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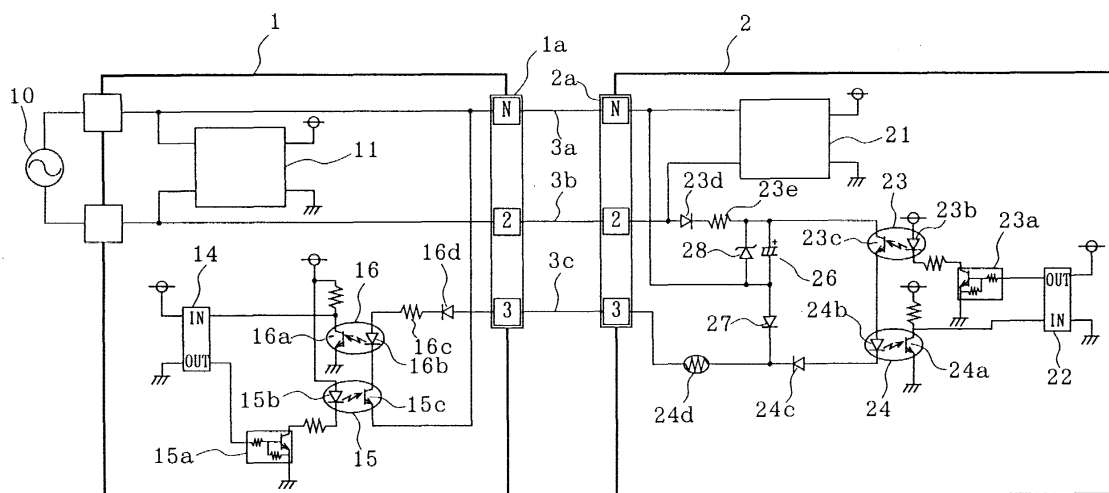
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(54) **Control circuit for an air conditioner**

(57) A PTC thermistor (24d) is used in a communication circuit. When AC power source (10) has been erroneously supplied to the communication circuit, the PTC thermistor (24d) is self-heated instantaneously by

an over-current and changes its resistance from a few Ω to a few $M\Omega$ so as to cut off the over-current to the communication circuit, thereby to protect the communication circuit.

FIG. 1



Description

BACKGROUND OF THE INVENTION

[0001] This invention relates to the control circuit of a separate type air conditioner having an outdoor machine and at least one indoor machine.

[0002] Fig. 12 is an electric circuit diagram showing a conventional communication apparatus between indoor and outdoor machines of an air conditioner, described in Japanese Patent Application Laid-Open No. 11-193950, for example. In the drawing, the air conditioner has one outdoor machine 1 and a plurality of indoor machines 2. Each of the plurality of indoor machines 2 is connected to the outdoor machine 1 via three connection lines 3 in parallel with each other. The outdoor machine 1 has a half-wave rectification DC power source circuit 12 connected between terminals of a commercial power source 10 (hereinafter to be referred to as an AC power source), an outdoor control DC power source 11 as outdoor control power source means connected between the terminals of the AC power source 10, an outdoor microcomputer 14 as outdoor control means, an outdoor transmission photo coupler 15 connected to a transmission port of the outdoor microcomputer 14, an outdoor reception photo coupler 16 connected to a reception port of the outdoor microcomputer 14, and a termination resistor 17 as first resistor means connected in parallel with the outdoor reception photo coupler 16.

[0003] Further, each indoor machine 2 has an indoor control DC power source 21 as indoor control power source means connected between a pair of connection lines 3a and 3b, an indoor microcomputer 22 as indoor control means, an indoor transmission photo coupler 23 connected to a transmission port of the indoor microcomputer 22, an indoor reception photo coupler 24 for the indoor microcomputer 22, and a positive temperature characteristic thermistor 25 for protecting an over-current, as second resistor means having a positive temperature coefficient, connected in series with a collector terminal of a phototransistor 23c of the indoor transmission photo coupler 23.

[0004] Next, the operation will be explained. Fig. 13 is a flowchart for explaining an erroneous wiring decision processing of the indoor machine. At step SP1, the transmission port of the indoor microcomputer 22 is turned ON, and a light receiving element 23c of the indoor transmission photo coupler 23 is turned OFF. At step SP2, a decision is made about an interruption in the frequency of the AC power source. When a decision has been made that there is an interruption in the frequency of the AC power source, it is recognized at step SP3 that the connection of the indoor/outdoor connection lines 3 is abnormal. At step SP4, the transmission port of the indoor microcomputer 22 is turned OFF, and the light receiving element 23c of the indoor transmission photo coupler 23 is turned ON, and thus, a series

of processing is finished. On the other hand, when a decision has been made at step SP2 that there is no interruption in the frequency of the AC power source, it is recognized at step SP5 that the connection of the indoor/outdoor connection lines 3 is normal. At step SP6, an operation based on a normal sequence is carried out.

[0005] Further, Fig. 14 is a flowchart for explaining an erroneous wiring decision processing of the outdoor machine. At step SP11, the transmission port of the outdoor microcomputer 14 is turned OFF, and a light receiving element 15c of the outdoor transmission photo coupler 15 is turned OFF. At step SP12, a decision is made about an interruption in the received data. When a decision has been made that there is an interruption in the received data, it is recognized at step SP18 that the connection of the indoor/outdoor connection lines 3 is abnormal. Again, the processing of step SP11 is carried out. On the other hand, when a decision has been made at step SP12 that there is no interruption in the received data, a wait processing is carried out at step SP13 until an erroneous wiring decision period of the indoor machine 2 has elapsed. At step SP14, the transmission port of the outdoor microcomputer 14 is turned ON, and the light receiving element 15c of the outdoor transmission photo coupler 15 is turned ON. At step SP15, a decision is made about whether the transmission output and the reception input are equal to each other or not. When the transmission output and the reception input are not equal to each other, a processing at step SP 18 is carried out. On the other hand, when a decision has been made at step SP15 that the transmission output and the reception input are equal to each other, it is recognized at step SP16 that the connection of the indoor/outdoor connection lines 3 is normal. At step SP17, an operation based on a normal sequence is carried out.

[0006] In the above case, according to a conventional communication circuit protecting apparatus for an air conditioner in which an AC power is supplied from an outdoor machine to an indoor machine, there has been a problem of a frequent occurrence that the AC power source is erroneously connected to a communication line at the time of the installation. When the AC power has been supplied to the communication line, there is a possibility of breaking the indoor transmission photo coupler depending on the response characteristic of the positive characteristic thermistor for protecting the communication circuit.

[0007] In the meantime, a separate type air conditioner has a zero-crossing circuit to detect a frequency of a commercial power source from the power line, and a serial communication circuit to control the operation of the air conditioner by communication by a serial signal between an outdoor machine and an indoor machine. Conventionally, an AC power supply for the zero-crossing circuit and the half-wave-rectified side of the serial communication circuit is taken in from the L-phase opposite to the N-phase (the neutral line) of the AC power source. Therefore, there has been a problem that when a serial

communication between the indoor machine and the outdoor machine has been started, the half-wave-rectified DC component current of the AC power source and the half-wave-rectified DC component current of the serial communication flow into the N-phase of the AC power source.

SUMMARY OF THE INVENTION

[0008] The present invention has been made to solve the above problems. It is an object of the present invention to provide a control circuit for an air conditioner, capable of securely protecting a communication line even when the AC power has been supplied to the communication line, and further capable of prompting the installation, decreasing a breaking of a board due to an installation error, decreasing the shipment of free service parts of the board, and improving profit. This object is attained by the constitutions defined in claims 1 to 3.

[0009] Another object of the present invention is to provide a reliable control circuit of an air conditioner, which can suppress a flow of excessive DC component current into the N-phase of the AC power source. This object is attained by the constitutions defined in claims 4 to 7.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

Fig. 1 is a control block diagram showing an air conditioner according to a first embodiment of this invention.

Fig. 2 is a control block diagram showing an erroneous wiring of an air conditioner in case 1 and case 2 according to the first embodiment of this invention.

Fig. 3 is a control block diagram showing an erroneous wiring of an air conditioner in case 3 and case 4 according to the first embodiment of this invention.

Fig. 4 is a control block diagram showing an erroneous wiring of an air conditioner in case 5 according to the first embodiment of this invention.

Fig. 5 is a control flowchart diagram showing the air conditioner according to the first embodiment.

Fig. 6 is a control block diagram showing an air conditioner according to a second embodiment of this invention.

Fig. 7 is a schematic configuration diagram in a third embodiment of this invention.

Fig. 8 is another schematic configuration diagram in the third embodiment of this invention.

Fig. 9 is another schematic configuration diagram in the third embodiment of this invention.

Fig. 10 is a schematic configuration diagram in a fourth embodiment of this invention.

Fig. 11 is a schematic configuration diagram in a fifth embodiment of this invention.

Fig. 12 is a control block diagram showing a con-

ventional communication circuit for an air conditioner.

Fig. 13 is a control flowchart diagram showing the conventional communication circuit for an air conditioner.

Fig. 14 is a control flowchart diagram showing an erroneous wiring decision processing of a communication circuit for an air conditioner.

BEST MODE FOR CARRYING OUT THE INVENTION

First Embodiment

[0011] A communication circuit protecting apparatus constituting a control device for an air conditioner according to a first embodiment of this invention will be explained below with reference to the drawings. Fig. 1 is a control block diagram of the air conditioner of this invention. In the drawing, the air conditioner consists of one outdoor machine 1 and a plurality of indoor machines 2. Each of the plurality of indoor machines 2 has a terminal board 2a comprising a terminal number N, a terminal number 2 and a terminal number 3, and the outdoor machine has an indoor terminal board 1a also comprising terminals No. N, No. 2 and No. 3. The terminal boards of the indoor machines are connected in parallel to the outdoor machine 1 with three indoor/outdoor connection lines 3a, 3b and 3c, respectively. The outdoor machine 1 has an outdoor control DC power source 11 as outdoor control power source means connected between terminals of a commercial power source 10 (hereinafter to be referred to as an AC power source), an outdoor microcomputer 14 as outdoor control means, an outdoor transmission photo coupler 15 consisting of a phototransistor 15c and a photo diode 15b connected to a transmission port of the outdoor microcomputer 14, an outdoor reception photo coupler 16 consisting of a phototransistor 16a connected to a reception port of the outdoor microcomputer 14 and a photo diode 16b, and a series circuit consisting of an outdoor current control resistor 16c and an outdoor diode 16d, connected to the photo diode 16b in series.

[0012] Further, each indoor machine 2 in which three indoor/outdoor connection lines 3a, 3b, 3c are connected to the terminals No. N, No. 2 and No. 3 of the terminal board 2a, respectively, comprises: an indoor control DC power source 21 as indoor control power source means; an indoor microcomputer 22 as indoor control means; an indoor transmission photo coupler 23 consisting of phototransistor 23c and a photodiode 23b connected to a transmission port of the indoor microcomputer 22 via an indoor transmission transistor 23a; an indoor reception photo coupler 24 consisting of a photodiode 24b and a phototransistor 24a connected to the indoor microcomputer 22; a series circuit of an indoor half-wave rectification diode 23d and an indoor current limiting resistor 23e connected in series to a collector terminal of the phototransistor 23c of the indoor transmission photo

coupler 23; a series circuit of a PTC thermistor 24d and a first indoor diode 24c connected in series to the photodiode 24b of the indoor reception photo coupler 24; a series circuit of an indoor Zener voltage stabilizing electrolytic capacitor 26 and a second indoor diode 27, connected in parallel with the circuit comprising the indoor transmission photo coupler 23 and the indoor reception photo coupler 24; and an indoor Zener diode 28 connected in parallel with the indoor Zener voltage stabilizing electrolytic capacitor 26.

