for controlling a contact device 2211 of a detector 20 according to an occurrence of a specified event. The detector 20 includes a first terminal 201, a second terminal 202, a third terminal 203, a fourth terminal 204, a relay 221 including the contact device 2211, a connection part 205, a voltage generation circuit 211, a capacitive device (capacitor C1), and a short-circuit detection circuit 222. The first terminal 201 and the second terminal 202 are configured to be electrically connected to a pair of first electric wires 31A, 32A to receive an application voltage applied between the pair of first electric wires 31A, 32A. The third terminal 203 and the fourth terminal 204 are configured to be electrically connected to a pair of second electric wires 31B, 32B. The contact device 2211 of the relay 221 is electrically connected between the first terminal 201 and the third terminal 203. The relay 221 is configured to open and close an electric circuit between the first terminal 201 and the third terminal 203. The relay 221 operates with electric energy stored in the capacitive device (capacitor C1) to consume the electric energy while the short circuit occurs. The connection part 205 electrically interconnects the second terminal 202 and the fourth terminal 204. The voltage generation circuit 211 is configured to generate an operation voltage from the application voltage. The capacitive device (capacitor C1) is electrically connected to the voltage generation circuit 211 and is configured to be charged by the operation voltage. The short-circuit detection circuit 222 is configured to detect an occurrence of short circuit between the pair of second electric wires 31B, 32B. The control method includes: receiving power from the electric energy stored in the capacitive device (capacitor C1); repeating a steady-state operation for detecting an occurrence of the specified event with the power received from the electric energy; and, in response to a detection of the occurrence of the short circuit by the short-circuit detection circuit 222, opening, with the power received from the electric energy, the contact device 2211 of the relay 221 prior to a first steady-state operation which is a first one of the steady-state operation after a detection of the occurrence of the short circuit.

[0099] With this configuration, when the short-circuit detection circuit 222 detects an occurrence of short circuit, the contact device 2211 of the relay 221 is opened before the steady-state operation. This can secure the electric energy for the operation of the relay 221 without increasing the capacitance of the capacitive device (capacitor C1). The capacitive device (capacitor C1) of the power supply circuit 21 can be downsized.

Reference Signs List

[0100]

10 Master Device

100	Alarm System
20	Detector
201	First Terminal
202	Second Terminal
203	Third Terminal
204	Fourth Terminal
205	Connection Part
211	Voltage Generation Circuit
221	Relay
2211	Contact Device
222	Short-Circuit Detection Circuit
231	First Sensor
232	Second Sensor
233	Third Sensor
24	Control Unit
31A, 32A	Pair of First Electric Wires
31B, 32B	Pair of Second Electric Wires
C1	Capacitor (First Capacitive Device)
C2	Capacitor (Second Capacitive Device)

Claims

1. A detector, comprising:

a first terminal and a second terminal configured to be electrically connected to a pair of first electric wires to receive an application voltage applied between the pair of first electric wires;
a third terminal and a fourth terminal configured to be electrically connected to a pair of second electric wires;
a relay including a contact device electrically connected between the first terminal and the third terminal and configured to open and close an electric circuit between the first terminal and the third terminal;
a connection part electrically interconnecting the second terminal and the fourth terminal;
a voltage generation circuit configured to generate an operation voltage from the application voltage;
a capacitive device electrically connected to the voltage generation circuit and configured to be charged by the operation voltage;
a short-circuit detection circuit configured to detect an occurrence of short circuit between the pair of second electric wires; and
a control unit that operates with electric energy stored in the capacitive device, the control unit being configured to repeat a steady-state operation for detecting an occurrence of a specified event, and further configured to open the contact device of the relay in response to a detection of the occurrence of the short circuit by the short-circuit detection circuit,
wherein
the relay operates with the electric energy stored in the capacitive device to consume the electric energy while the short circuit occurs, and
the control unit is configured to, when the short-circuit detection circuit detects the occurrence of the short circuit, open the contact device of the relay prior to a first steady-state operation which is a first one of the steady-state operation after a detection of the occurrence of the short circuit.