[0013] A connection of the communication line in the first embodiment will be explained. When the outdoor terminal board 1a of the outdoor machine 1 and the indoor terminal board 2a of the indoor machine 2 have been correctly connected with the indoor/outdoor connection lines 3a, 3b, 3c in installation work and the AC power source 10 is subsequently supplied to the outdoor machine 1, the AC power source 10 is outputted from the terminal No. N and the terminal No. 2 of the outdoor terminal board 1a. The AC power source 10 is transmitted through the indoor/outdoor connection lines 3a, 3b and is supplied to the terminal No. N and the terminal No. 2 of the indoor terminal board 2a, and thus the AC power source 10 is supplied to the indoor machine 2. Based on the supplied AC power source 10, the outdoor control power source 11 of the outdoor machine 1 generates a control power, so that the outdoor microcomputer 14 operates. Similarly, based on the supplied AC power source 10, the indoor control power source 21 of the indoor machine 2 generates a control power, so that the indoor microcomputer 22 operates. When the microcomputer 22 satisfies a serial communication starting condition which shows a normal operation of the indoor machine 2, and also three or more minutes has elapsed since the start of the supply of the AC power source 10, a signal to turn ON/OFF the indoor transmission transistor 23a is transmitted to the indoor transmission transistor 23a from the serial signal transmission port of the indoor microcomputer 22. Upon receiving the transmitted ON/OFF signal, the indoor transmission transistor 23a is ON/OFF operated. When the indoor transmission transistor 23a has been ON/OFF operated, the photodiode 23b of the indoor transmission photo coupler 23 is turned ON/OFF. When the photodiode of the indoor transmission photo coupler 23 has been turned ON/OFF, the phototransistor of the indoor transmission photo coupler 23 is turned ON/OFF. When the phototransistor of the indoor transmission photo coupler 23 has been turned ON/OFF, an indoor half-wave rectifier diode 23d of the indoor machine 2 rectifies the power supplied from the AC power source 10 into half-wave form. The half-wave-rectified AC power source 10 passes through the indoor current limiting resistor 23e which is a resistor for limiting a current to a level not to destroy the indoor transmission photo coupler 23 and the indoor reception photo coupler 24, and becomes a non-insulated DC power source at the indoor Zener diode 28. The voltage and current of the DC power source are turned into a

serial signal for communication between indoor and outdoor machines based on the ON/OFF of the indoor transmission photo coupler 23. The serial signal is transmitted from the indoor transmission photo coupler 23 to the indoor reception photo coupler 24. After the indoor reception photo coupler 24 has received the serial signal, the indoor reception photo coupler 24 transmits this signal to the first indoor diode 24c. After the first indoor diode 24c has received the serial signal, the first indoor diode 24c transmits this signal to the PTC thermistor 24d. After the PTC thermistor 24d has received the serial signal, the PTC thermistor 24d transmits this signal to the terminal number 3 of the indoor terminal board 2a. The indoor terminal board 2a transmits the received serial signal to an indoor/outdoor connection line 3c that connects the terminal No. 3 of the indoor terminal board 2a to the terminal No. 3 of the outdoor terminal board 1a of the outdoor machine 1. The serial signal is transmitted through the indoor/outdoor connection line 3c, so that the serial signal is received by the terminal number 3 of the outdoor terminal board 1a of the outdoor machine 1.

[0014] The received serial signal is transmitted from the terminal No. 3 of the outdoor terminal board 1a to the outdoor diode 16d. The outdoor diode 16d receives the serial signal and transmits it to the outdoor current limiting resistor 16c. When the outdoor current limiting resistor 16c has received the serial signal, the outdoor current limiting resistor 16c transmits the serial signal to the outdoor reception photo coupler 16. When the outdoor reception photo coupler 16 has received the serial signal, the outdoor reception photo coupler 16 transmits the serial signal to the outdoor transmission photo coupler 15 on the one hand. That is, when the photodiode 16b of the outdoor reception photo coupler 16 has been turned ON/OFF, the phototransistor 16a of the outdoor reception photo coupler 16 is turned ON/OFF on the other hand, and the ON/OFF signal is subsequently inputted to the reception port of the outdoor microcomputer 14. The outdoor microcomputer 14 analyzes the inputted serial signal and replaces this signal with a control signal for operating the outdoor machine 1. Based on a result of this operation, an ON/OFF signal is transmitted, as the serial signal from the outdoor machine 1, from the transmission port of the outdoor microcomputer 14 to the outdoor transmission transistor 15a.

[0015] Next, the outdoor transmission transistor 15a that has received the serial signal transmits the serial signal to the outdoor transmission photo coupler 15. When the outdoor transmission photo coupler 15 has received the serial signal, the photodiode 15b of the outdoor transmission photo coupler 15 is turned ON/OFF and the phototransistor 15c of the outdoor transmission photo coupler 15 is turned ON/OFF. When the phototransistor 15c of the outdoor transmission photo coupler 15 has been turned ON/OFF, the ON/OFF signal of the phototransistor 15 can be superposed on the serial signal received from the outdoor reception photo cou-

pler 16 in the outdoor transmission photo couple 15 connected to the N-phase of the AC power source 10. The superposed serial signal is transmitted from the outdoor transmission photo coupler 15 to the terminal No. N of the outdoor terminal board 1a. The terminal No. N of the outdoor terminal board 1a receives the serial signal, and transmits this signal to the indoor/outdoor connection line 3a that connects the terminal No. N of the outdoor terminal board 1a to the terminal No. N of the indoor terminal board 2a of the indoor machine 2. The serial signal is transmitted through the indoor/outdoor connection line 3a. The terminal No. N of the indoor terminal board 2a receives the serial signal and transmits it to the minus side of the DC power source at the indoor Zener diode 28. In other words, the minus (-) side of the indoor Zener voltage stabilizing electrolytic capacitor 26 acting as a reference ground of the serial communication circuit is turned ON/OFF based on the ON/OFF of the serial signal from the outdoor machine 1, so that the phototransistor of the indoor transmission photo coupler 23 is turned ON/OFF at the outdoor transmission photo coupler 15. The indoor transmission photo coupler 23 receives the serial signal and subsequently transmits it to the indoor reception photo coupler 24, so that the indoor reception photo coupler 24 receives this serial signal. When the photodiode 24b of the indoor reception photo coupler 24 is turned ON/OFF based on the received serial signal, the phototransistor 24a of the indoor reception photo coupler 24 is turned ON/OFF. When the phototransistor 24a of the indoor reception photo coupler 24 is turned ON/OFF, the reception port of the indoor microcomputer 22 becomes Hi/Lo, so that the indoor microcomputer 22 receives and analyzes the serial signal from the outdoor machine, and transmits a new serial signal from the transmission port of the indoor microcomputer 22. Based on the above-described flow of the serial signals, the serial communication between the outdoor machine 1 and the indoor machine 2 is established.

[0016] Next, the first embodiment is described by cases.

Case 1:

[0017] The outdoor terminal board 1a of the outdoor machine 1 and the indoor terminal board 2a of the indoor machine 2 have been erroneously connected in installation as shown by indoor/outdoor connection lines 31 in Fig. 2.

[0018] When the outdoor machine 1 and the indoor machine 2 have been erroneously connected in installation by the indoor/outdoor connection lines 31 and the AC power source 10 is supplied to the outdoor machine 1, the AC power source 10 is supplied to the outdoor control power source 11 of the outdoor machine 1. The outdoor control power source 11 generates a control power supply, and the outdoor machine 1 becomes in a state of waiting for a serial signal from the indoor machine 2.

However, the AC power source 10 is not correctly supplied to the indoor machine 2, since the indoor/outdoor connection lines 31 are connected so as to connect the terminal No. N of the outdoor terminal board 1a of the outdoor machine 1 to the terminal No. N of the indoor terminal board 2a of the indoor machine 2, the terminal No. 2 of the outdoor terminal board 1a to the terminal No. 3 of the indoor terminal board 2a, and the terminal No. 3 of the outdoor terminal board 1a to the terminal No. 2 of the indoor terminal board 2a, respectively. That is, the AC power source 10 is not being supplied between the terminal No. N and the terminal No. 2 of the indoor terminal board 2a of the indoor machine 2, so that the indoor control power source 21 of the indoor machine 2 cannot operate and the indoor machine 2 does not operate (as the indoor microcomputer 22 cannot operate, the indoor machine 2 does not operate even when a trial operation switch has been depressed). On the other hand, the AC power source 10 is supplied between the terminal No. N and the terminal No. 3 of the indoor terminal board 2a of the indoor machine 2. The AC power source 10 supplied from the terminal No. 3 of the indoor terminal board 2a is supplied to the PTC thermistor 24d. However, since the PTC thermistor 24d is connected to cathodes of the second indoor diode 27 and the first indoor diode 24c, no current flows to the second indoor diode 27 and the first indoor diode 24c, so that the serial communication circuit of the indoor machine 2 is protected.

[0019] Further, the AC power source 10 supplied from the terminal No. N of the indoor terminal board 2a is supplied to the second indoor diode 27 of the indoor machine 2. The power source is then supplied to the PTC thermistor 24d, the terminal No. 3 of the indoor terminal board 2a, and then the terminal No. 2 of the outdoor terminal board 1a of the outdoor machine 1 through an indoor/outdoor connection line 31. Then, the power returns to the AC power source 10.

[0020] However, when the AC power source 10 is supplied over the above-described route, an over-current continues to flow because of a low load resistance of its circuit so that the second indoor diode 27 which is a part of the circuit is burnt out. In order to prevent this burning, the internal resistance of the PTC thermistor 24d instantaneously increases from a few Ω to a few $M\Omega$ when the over-current flows to the PTC thermistor 24d. Thus, the over-current is shut off so that the second indoor diode 27 is protected.

[0021] This state where the resistance of the PTC thermistor 24d is a few $M\Omega$, continues until the supply of the AC power source 10 is stopped. After the supply of the AC power source 10 has been stopped, the outdoor machine 1 and the indoor machine 2 are connected correctly by the indoor/outdoor connection lines 3 as shown in Fig. 1 and the AC power source 10 is supplied to the outdoor machine 1. In this way, the normal operation is obtained.

Case 2:

[0022] The outdoor terminal board 1a of the outdoor machine 1 and the indoor terminal board 2a of the indoor machine 2 have been erroneously connected in installation as shown by an indoor/outdoor connection lines 32 in Fig. 2.

[0023] When the outdoor machine 1 and the indoor machine 2 have been erroneously connected in installation by the indoor/outdoor connection lines 32 and the AC power source 10 is supplied to the outdoor machine 1, the AC power source 10 is supplied to the outdoor control power source 11 of the outdoor machine 1. The outdoor control power source 11 generates a control power supply, and the outdoor machine 1 becomes in a state of waiting for a serial signal from the indoor machine 2. However, the AC power source 10 is not correctly supplied to the inner machine 2, since the indoor/outdoor connection lines 32 in the case 2 are connected so as to connect the terminal No. N of the outdoor terminal board 1a of the outdoor machine 1 to the terminal No. 3 of the indoor terminal board 2a of the indoor machine 2, the terminal No. 2 of the outdoor terminal board 1a to the terminal No. N of the indoor terminal board 2a, and the terminal No. 3 of the outdoor terminal board 1a to the terminal No. 2 of the indoor terminal board 2a, respectively.

[0024] Accordingly, the AC power source 10 is not being supplied between the terminal No. N and the terminal No. 2 of the indoor terminal board 2a of the indoor machine 2, so that the indoor control power source 21 of the indoor machine 2 cannot operate and the indoor machine 2 does not operate. In other words, as the indoor microcomputer 22 cannot operate, the indoor machine 2 does not operate even when a trial operation switch has been depressed. On the other hand, the AC power source 10 is supplied between the terminal No. N and the terminal No. 3 of the indoor terminal board 2a of the indoor machine 2. The AC power source 10 supplied from the terminal No. 3 of the indoor terminal board 2a is supplied to the PTC thermistor 24d. However, since the PTC thermistor 24d is connected to the cathodes of the second indoor diode 27 and the first indoor diode 24c, no current flows to the second indoor diode 27 and the first indoor diode 24c, so that the serial communication circuit of the indoor machine 2 is protected. Further, the AC power source 10 supplied from the terminal No. N of the indoor terminal board 2a is supplied to the second indoor diode 27 of the indoor machine 2. The power source is then supplied to the PTC thermistor 24d, the terminal No. 3 of the indoor terminal board 2a, and then the terminal No. N of the outdoor terminal board 1a of the outdoor machine 1 through an indoor/outdoor connection line 32. Then, the power returns to the AC power source 10.

[0025] However, when the AC power source 10 is supplied over the above-described route, an over-current continues to flow because of a low load resistance

of its circuit so that the second indoor diode 27 which is a part of the circuit is burnt out. In order to prevent this burning, the internal resistance of the PTC thermistor 24d instantaneously increases from a few Ω to a few $M\Omega$ when the over-current flows to the PTC thermistor 24d. Thus, the over-current is shut off so that the second indoor diode 27 is protected. This state continues until the supply of the AC power source 10 is stopped. After the supply of the AC power source 10 has been stopped, the outdoor machine 1 and the indoor machine 2 are connected correctly by the indoor/outdoor connection lines 3 as shown in Fig. 1 and the AC power source 10 is supplied to the outdoor machine 1. In this way, the normal operation is obtained.

Case 3:

[0026] The outdoor terminal board 1a of the outdoor machine 1 and the indoor terminal board 2a of the indoor machine 2 have been erroneously connected in installation as shown by indoor/outdoor connection lines 33 in Fig. 3.

[0027] When the outdoor machine 1 and the indoor machine 2 have been erroneously connected in installation by the indoor/outdoor connection lines 33 and the AC power source 10 is supplied to the outdoor machine 1, the AC power source 10 is supplied to the outdoor control power source 11 of the outdoor machine 1. The outdoor control power source 11 generates a control power supply, and the outdoor machine 1 becomes in a state of waiting for a serial signal from the indoor machine 2. However, the AC power source 10 is not correctly supplied to the indoor machine 2, since the indoor/outdoor connection lines 33 are connected so as to connect the terminal No. N of the outdoor terminal board 1a of the outdoor machine 1 to the terminal No. 2 of the indoor terminal board 2a of the indoor machine 2, the terminal No. 2 of the outdoor terminal board 1a to the terminal No. 3 of the indoor terminal board 2a, and the terminal No. 3 of the outdoor terminal board 1a to the terminal No. N of the indoor terminal board 2a, respectively.

[0028] The AC power source 10 is not being supplied between the terminal No. N and the terminal No. 2 of the indoor terminal board 2a of the indoor machine 2, so that the indoor control power source 21 of the indoor machine 2 cannot operate and the indoor machine 2 does not operate. In other words, as the indoor microcomputer 22 cannot operate, the indoor machine 2 does not operate even when a trial operation switch has been depressed. On the other hand, the AC power source 10 is supplied between the terminal No. 2 and the terminal No. 3 of the indoor terminal board 2a of the indoor machine 2. The AC power source 10 supplied from the terminal No. 3 of the indoor terminal board 2a is supplied to the PTC thermistor 24d. However, the PTC thermistor 24d is connected to cathodes of the second indoor diode 27 and the first indoor diode 24c.

[0029] Therefore, no current flows to the second indoor diode 27 and the first indoor diode 24c, so that the serial communication circuit of the indoor machine 2 is protected. On the other hand, the AC power source 10 supplied from the terminal No. 2 of the indoor terminal board 2a is supplied to the indoor half-wave rectifier diode 23d of the indoor machine 2, and then to the indoor current limiting resistor 23e. The indoor current limiting resistor 23e limits the current to such a level that the indoor transmission photo coupler 23 and the indoor reception photo coupler 24 are not broken. Therefore, even if the AC power source 10 is erroneously supplied between the terminal No. 2 and the terminal No. 3 of the indoor terminal board 2a of the indoor machine 2, the serial communication circuit of the indoor machine 2 is protected.

Case 4:

[0030] The outdoor terminal board 1a of the outdoor machine 1 and the indoor terminal board 2a of the indoor machine 2 have been erroneously connected in installation as shown by indoor/outdoor connection lines 34 in Fig. 3.

[0031] When the AC power source 10 has been supplied to the outdoor machine 1, the AC power source 10 is supplied to the outdoor control power source 11 of the outdoor machine 1. The outdoor control power source 11 generates a control power supply, and the outdoor machine 1 becomes in a state of waiting for a serial signal from the indoor machine 2. However, the AC power source 10 is not correctly supplied to the indoor machine 2, since the indoor/outdoor connection lines 34 are connected so as to connect the terminal No. N of the outdoor terminal board 1a of the outdoor machine 1 to the terminal No. 3 of the indoor terminal board 2a of the indoor machine 2, the terminal No. 2 of the outdoor terminal board 1a to the terminal No. 2 of the indoor terminal board 2a, and the terminal No. 3 of the outdoor terminal board 1a to the terminal No. N of the indoor terminal board 2a.

[0032] The AC power source 10 is not being supplied between the terminal No. N and the terminal No. 2 of the indoor terminal board 2a of the indoor machine 2, so that the indoor control power source 21 of the indoor machine 2 cannot operate and the indoor machine 2 does not operate. In other words, as the indoor microcomputer 22 cannot operate, the indoor machine 2 does not operate even when a trial operation switch has been depressed. On the other hand, the AC power source 10 is supplied between the terminal No. 2 and the terminal No. 3 of the indoor terminal board 2a of the indoor machine 2. The AC power source 10 supplied from the terminal No. 3 of the indoor terminal board 2a is supplied to the PTC thermistor 24d. However, since the PTC thermistor 24d is connected to the cathodes of the first indoor diode 24c and the second indoor diode 27, no current flows to the second indoor diode 27 and the first

indoor diode 24c so that the serial communication circuit of the indoor machine 2 is protected.

[0033] The AC power source 10 supplied from the terminal No. 2 of the indoor terminal board 2a is supplied to the indoor half-wave rectifier diode 23d of the indoor machine 2, and then to the indoor current limiting resistor 23e. The indoor current limiting resistor 23e limits the current to such a level that the indoor transmission photo coupler 23 and the indoor reception photo coupler 24 are not broken. Therefore, even if the AC power source 10 is erroneously supplied between the terminal No. 2 and the terminal No. 3 of the indoor terminal board 2a of the indoor machine 2, the serial communication circuit of the indoor machine 2 is protected.

Case 5:

[0034] The outdoor terminal board 1a of the outdoor machine 1 and the indoor terminal board 2a of the indoor machine 2 have been erroneously connected as shown by indoor/outdoor connection lines 35 in Fig. 4.

[0035] When the AC power source 10 is supplied to the outdoor machine 1, the AC power source 10 is outputted from the terminal No. N and the terminal No. 2 of the outdoor terminal board 1a. The AC power source 10 is transmitted through the indoor/outdoor connection lines 35 and is supplied to the terminal No. 2 and the terminal No. N of the indoor terminal board 2a, and thus the AC power source 10 is supplied to the indoor machine 2. Based on the supplied AC power source 10, the outdoor control power source 11 of the outdoor machine 1 generates a control power, so that the outdoor microcomputer 14 operates. Similarly, based on the supplied AC power source 10, the indoor control power source 21 of the indoor machine 2 generates a control power, so that the indoor microcomputer 22 operates. When the microcomputer 22 satisfies a serial communication starting condition which shows a normal operation of the indoor machine 2, and three or more minutes has elapsed since the start of the supply of the AC power source 10, a signal to turn ON/OFF the indoor transmission transistor 23a is transmitted to the indoor transmission transistor 23a from the serial signal transmission port of the indoor microcomputer 22. Upon receiving the transmitted ON/OFF signal, the indoor transmission transistor 23a is ON/OFF operated. When the indoor transmission transistor 23a has been ON/OFF operated, the photodiode 23b of the indoor transmission photo coupler 23 is turned ON/OFF. When the photodiode 23b of the indoor transmission photo coupler 23 has been turned ON/OFF, the phototransistor 23c of the indoor transmission photo coupler 23 is turned ON/OFF. When the phototransistor 23c of the indoor transmission photo coupler 23 has been turned ON/OFF, the indoor half-wave rectifier diode 23d of the indoor machine 2 rectifies the power supplied from the AC power source 10 into half-wave form. The half-wave-rectified AC power source 10 passes through the indoor current limiting re-

sistor 23e which is a resistor for limiting a current to a level not to destroy the indoor transmission photo coupler 23 and the indoor reception photo coupler 24, and makes a non-insulated DC power source at the indoor Zener diode 28. The voltage and current of the DC power source are turned into a serial signal for communication between indoor and outdoor machines based on the ON/OFF of the indoor transmission photo coupler 23. The serial signal is transmitted from the indoor transmission photo coupler 23 to the indoor reception photo coupler 24. After the indoor reception photo coupler 24 has received the serial signal, the indoor reception photo coupler 24 transmits this signal to the first indoor diode 24c. After the first indoor diode 24c has received the serial signal, the first indoor diode 24c transmits this signal to the PTC thermistor 24d. After the PTC thermistor 24d has received the serial signal, the PTC thermistor 24d transmits this signal to the terminal No. 3 of the indoor terminal board 2a. The indoor terminal board 2a transmits the received serial signal to an indoor/outdoor connection line 35 that connects the terminal NO. 3 of the indoor terminal board 2a to the terminal No. 3 of the first outdoor terminal board 1a of the outdoor machine 1. The serial signal is transmitted through the indoor/outdoor connection line 35, so that the serial signal is received by the terminal No. 3 of the outdoor terminal board 1a of the outdoor machine 1. The received serial signal is transmitted from the terminal No. 3 of the outdoor terminal board 1a to the outdoor diode 16d. The outdoor diode 16d receives the serial signal and transmits it to the outdoor current limiting resistor 16c.

[0036] When the outdoor current limiting resistor 16c has received the serial signal, the outdoor current limiting resistor 16c transmits the serial signal to the outdoor reception photo coupler 16. When the outdoor reception photo coupler 16 has received the serial signal, the outdoor reception photo coupler 16 transmits the serial signal to the outdoor transmission photo coupler 15 on the one hand. That is, when the photodiode 16b of the outdoor reception photo coupler 16 has been turned ON/OFF, the phototransistor 16a of the outdoor reception photo coupler 16 is turned ON/OFF on the other hand, and the ON/OFF signal is subsequently inputted to the reception port of the outdoor microcomputer 14. The outdoor microcomputer 14 analyzes the inputted serial signal and replaces this signal with a control signal for operating the outdoor machine 1. Based on a result of this operation, an ON/OFF signal is transmitted as the serial signal from the outdoor machine 1 from the transmission port of the outdoor microcomputer 14 to the outdoor transmission transistor 15a. Next, the outdoor transmission transistor 15a that has received the serial signal transmits the serial signal to the outdoor transmission photo coupler 15. When the outdoor transmission photo coupler 15 has received the serial signal, the photodiode 15b of the outdoor transmission photo coupler 15 is turned ON/OFF, and the phototransistor 15c of the outdoor transmission photo coupler 15 is turned

ON/OFF. When the phototransistor 15c of the outdoor transmission photo coupler 15 has been turned ON/OFF, the ON/OFF signal of the phototransistor 15c can be superposed on the serial signal received from the outdoor reception photo coupler 16, in the outdoor transmission photo coupler 15 connected to the N-phase of the AC power source 10. The superposed serial signal is transmitted from the outdoor transmission photo coupler 15 to the terminal No. N of the outdoor terminal board 1a. The terminal No. N of the outdoor terminal board 1a receives the serial signal, and transmits this signal to the indoor/outdoor connection line 35 that connects the terminal No. N of the outdoor terminal board 1a and the terminal No. 2 of the indoor terminal board 2a of the indoor machine 2. The serial signal is transmitted through the indoor/outdoor connection line 35. The terminal No. 2 of the indoor terminal board 2a received the serial signal and transmits it again to the indoor half-wave rectifier diode 23d. However, as the serial communication circuit is not connected to the DC power source at the indoor Zener diode 28, the serial communication is not established. At this point of time, a sign of malfunction is displayed on a monitor of the indoor machine 2 to inform the abnormal situation.