2. The detector of claim 1, further comprising a sensor configured to sense a sensing target, wherein
the steady-state operation includes a detection operation for determining whether the specified event has occurred based on the sensing target sensed by the sensor.

3. The detector of claim 2, wherein
the specified event is fire,
the detection operation includes at least one of:

a heat detection operation for determining whether a temperature sensed by the sensor, serving as a temperature sensor, exceeds a threshold;
a smoke detection operation for determining whether concentration of smoke in an air sensed by the sensor, serving as a smoke sensor, exceeds a threshold; and
a carbon monoxide detection operation for determining whether concentration of carbon monoxide in the air sensed by the sensor, serving as a carbon monoxide sensor, exceeds a threshold.

4. The detector of any one of claims 1 to 3, wherein
the capacitive device is a first capacitive device,
the detector further comprises a second capacitive device,
the second capacitive device is charged by the electric energy stored in the first capacitive device,
the relay operates with and consumes the electric energy stored in the first capacitive device and electric energy stored in the second capacitive device, while the short circuit occurs.

5. The detector of any one of claims 1 to 4, wherein
the short-circuit detection circuit includes

a first short-circuit detection circuit configured to detect an occurrence of short circuit between the pair of first electric wires, and
a second short-circuit detection circuit configured to detect the occurrence of the short circuit between the pair of second electric wires.

6. An isolator configured to be equipped in the detector of any one of claims 1 to 5, the isolator comprising

at least the relay and the short-circuit detection circuit.

7. An alarm system, comprising:

a plurality of the detectors of any one of claims 1 to 5, and
a master device,
wherein
the plurality of detectors are electrically connected in series such that third and fourth terminals of one of adjacent two detectors of the plurality of detectors are connected to a pair of second electric wires to be connected to a pair of first electric wires connected to first and second terminals of another one of the adjacent two detectors,
the master device includes an application unit electrically connected to a pair of first electric wires electrically connected to first and second terminals of a detector located at a first end of the plurality of detectors connected in series, the application unit being configured to apply the application voltage between the pair of first electric wires.

8. The alarm system of claim 7, wherein
the application unit is further electrically connected to a pair of second electric wires electrically connected to third and fourth terminals of a detector located at a second end, which is far away from the first end, of the plurality of detectors connected in series, the application unit being configured to apply the application voltage between the pair of second electric wires.

9. A control method for controlling a contact device of a detector according to an occurrence of a specified event,
the detector includes a first terminal, a second terminal, a third terminal, a fourth terminal, a relay including the contact device, a connection part, a voltage generation circuit, a capacitive device, and a short-circuit detection circuit,
wherein
the first terminal and the second terminal are configured to be electrically connected to a pair of first electric wires to receive an application voltage applied between the pair of first electric wires,
the third terminal and the fourth terminal are configured to be electrically connected to a pair of second electric wires,
the contact device of the relay is electrically connected between the first terminal and the third terminal,
the relay being configured to open and close an electric circuit between the first terminal and the third terminal, the relay operating with electric energy stored in the capacitive device to consume the electric energy while the short circuit occurs,
the connection part electrically interconnects the second terminal and the fourth terminal,
the voltage generation circuit is configured to generate an operation voltage from the application voltage,
the capacitive device is electrically connected to the voltage generation circuit and is configured to be charged by the operation voltage,
the short-circuit detection circuit is configured to detect an occurrence of short circuit between the pair of second electric wires,
the control method comprising:

receiving power from the electric energy stored in the capacitive device;
repeating a steady-state operation for detecting an occurrence of the specified event with the power received from the electric energy; and
in response to a detection of the occurrence of the short circuit by the short-circuit detection circuit, opening, with the power received from the electric energy, the contact device of the relay prior to a first steady-state operation which is a first one of the steady-state operation after a detection of the occurrence of the short circuit.