[0037] Fig. 5 is a flowchart showing the operation of the air conditioner of this invention. The flowchart will be explained. At step SP1, the indoor machine and the outdoor machine are connected in installation. At step SP2, the AC power source is supplied to the outdoor machine. Then, at step SP3, the trial operation switch of the indoor machine is depressed. At step SP4, it is confirmed whether the indoor machine operates or not. If the indoor machine operates, at step SP5, lapse of three minutes is waited after the supply of the AC power source has been started at step SP2. Then, at step SP6, if both the outdoor machine and the indoor machine operate normally, the connection in installation is completed. If the outdoor machine and the indoor machine do not operate normally at step SP6, the AC power source is turned OFF at step SP8. When the AC power source has been turned OFF, an erroneous wiring connection lines between the indoor machine and the outdoor machine is checked at step SP9. If there is an erroneous wiring, the erroneous wiring between the indoor machine and the outdoor machine is corrected at step SP10. The process then returns to step SP2 again, and the AC power source is turned ON. At step SP9, if the wiring is correct without an erroneous wiring, the process proceeds to step SP11. As the air conditioner does not operate normally because of other factors than the erroneous wiring between the indoor machine and the outdoor machine, other parts such as a board are checked and replaced. The process returns again to step SP2, and the AC power source is turned ON.

[0038] On the other hand, at step SP4, it is checked whether the indoor machine operates or not. If the indoor machine does not operate, an erroneous wiring of the connection lines between the indoor machine and

the outdoor machine is recognized at step SP12. At this point of time, although the AC power source is supplied to the serial signal circuit by the erroneous wiring, it is possible to protect the serial circuit of the indoor machine by the PTC thermistor, the indoor current limiting resistor and the indoor diode at step SP13. In other words, instead of turning OFF the AC power source at step SP14, the AC power source may be turned OFF at the point of time when the erroneous wiring has been found. After the AC power source has been turned OFF, the connection between the indoor machine and the outdoor machine is corrected at step SP15. Then, the process returns to step SP2 again, and the AC power source is turned ON. It is confirmed at step SP3 and step SP4 that the indoor machine and the outdoor machine operate normally. The process becomes END at step SP7 after passing through step SP5 and step SP6.

[0039] As explained above, according to the present invention, even if the indoor machine and the outdoor machine have been erroneously connected and then the AC power source is supplied, the serial circuit is not destroyed so that replacement of the boards caused by the erroneous wiring is not necessary. As a result, the shipment rate of free services boards is decreased, the profit rate is increased, and replacement of the boards in installation becomes unnecessary. Thus, the installation efficiency is increased. Further, in the case where the serial circuit of the indoor machine shown in Figs. 1 to 4 is used, even if the response of the PTC thermistor is delayed and the change in its resistance from a few Ω to a few $M\Omega$ is delayed, only the second indoor diode 27 is loaded and the indoor transmission photo coupler 23 and the indoor reception photo coupler 24 are not influenced at all. Therefore, the continued use of the boards can be ensured in future without replacing the boards.

Second Embodiment

[0040] Fig. 6 is a block diagram showing a structure in which the outdoor machine and the indoor machine have been connected normally in a second embodiment. In Fig. 6, the PCT thermistor 24d in the first embodiment is replaced by a fuse 29 and the other constitution is the same as in Fig. 1. In this constitution, the fuse 29 is blown off when an over-current flows in the communication circuit due to an erroneous wiring.

Third Embodiment

[0041] A structure and operation of a third embodiment of this invention will be explained with reference to Fig. 7.

[0042] First, as shown in this drawing, when an outdoor terminal board (403) of an outdoor machine (401) and an indoor terminal board (413) of an indoor machine (412) of an air conditioner have been connected by indoor/outdoor connection lines (411), and an AC power

source (402) is supplied to the outdoor machine (401), the AC power source (402) outputted from the terminal No. N and terminal No. 2 of the outdoor terminal board (403) is supplied to the terminal No. N and terminal No. 2 of the indoor terminal board (413) via the indoor/outdoor connection lines (411), so that the power is supplied to the indoor machine (412). The power is converted into a low voltage by an indoor control power source (420) of the indoor machine (412) to create an indoor control power supply for operating an indoor microcomputer (434).

[0043] At the same time, the AC power is similarly converted into a low voltage by an outdoor control power source (404) in the outdoor machine (401), to create an outdoor control power supply for operating an outdoor microcomputer (405).

[0044] Next, when an indoor microcomputer (434) is operated by the indoor control power supply, an indoor choke coil (416) removes noise from the AC power source (402) which is a commercial power supply to make the AC power source without noise. The power source is then half-wave rectified by an indoor half-wave rectifier diode (421) which is connected to the N-phase of the neutral line, that is, the terminal No. N of the indoor terminal board (413) of the indoor machine (412). After that, the power source flows to an indoor current limiting resistor (422) which limits it to a current level that does not destroy the photodiode of an indoor zero-crossing photo coupler (423), and is then transmitted to the indoor zero-crossing photo coupler (423).

[0045] As a result, the photodiode of the indoor zero-crossing photo coupler (423) makes its phototransistor ON/OFF operate. At the same time, this ON/OFF signal is transmitted to a zero-crossing input terminal of the indoor microcomputer (434). Therefore, the indoor microcomputer controls the operation of the indoor machine based on this operation signal.

[0046] In this case, the limited current that has passed through the photodiode of the indoor zero-crossing photo coupler (423) returns to the L-phase on the opposite side of the neutral line of the AC power source (402) (the terminal No. 2 of the indoor terminal board of the indoor machine). The above is the structure and operation of the zero-crossing circuit that detects the frequency of a commercial power supply by half-wave rectification.

[0047] Next, a structure and operation of the serial communication circuit will be explained.

[0048] First, the indoor microcomputer (434) that has received the serial signal transmits a serial signal from its transmission port to turn ON/OFF an indoor transmission transistor (432), thereby making the serial communication circuit operate. Next, the photodiode of the indoor transmission photo coupler (431) connected to this indoor transmission transistor (432) is turned ON/OFF so that its phototransistor is accordingly turned ON/OFF.

[0049] Further, based on the ON/OFF operation of this phototransistor, the power supplied from the L-phase opposite to the neutral line of the AC power

source (402) is half-wave rectified by an indoor communication half-wave rectifier diode (424). Further, an indoor serial current limiting resistor (425) limits the power source to a current level that does not destroy the indoor transmission photo coupler (431) and an indoor reception photo coupler (433). Thereafter, an indoor Zener diode (426) converts the power source into a non-insulated DC power supply.

[0050] Next, based on the ON/OFF of the indoor transmission photo coupler (431), the voltage and current of the converted DC power supply are turned into a serial signal that is a communication signal between indoor and outdoor machines. This serial signal is transmitted to an indoor diode (429) via the indoor reception photo coupler (433), and then the terminal No. 3 of the indoor terminal board (413) connected to the terminal No. 3 of the outdoor terminal board (403) via an PTC thermistor (430).

[0051] Next, the serial signal transmitted to the terminal No. 3 of this outdoor terminal board (403) is transmitted to an outdoor current limiting resistor (408) via an outdoor diode (407). The serial signal is then limited to a current level that does not destroy the photodiode of an outdoor photo coupler (406), and transmitted to an outdoor transmission photo coupler (410) via the photodiode of the outdoor reception photo coupler (406).

[0052] As a result, the photodiode of the outdoor reception photo coupler (406) is turned ON/OFF and its phototransistor is consequently turned ON/OFF. When the ON/OFF signal is inputted to the reception port of the outdoor microcomputer (405), the outdoor microcomputer (405) analyzes the received serial signal, generates a control signal based on a result of this analysis, controls the operation of the outdoor machine (401), and transmits contents of the control as a serial signal (an ON/OFF signal) from the transmission port to the outdoor transmission photo coupler (410) via an outdoor transmission transistor (409). As a result, the photodiode of the outdoor transmission photo coupler (410) is turned ON/OFF, and at the same time, its phototransistor is also turned ON/OFF.

[0053] Therefore, the ON/OFF signal transmitted from the outdoor transmission transistor (409) to the outdoor transmission photo coupler (410) is superposed on the serial signal received from the outdoor reception photo coupler (406) in the outdoor transmission photo coupler (410) connected to the N-phase.

[0054] Next, the superposed serial signal is transmitted from the outdoor transmission photo coupler (410) to the terminal No. N of the outdoor terminal board (403), the terminal No. N of the indoor terminal board (413) connected to the terminal No. N of the outdoor terminal board (403), and then the minus side of the DC power source at the indoor Zener diode (426) connected to the terminal No. N of the indoor terminal board (413).

[0055] As a result, a reference ground of the serial communication circuit which is the minus side of an indoor Zener voltage stabilization electrolytic capacitor

(427) is also turned ON/OFF according to the ON/OFF serial signal from the outdoor transmission photo coupler (410). Consequently, the phototransistor of the indoor transmission photo coupler (431) is turned ON/OFF, and the photodiode connected to the phototransistor is also turned ON/OFF.

[0056] Next, based on the ON/OFF of this photodiode, the reception port of the indoor microcomputer (434) turns Hi/Lo, and the indoor microcomputer (434) analyzes the serial signal from the outdoor machine and transmits a new serial signal from the transmission port of the indoor microcomputer (434).

[0057] As explained above, the power supply for the serial communication circuit between the indoor machine and the outdoor machine is taken in from the L-phase opposite to the N-phase of the AC power source, and the power supply for the zero-crossing circuit to detect the frequency of the AC power source is taken in through a half-wave rectifier diode from the N-phase which is a neutral line of the AC power source. Therefore, the respective DC component currents are not added together, and these currents flow to respective phases of the AC power source, so that a highly reliable control circuit for a separate type air conditioner that prevents an occurrence of a malfunction of each machine caused by higher harmonics can be obtained as a result.

[0058] Furthermore, a structure and operation of other example of the third embodiment will be explained with reference to Fig. 8.

[0059] First, as shown in this drawing, when an outdoor terminal board (503) of an outdoor machine (501) and an indoor terminal board (513) of an indoor machine (512) of an air conditioner have been connected by indoor/outdoor connection lines (511) and an AC power source is supplied to the indoor machine (512), the AC power source (502) outputted from a terminal No. N and a terminal No. L of the indoor terminal board (513) is converted into a low voltage by an indoor control power source (520) and makes an indoor control power supply to operate an indoor microcomputer (534).

[0060] Next, an indoor choke coil (516) removes noise from the AC power source (502) of a commercial power supply. The power source is rectified in half wave form by an indoor half-wave rectifier diode (521) connected to the N-phase of the neutral line, that is, the terminal No. N of the indoor terminal board (513) of the indoor machine (512). After that, the rectified power supply is transmitted to an indoor current limiting resistor (522) to limit it to a current level that does not destroy a photodiode of an indoor zero-crossing photo coupler (523), and then transmitted to the indoor zero-crossing photo coupler (523). As a result, the photodiode of the indoor zero-crossing photo coupler (523) makes its phototransistor ON/OFF. At the same time, this signal is inputted to a zero-crossing input port of the indoor microcomputer (534) so that the indoor microcomputer controls the operation of the indoor machine based on this signal.

[0061] In this case, the current that has passed

through the photo diode of the indoor zero-crossing photo coupler (523) returns to the L-phase opposite to the neutral line of the AC power source (502), that is, the terminal No. L of the indoor terminal board (513) of the indoor machine (512). The above is the structure and operation of the zero-crossing circuit to detect the frequency of the AC power supply by half-wave rectification.

[0062] Next, the serial communication circuit will be explained.

[0063] First, in this serial communication circuit, a signal for turning ON/OFF an indoor transmission transistor (532) is transmitted from the serial signal transmission port of the indoor microcomputer (534). Next, the photodiode of the indoor transmission photo coupler (531) connected to this indoor transmission transistor (532) is turned ON/OFF so that the phototransistor of the indoor transmission photo coupler (531) is subsequently turned ON/OFF.

[0064] However, at this point of time, since a 52C relay (535) in the drawing has not yet been turned ON, the L-phase opposite to the neutral line of the AC power source (502) at the terminal No. L of the indoor terminal board (513) of the indoor machine (512) is not supplied to a terminal No. 2 of the indoor terminal board. Therefore, the serial communication circuit does not operate, and waits (for three minutes, for example).

[0065] Next, when the indoor microcomputer (534) judges that the serial communication starting condition has been satisfied, in other words, the indoor machine 512 normally operates after the lapse of three or more minutes since the starting of the supply of the AC power source (502), the indoor microcomputer (534) transmits an ON signal to a 52C relay driving transistor (536) thereby to turn ON the 52C relay. Therefore, the L-phase opposite to the neutral line of the AC power source (502) is connected to a terminal No. 2 of the outdoor terminal board (503) of the outdoor machine (501) of the air conditioner via the terminal No. 2 of the indoor terminal board (513) of the indoor machine (512) and an indoor/outdoor connection line (511). Thus, the AC power source (502) is supplied to the outdoor machine (501) of the air conditioner.

[0066] Next, the AC power source (502) supplied to the outdoor machine (501) is supplied to the outdoor control power source (504), so that the outdoor microcomputer (505) operates to operate the outdoor machine. At the same time, the AC power source (502) is also supplied to the serial communication circuit of the indoor machine (512).

[0067] However, at this point of time, the indoor transmission transistor (532) and the subsequent phototransistor of the indoor transmission photo coupler (531) are turned ON/OFF according to the serial signal of the indoor microcomputer (534). Therefore, the following operation is added.

[0068] The power source supplied from the terminal No. L of the indoor terminal board (513) of the indoor

machine (512) is half-wave rectified by the indoor communication half-wave rectifier diode (524), and then limited by an indoor serial current limiting resistor (525) to a current level that does not destroy the indoor transmission photo coupler (531) and the indoor reception photo coupler (533). Then, an indoor Zener diode (526) converts the power source into a non-insulated DC power supply. Based on the ON/OFF of the indoor transmission photo coupler (531), the power supply is turned into a serial communication signal between the indoor and outdoor machines. The serial communication signal is transmitted to an indoor communication diode (529) via the indoor reception photo coupler (533), and then to a terminal No. 3 of the indoor terminal board (513) via an indoor serial current limiting resistor 2 (530).

[0069] Next, the serial signal is transmitted to the terminal No. 3 of the outdoor terminal board (503) of the outdoor machine (501) connected to the indoor terminal board (513), and then to an outdoor current limiting resistor (508) via an outdoor diode (507). Thereafter, the serial signal is further transmitted to an outdoor transmission photo coupler (510) via an outdoor reception photo coupler (506). As a result, the photodiode of the outdoor reception photo coupler (506) is turned ON/OFF, and at the same time, its phototransistor is also turned ON/OFF.

[0070] Next, the ON/OFF signal is inputted to the reception port of the outdoor microcomputer (505) according to the ON/OFF of the phototransistor. The outdoor microcomputer (505) then analyzes the inputted result and substitutes a control signal to operate the outdoor machine (501). Therefore, the ON/OFF signal is transmitted as a serial signal from the outdoor microcomputer (505) to the outdoor transmission transistor (509), and the photodiode of the outdoor transmission photo coupler (510) is turned ON/OFF so that its phototransistor is also turned ON/OFF. By this ON/OFF, the ON/OFF signal transmitted from the outdoor transmission transistor to the outdoor transmission photo coupler (510) is superposed on the serial signal received from the outdoor reception photo coupler (506), in the outdoor transmission photo coupler (510) connected to the N-shape of the AC power source.

[0071] Next, the superposed serial signal is transmitted from the outdoor transmission photo coupler (510) to the terminal No. N of the outdoor terminal board (503), received by the terminal No. N of the indoor terminal board (513), and then transmitted to the minus side of the DC power source at indoor Zener diode (526). Therefore, a reference ground of the serial communication circuit which is the minus side of an indoor Zener voltage stabilizing electrolytic capacitor (527) is turned ON/OFF based on the serial signal from the outdoor transmission photo coupler (510). As a result, the phototransistor of the indoor transmission photo coupler (533) is also turned ON/OFF, and the photodiode connected to the phototransistor is also turned ON/OFF.

[0072] As a result, the reception port of the indoor mi-

crocomputer (534) turns Hi/Lo, so that the indoor microcomputer (534) receives and analyzes the serial signal from the outdoor machine to transmit a new serial signal from its transmission port.

[0073] As explained above, after the indoor microcomputer has confirmed the operation state of the indoor machine, the power supply for the serial communication circuit between the indoor machine and the outdoor machine is taken in from the L-phase opposite to the N-phase of the AC power source. Then, the power supply for the zero-crossing circuit to detect the frequency of the AC power supply is taken in through a half-wave rectifier diode, from the N-phase of the neutral line of the AC power source. Therefore, after confirming the operation state of the indoor machine, the respective DC component currents are not added together, and these currents flow to respective phases of the AC power source, so that a highly reliable control circuit for a separate type air conditioner that prevents an occurrence of a malfunction of each machine caused by a higher harmonics can be obtained as a result.

[0074] Further, Fig. 9 is a control circuit of a case where an AC power source is provided separately for the outdoor machine (601) and the indoor machine (612). Based on this arrangement, a power supply wiring for supplying the AC power source from the outdoor machine (601) to each indoor machine (612) is not necessary.

Fourth Embodiment

[0075] A structure and operation of a fourth embodiment will be explained with reference to Fig. 10.

[0076] First, as shown in this drawing, when an outdoor terminal board (803) of an outdoor machine (801) and an indoor terminal board (813) of an indoor machine (812) of an air conditioner have been connected with an indoor/outdoor connection lines (811), and an AC power source (802) is supplied to the outdoor machine (801), the AC power source (802) outputted from a terminal No. N and a terminal No. 2 of the outdoor terminal board (803) is transmitted through the indoor/outdoor connection line (811) and is supplied to a terminal No. N and a terminal No. 2 of the indoor terminal board (813). On the outdoor machine side, an outdoor control power source (804) generates control power supply to operate an outdoor microcomputer (805). Similarly, on an indoor machine side, an indoor control power source (820) generates control power supply to operate an indoor microcomputer (834).

[0077] Next, when this indoor microcomputer (834) has been operated, an indoor choke coil (816) removes noise from the AC power source (802) as a commercial power supply to make an AC power source without noise. The power source is then rectified in half-wave form by an indoor half-wave rectifier diode (821) connected to the L-phase opposite to the neutral line, that is, the terminal No. 2 of the indoor terminal board (813)

of the indoor machine (812), and then transmitted to an indoor zero-crossing photo coupler (823).

[0078] As a result, the phototransistor of the indoor zero-crossing photo coupler (823) ON/OFF operates. This ON/OFF operation signal is inputted to the zero-crossing input port of the indoor microcomputer (834), so that the indoor microcomputer controls the operation of the indoor machine based on this signal.

[0079] Incidentally, the current that has passed through the photodiode of the indoor zero-crossing photo coupler (823) returns to the N-phase of the neutral line of the AC power source (802), that is, the terminal No. N of the indoor terminal board (813) of the indoor machine (812). The above is the structure and operation of the zero-crossing circuit.

[0080] Next, the indoor microcomputer (834) that has received the serial signal by the above operation of the zero-crossing circuit starts a serial communication.

[0081] That is, the indoor microcomputer (834) transmits a serial signal from its transmission port to an indoor transmission transistor (832), to operate the transistor (832). The photodiode of an indoor transmission photo coupler (831) connected to this indoor transmission transistor (832) is turned ON/OFF, and its phototransistor is consequently turned ON/OFF.

[0082] Next, based on the ON/OFF operation of this phototransistor, the power supplied from the N-phase of the neutral line of the AC power source (802) is half-wave rectified by an indoor communication half-wave rectifier diode (824), and limited by an indoor serial current limiting resistor (825) to a current level that does not destroy the indoor transmission photo coupler (831) and an indoor reception photo coupler (833). Thereafter, an indoor Zener diode (826) converts the power source into a non-insulated DC power supply.

[0083] Next, based on the ON/OFF of the indoor transmission photo coupler (831), the voltage and current of the converted DC power supply is turned into a serial signal which is a communication signal between the indoor and outdoor machines. This serial signal is transmitted to an indoor communication diode (829) via the indoor reception photo coupler (833), and thereafter, to a terminal No. 3 of the indoor terminal board (813) connected to a terminal No. 3 of the outdoor terminal board (803), via an PTC thermistor (830).

[0084] Next, the serial signal transmitted from the indoor terminal board (813) to the terminal No. 3 of the outdoor terminal board (803) is further transmitted to an outdoor current limiting resistor (808) via an outdoor diode (807). The current of the serial signal is then limited, and the serial signal is then transmitted to an outdoor transmission photo coupler (810) via the outdoor reception photo coupler (806).

[0085] As a result, the photodiode and phototransistor of the outdoor communication reception photo coupler (806) are turned ON/OFF so that the ON/OFF signal is inputted to the reception port of the outdoor microcomputer (805). The outdoor microcomputer (805) analyzes

this signal, generates a control signal based on a result of this analysis so as to control the operation of the outdoor machine (801). At the same time, the control contents are transmitted as a serial signal from its transmission port to the outdoor transmission photo coupler (810) via an outdoor transmission transistor (809).

[0086] Therefore, the serial signal from the outdoor transmission transistor (809) and the serial signal received from the outdoor reception photo coupler (806) are combined and superposed together by the outdoor transmission photo coupler (810) connected to the L-phase.

[0087] Next, the superposed serial signal is transmitted from the outdoor transmission photo coupler (810) to the terminal No. 2 of the outdoor terminal board (803), and then to the terminal No. 2 of the indoor terminal board (813) via an indoor/outdoor connection line (811). Therefore, the serial signal is transmitted to the minus side of the DC power source at the indoor Zener diode (826) connected to the terminal No. 2 of the indoor terminal board (813).

[0088] As a result, a reference ground of the serial communication circuit which is the minus side of an indoor Zener voltage stabilization electrolytic capacitor (827) is also turned ON/OFF by the ON/OFF serial signal from the outdoor machine (801). Therefore, the phototransistor of the indoor transmission photo coupler (833) is turned ON/OFF, and photodiode connected to the phototransistor is also turned ON/OFF.

[0089] Next, based on the ON/OFF of this photodiode, the reception port of the indoor microcomputer (834) is turned Hi/Lo, so that the indoor microcomputer (834) receives and analyzes the serial signal from the outdoor machine. Thus, a new serial signal is transmitted from the transmission port of the indoor microcomputer (834).

[0090] Based on the above flow of the serial signal, a serial communication is established between the outdoor machine (801) and the indoor machine (812).

[0091] As explained above, the power supply for the zero-crossing circuit is taken in from the L-phase opposite to the N-phase of the AC power source, and the power supply for the serial communication circuit is taken in from the N-phase of the neutral line of the AC power source. Therefore, the respective DC component currents are not added together, and these currents flow to respective phases of the AC power source so that a highly reliable control circuit for a separate type air conditioner that prevents an occurrence of a malfunction of each machine caused by higher harmonics can be obtained as a result.