FIG. 1

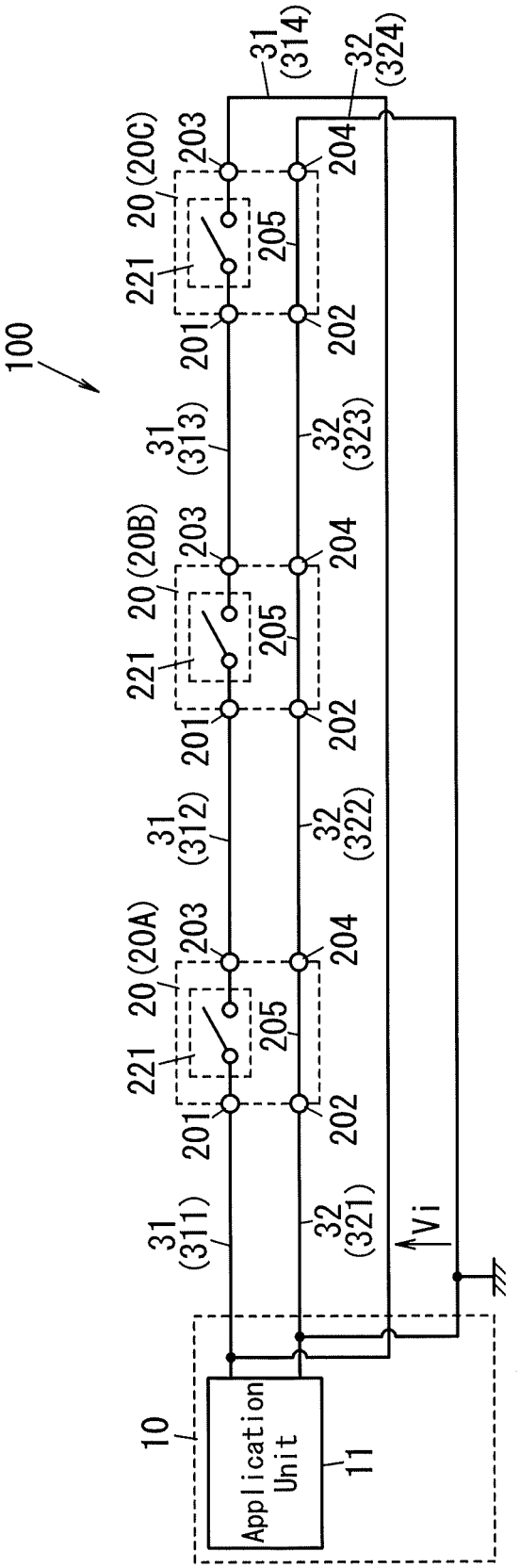

100
10
Application Unit
11
31 (311)
31 (312)
31 (313)
31 (314)
32 (321)
32 (322)
32 (323)
32 (324)
20 (20A)
20 (20B)
20 (20C)
201
202
203
204
205
221
Vi