Fifth Embodiment

[0092] A structure and operation of a fifth embodiment will be explained with reference to a flowchart of Fig. 11.

[0093] The fifth embodiment is constituted such that, in relation to the shifting from the zero-crossing circuit operation to the serial communication circuit operation

in the third or fourth embodiment, it is judged whether or not the indoor machine has been normally operated in the zero-crossing circuit operation for a predetermined time period. If the indoor machine is normally operated, the operation shifts from the zero-crossing circuit to the serial communication circuit.

[0094] First, as shown in the flowchart, the indoor machine and the outdoor machine of the air conditioner are installed and wired (701). After the AC power source has been turned on (702), a trial operation switch of the indoor machine is depressed or the operation is remote controlled, that is, an ON signal is transmitted (703). When three minutes has passed (704) since then an indoor microcomputer judges whether the operation state of the indoor machine is normal or abnormal (705).

[0095] Next, when the result of the judgement is an abnormal state (NO), the indoor microcomputer issues instructions for displaying the abnormal state, stopping in the abnormal state (actuator), and starting count of a restarting time (three minutes, for example) (710), so that the display of abnormality, the abnormal stopping (actuator), and the time counting (710) are carried out. After three minutes (711), the process returns to step (705). The indoor microcomputer judges again whether the operation state of the indoor machine is normal or abnormal. When a result is NO, the same operation is repeated.

[0096] Further, when the operation state of the indoor machine is normal (YES) at step (705), the indoor microcomputer instructs the indoor serial communication circuit to start transmitting a serial signal (706) so that the indoor serial communication circuit transmits the serial signal to the indoor machine and the outdoor machine respectively via an indoor/outdoor connection line.

[0097] Next, an outdoor microcomputer judges whether the operation state of the outdoor machine is normal or abnormal after receiving this serial signal (707). When the operation state is abnormal (NO), the outdoor microcomputer transmits a serial abnormal signal representing this abnormal state to outdoor serial communication circuit. Then, the outdoor serial communication circuit transmits the serial abnormal signal to the indoor microcomputer via the indoor serial communication circuit (709).

[0098] Next, the indoor microcomputer having received the serial abnormal signal (709) issues an instruction for displaying the abnormal state, stopping in the abnormal state (actuator), and starting count for three-minutes (710). After three minutes (711), the process returns to step (705). The indoor microcomputer then judges whether the operation state of the indoor machine is normal or abnormal. When a result is NO, a similar operation is repeated.

[0099] When the operation state of the outdoor machine is normal (YES) at the above step 707, the outdoor microcomputer transmits its contents to the indoor microcomputer via the indoor/outdoor connection line, and

indoor microcomputer having received the contents transmits a serial signal representing the latest operation state information of the indoor machine to the outdoor machine. Therefore, the both machines can continue to operate confirming the operation state of each other. At the same time, the serial communication is started after a predetermined time since a remote control or the like issues the instruction of operation ON. Therefore, at the starting time for the first three minutes, the DC current component is generated in only the zero-crossing circuit.

[0100] As explained above, according to this invention, at the time of shifting from the zero-crossing circuit operation to the serial communication circuit operation, a judgement is made whether the indoor machine in operation state of the zero-crossing circuit is operating normally or not during the predetermined period of time. When the operation is normal, the operation shifts to the serious communication circuit operation. Therefore, a DC current component is not generated in the serial communication circuit during the predetermined period of time (three minutes, for example) after the power supply has been started, so as to prevent wasting of electricity. As a result, it is possible to obtain an economic and highly reliable control circuit which can securely communicate, for a separate type air conditioner.

Claims

1. A control circuit for a separate type air conditioner which consists of an outdoor machine (1) and an indoor machine (2) connected together by a power line and a communication line,
characterized in that:
the control circuit comprises a transmission photo coupler (23), a reception photo coupler (24) and a controller (22), arranged in a communication circuit of the indoor machine;
the transmission photo coupler (23) and the reception photo coupler (24) are connected together in series;
the transmission photo coupler (23) and the reception photo coupler (24) are connected respectively to the controller (22); and
the reception photo coupler (24) is connected in series to a current stopper (24d, 29) to cut off a current of the circuit in response to an over-current more than a predetermined current value.
2. A control circuit for a separate type air conditioner according to claim 1, the control circuit comprises a transmission photo coupler (23), a reception photo coupler (24) and a controller (22), arranged in a communication circuit of the indoor machine;

a phototransistor (23c) of the transmission photo coupler and a photodiode (24b) of the reception photo coupler are connected together in series; a photodiode (23b) of the transmission photo coupler and a phototransistor (24a) of the reception photo coupler are connected respectively to the controller (22); and the photodiode (24b) of the reception photo coupler is connected in series to a current stopper (24d, 29) to cut off a current of the circuit in response to an over-current more than a predetermined current value.

3. A control circuit for a separate type air conditioner according to claim 1 or 2, wherein the current stopper is a PTC thermistor (24d).
4. A control circuit for a separate type air conditioner according to claim 1 or 2, wherein the current stopper is a fuse (29).
5. A control circuit for a separate type air conditioner which consists of an outdoor machine (401) and an indoor machine (412) connected together by a power line and a communication line and is operated under the control of communications by a serial signal between the outdoor machine and the indoor machine,
characterized in that:

the control circuit comprises a zero-crossing circuit (423) to detect a frequency of a commercial power source from the power line and a power supply for a serial communication circuit (431, 433), both provided in the indoor machine;
a power is supplied to the zero-crossing circuit (423) from the N-shape of a neutral line of the commercial power source (402);
and a power is supplied to the power supply for a serial communication circuit (431, 433) from the L-phase opposite to the neutral line.

6. A control circuit for a separate type air conditioner which consists of an outdoor machine (801) and an indoor machine (812) connected together by a power line and a communication line and is operated under control of communications by a serial signal between the outdoor machine and the indoor machine,
characterized in that:

the control circuit comprises a zero-crossing circuit (823) to detect a frequency of a commercial power source from the power line and a power supply for a serial communication circuit (831, 833), both provided in the indoor machine;

a power is supplied to the zero-crossing circuit (823) from the L-phase opposite to a neutral line of the commercial power source (802) and a power is supplied to the power supply for a serial communication circuit (831, 833) from the N-phase of the neutral line. 5

7. A control circuit for a separate type air conditioner according to any one of Claim 5 or 6, wherein the control circuit makes a decision about whether the operation state of the indoor machine is normal or not after a predetermined period of time since the power supply to the zero-crossing circuit has been started, and starts to the operation of the serial communication circuit when the operation of the indoor machine is normal. 10 15
8. A control circuit for a separate type air conditioner according to Claim 7, wherein the control circuit has a relay (535) in the serial communication circuit (531, 533), and operates the relay to start the operation of the serial communication circuit when the operation state of the indoor machine is normal. 20

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FIG. 1

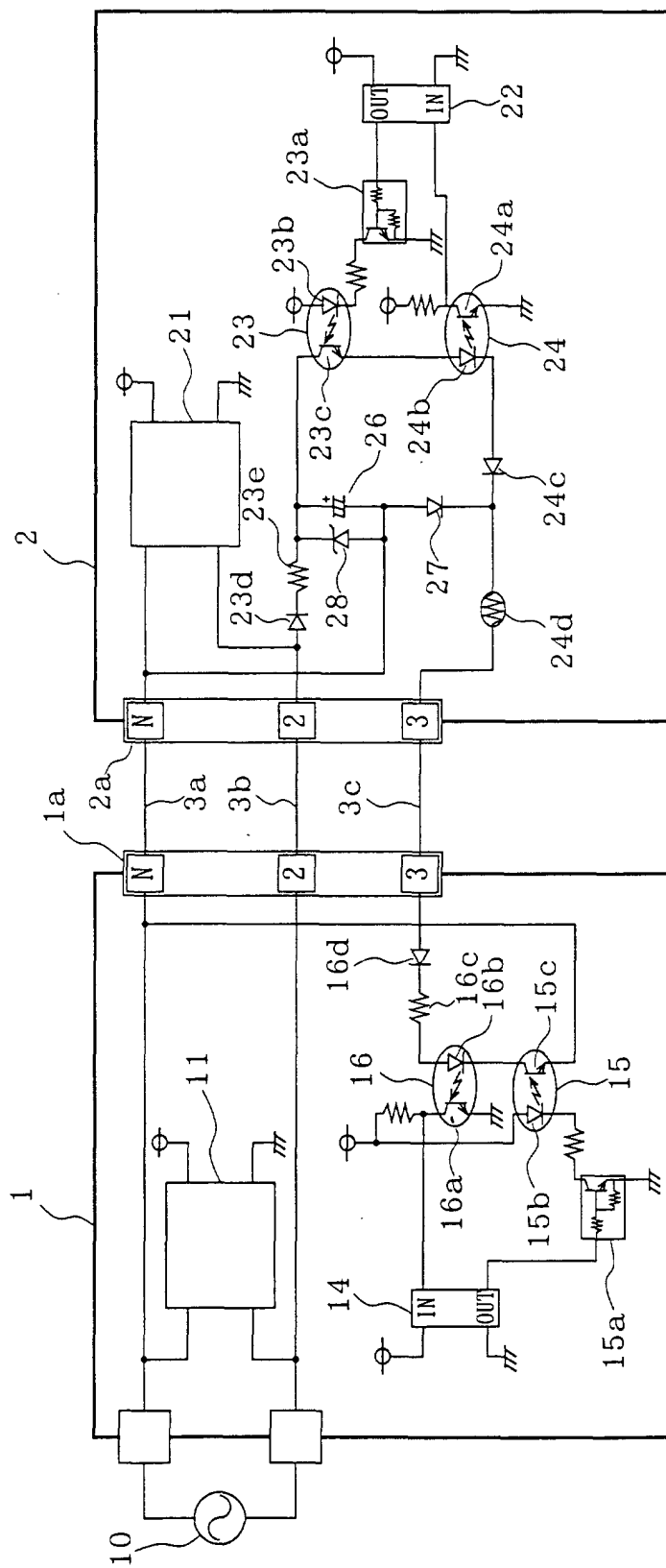


FIG. 2

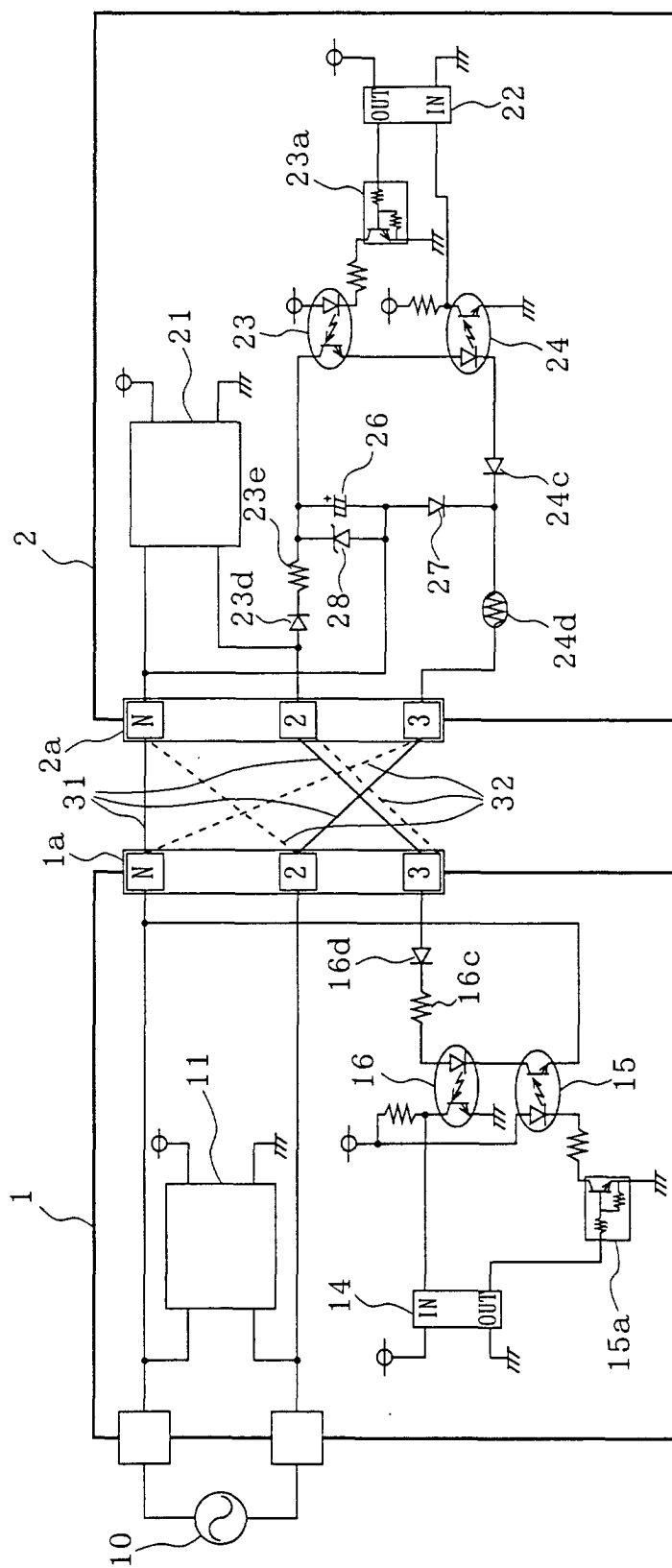


FIG. 3

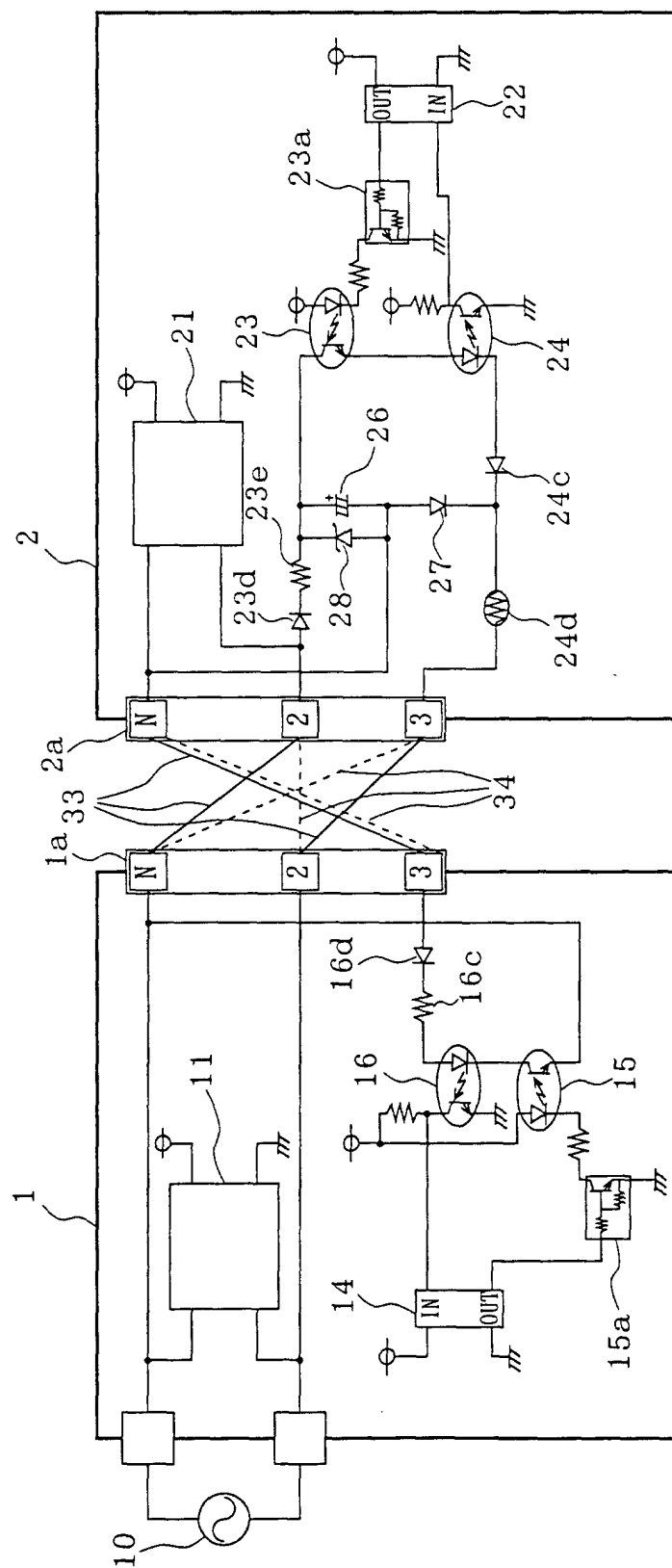


FIG. 5