FIG. 2

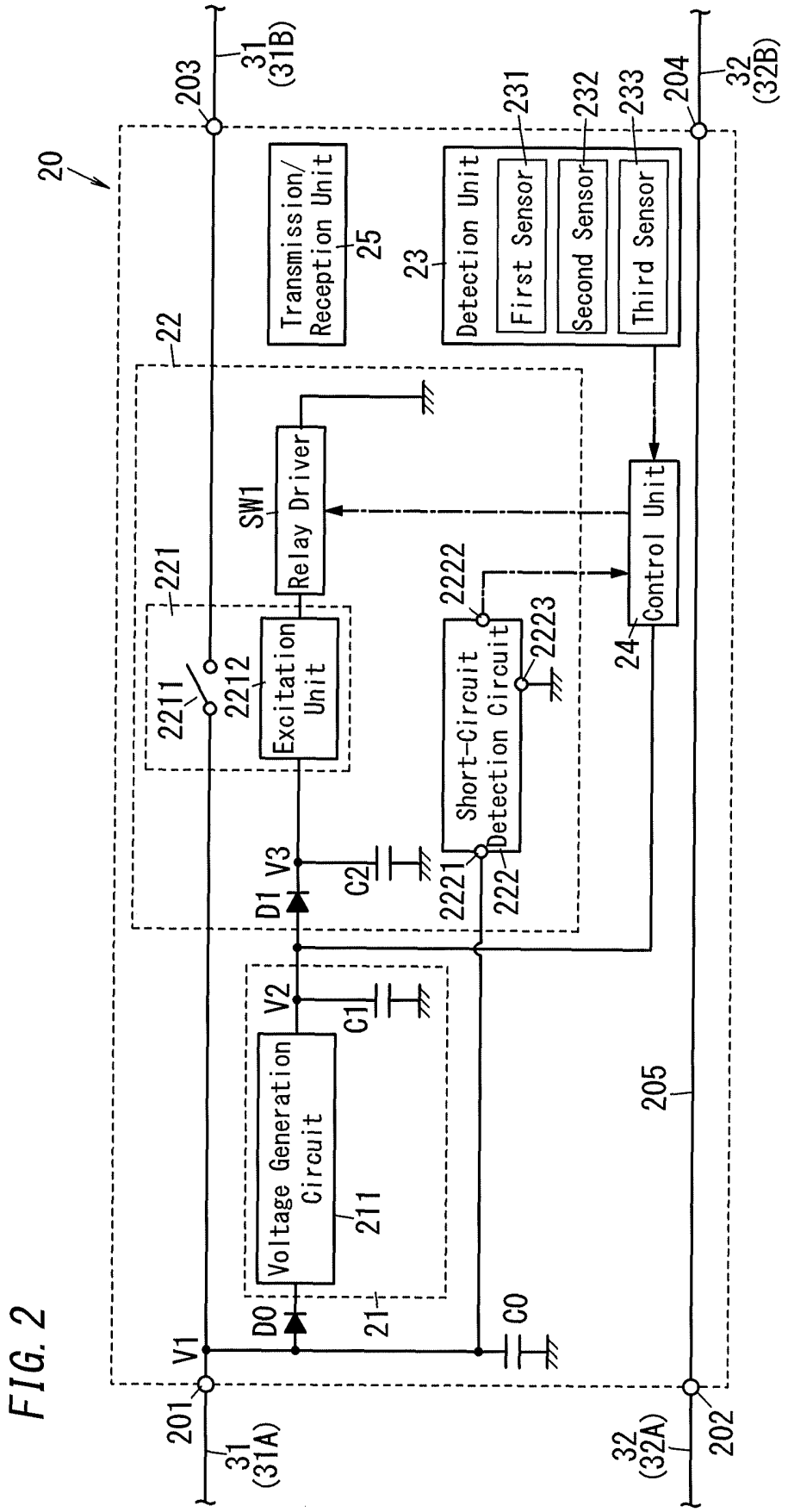

20
203
31
(31B)
204
32
(32B)
231
232
233
Transmission/
Reception Unit
25
23
Detection Unit
First Sensor
Second Sensor
Third Sensor
22
SW1
Relay Driver
Control Unit
221
2222
2211
2212
Excitation
Unit
2223
24
Short-Circuit
Detection Circuit
D1
V3
C2
2221
222
V2
C1
Voltage Generation
Circuit
211
205
D0
21
C0
V1
201
31
(31A)
32
(32A)
202

FIG. 3

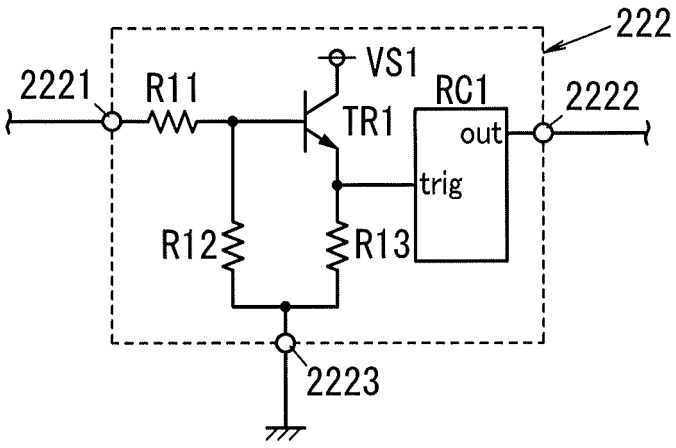


FIG. 4

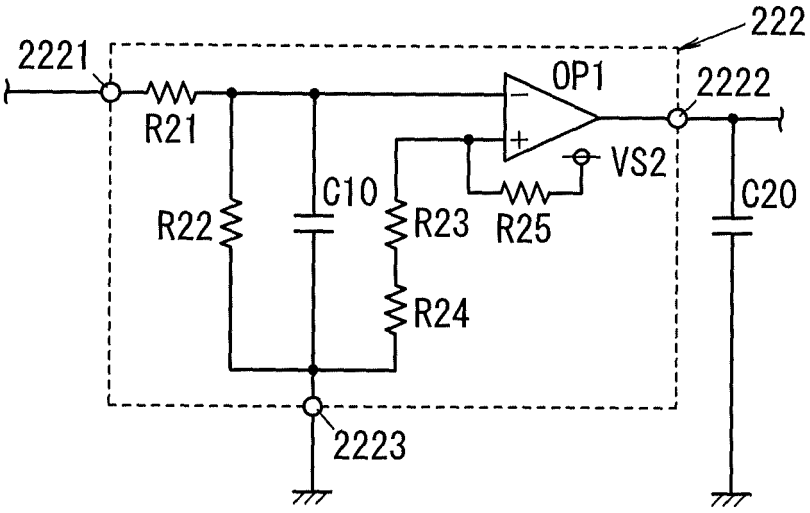


FIG. 5

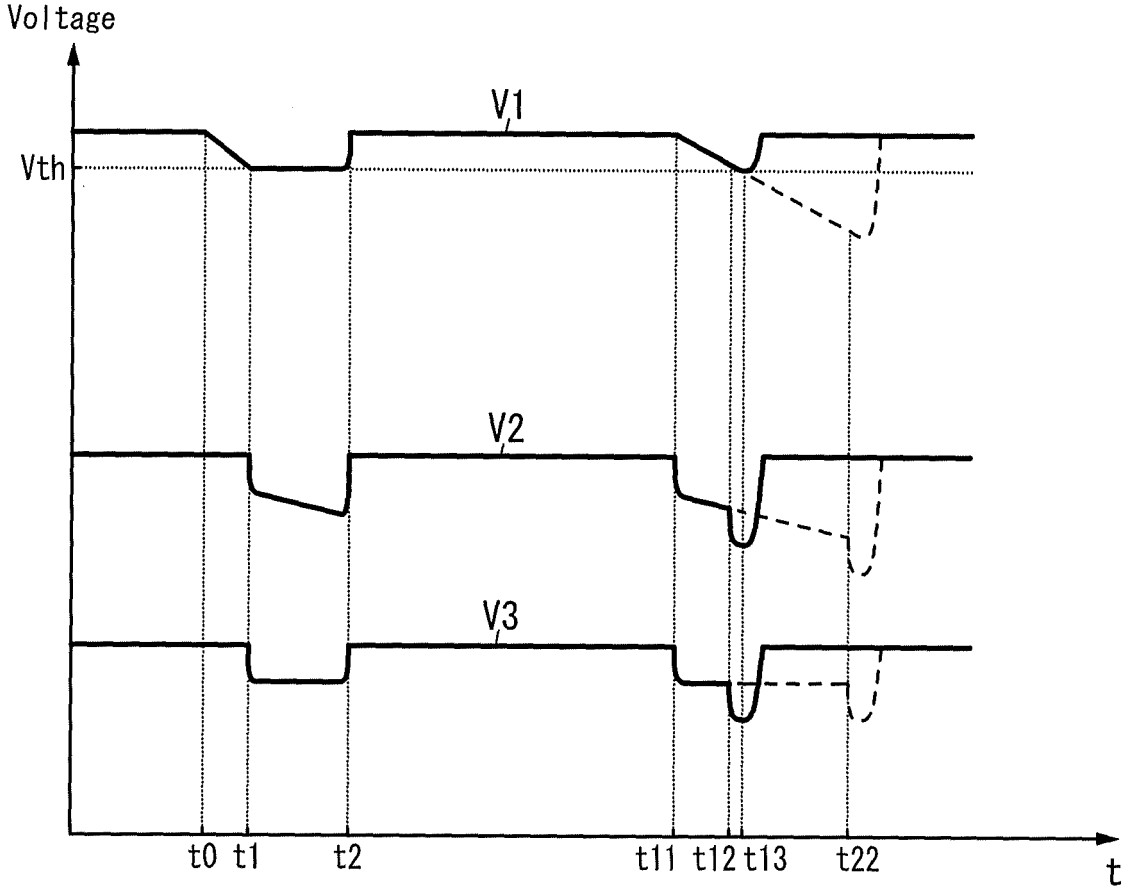
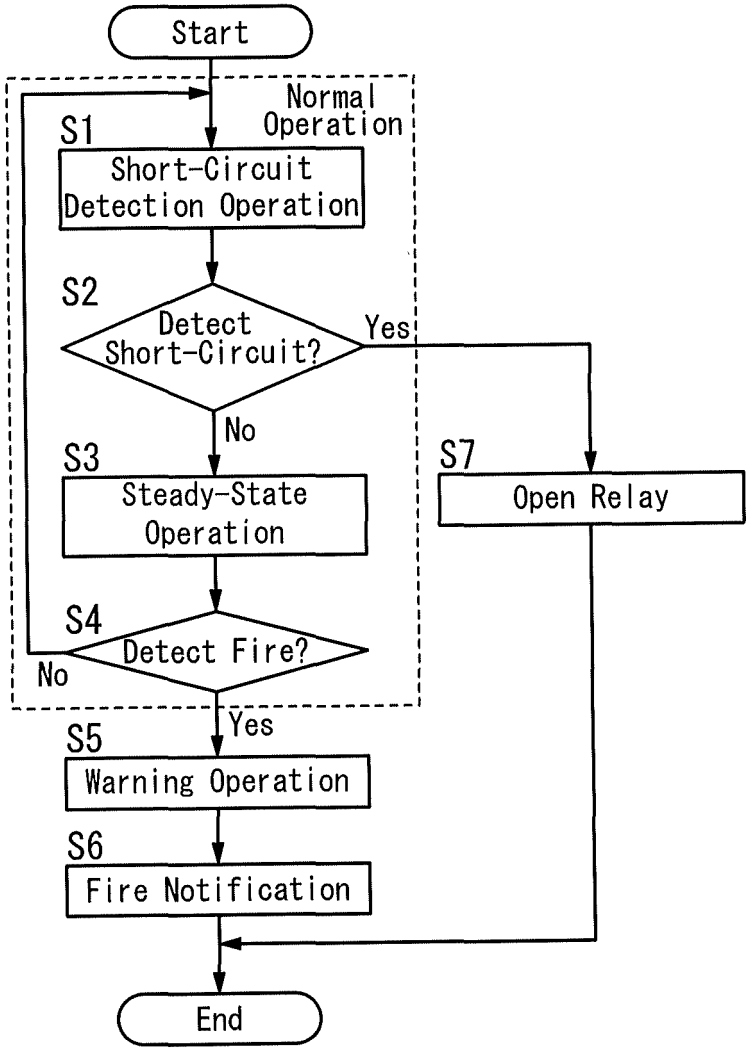


FIG. 6


Start
Normal Operation
S1
Short-Circuit Detection Operation
S2
Detect Short-Circuit?
Yes
No
S3
Steady-State Operation
S4
Detect Fire?
No
Yes
S5
Warning Operation
S6
Fire Notification
S7
Open Relay
End

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/033311

A. CLASSIFICATION OF SUBJECT MATTER
G08B29/18(2006.01)i, *G08B17/00*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G08B29/18, G08B17/00

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2007-323197 A (Nohmi Bosai Ltd.), 13 December 2007 (13.12.2007), paragraphs [0011] to [0056] (Family: none)	1-9
A	JP 2007-323131 A (Nohmi Bosai Ltd.), 13 December 2007 (13.12.2007), paragraphs [0008] to [0016] (Family: none)	1-9
A	US 2015/0214842 A1 (BARSON Michael), 30 July 2015 (30.07.2015), paragraphs [0031] to [0044] & EP 2899704 A1	1-9

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 October 2017 (06.10.17)	17 October 2017 (17.10.17)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H962975 A **[0005]**