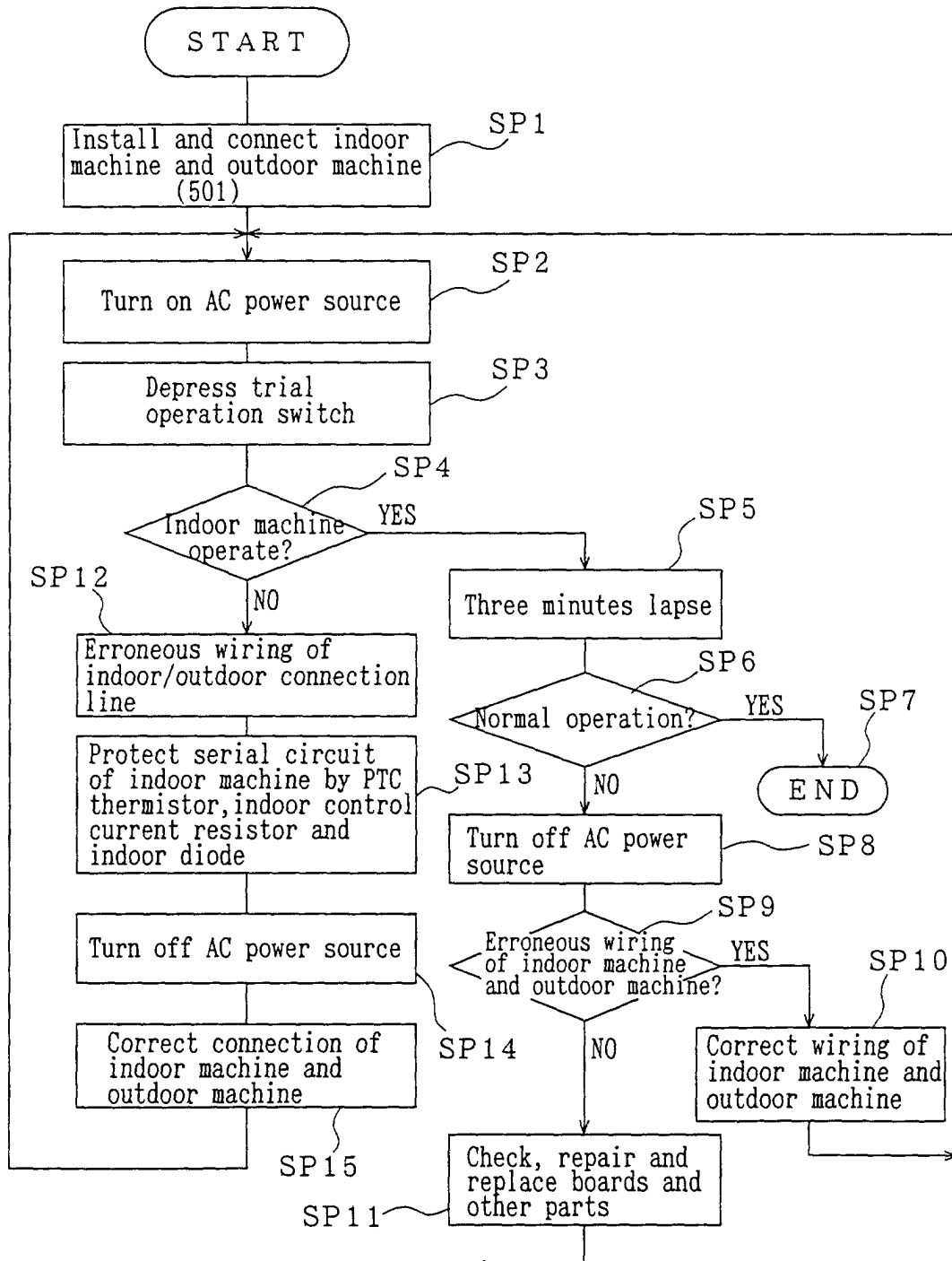


FIG. 6

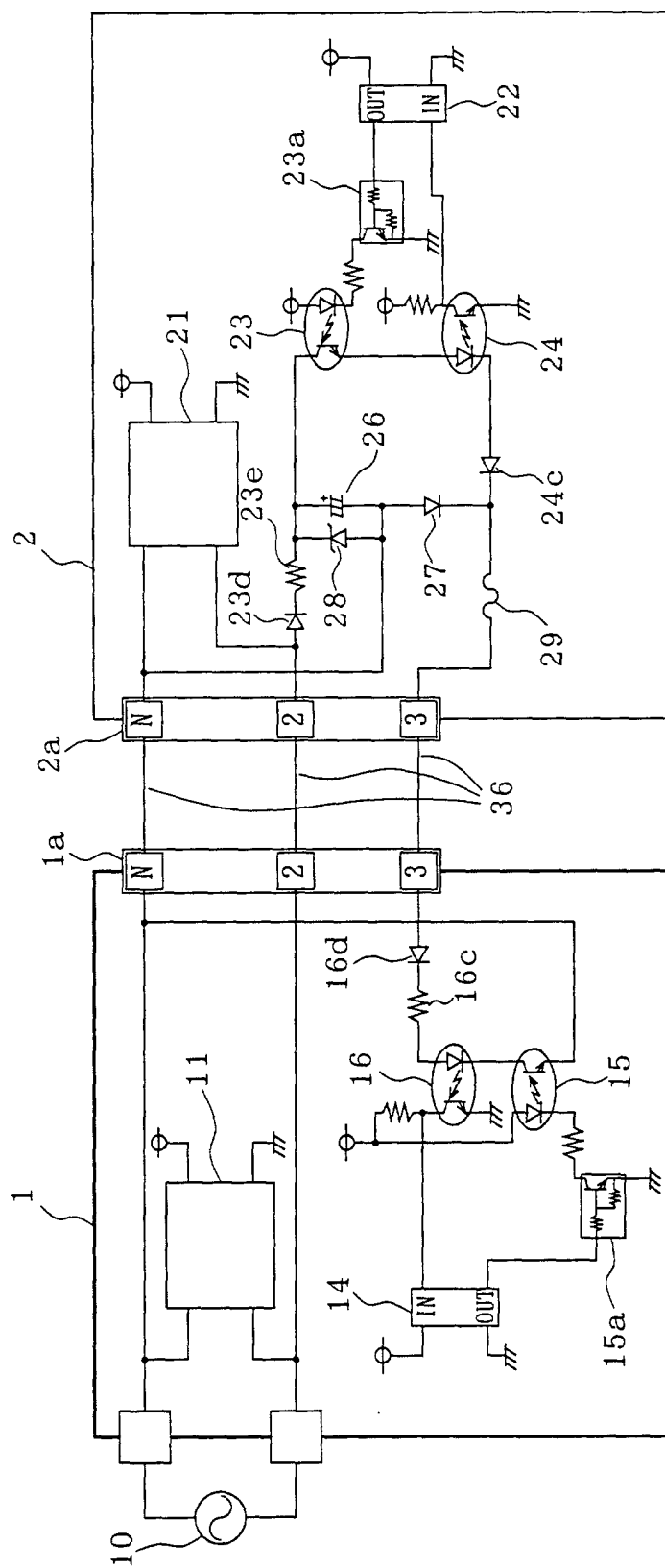


FIG. 7

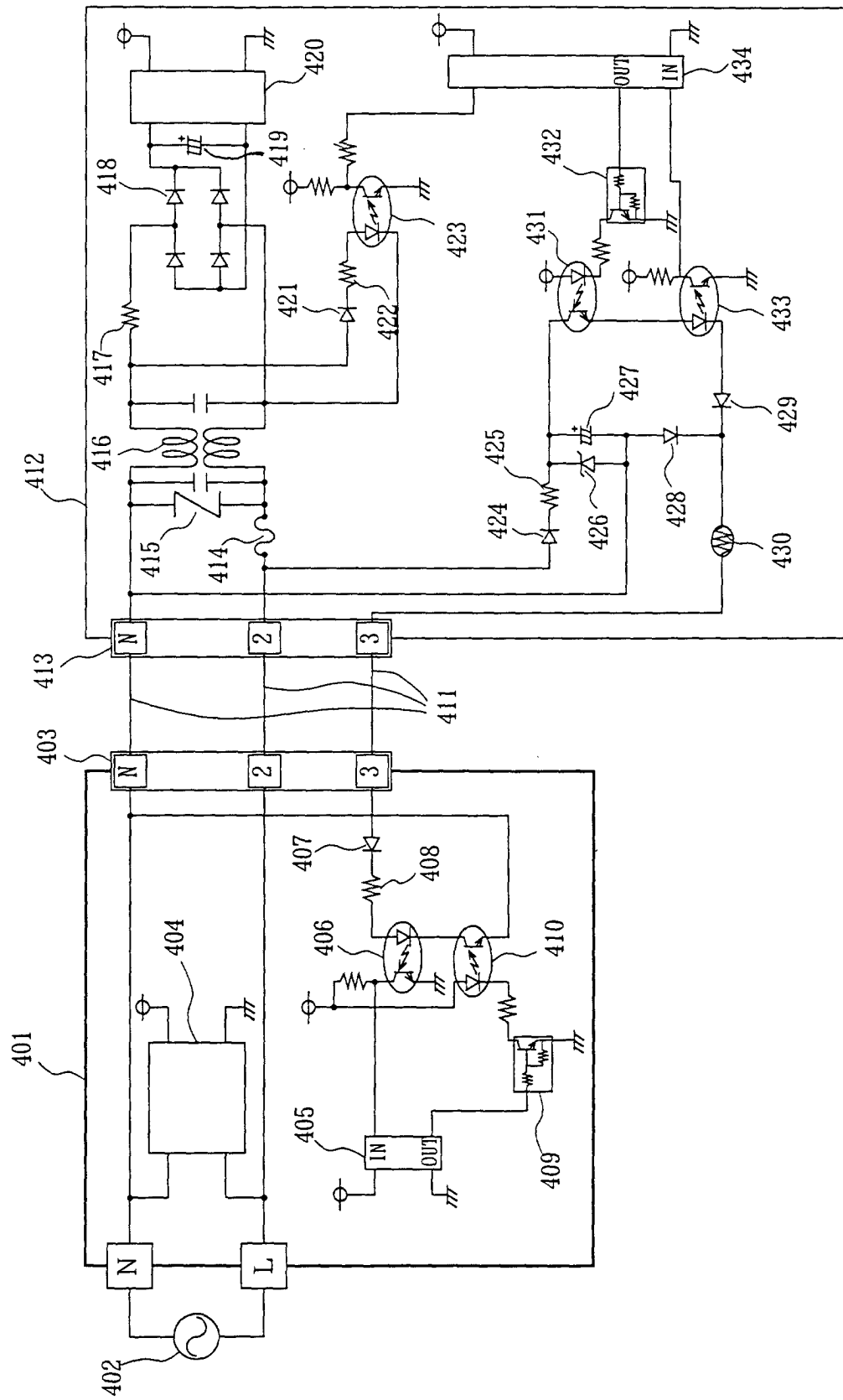


FIG. 8

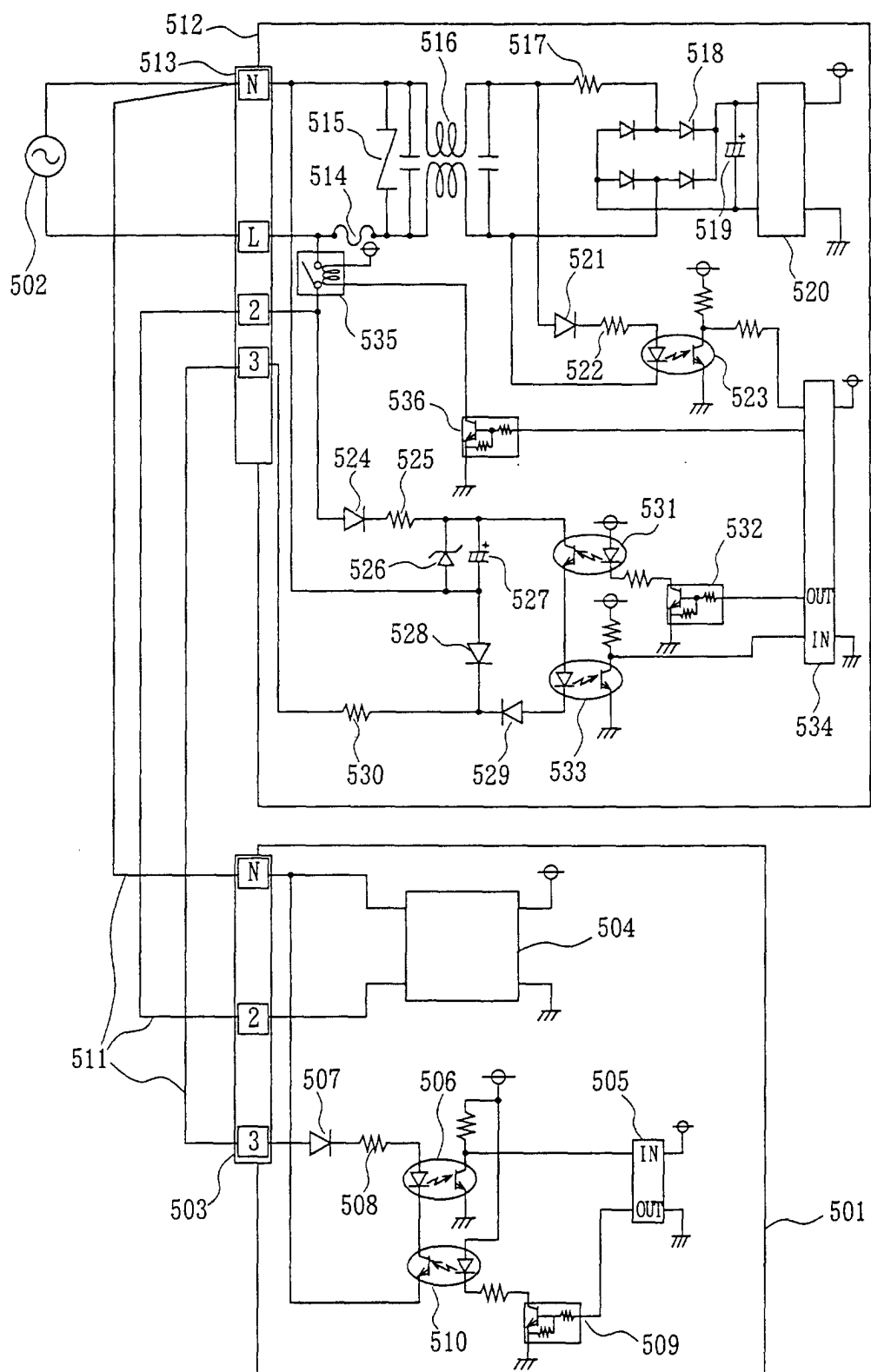


FIG. 9

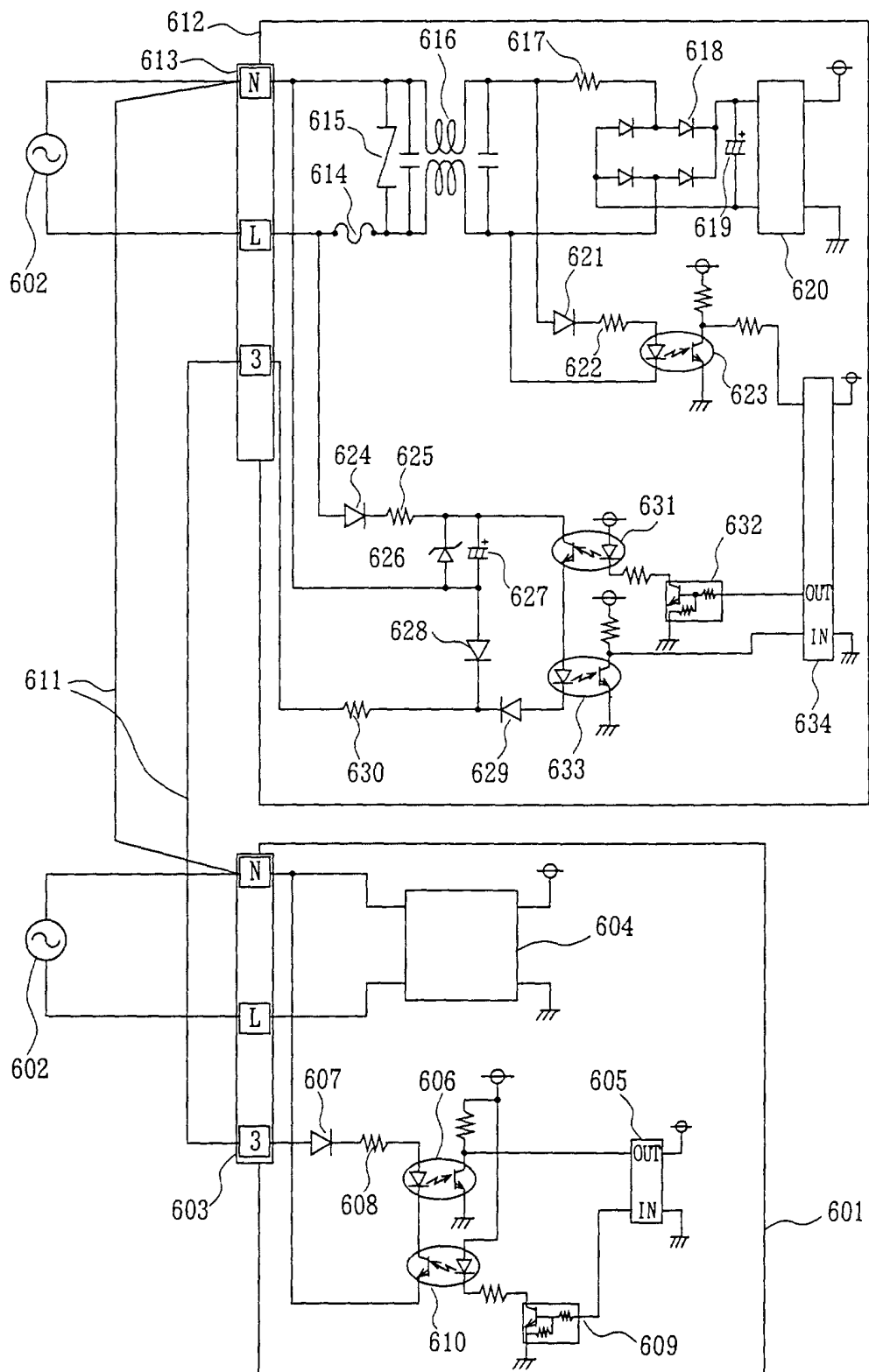


FIG. 10

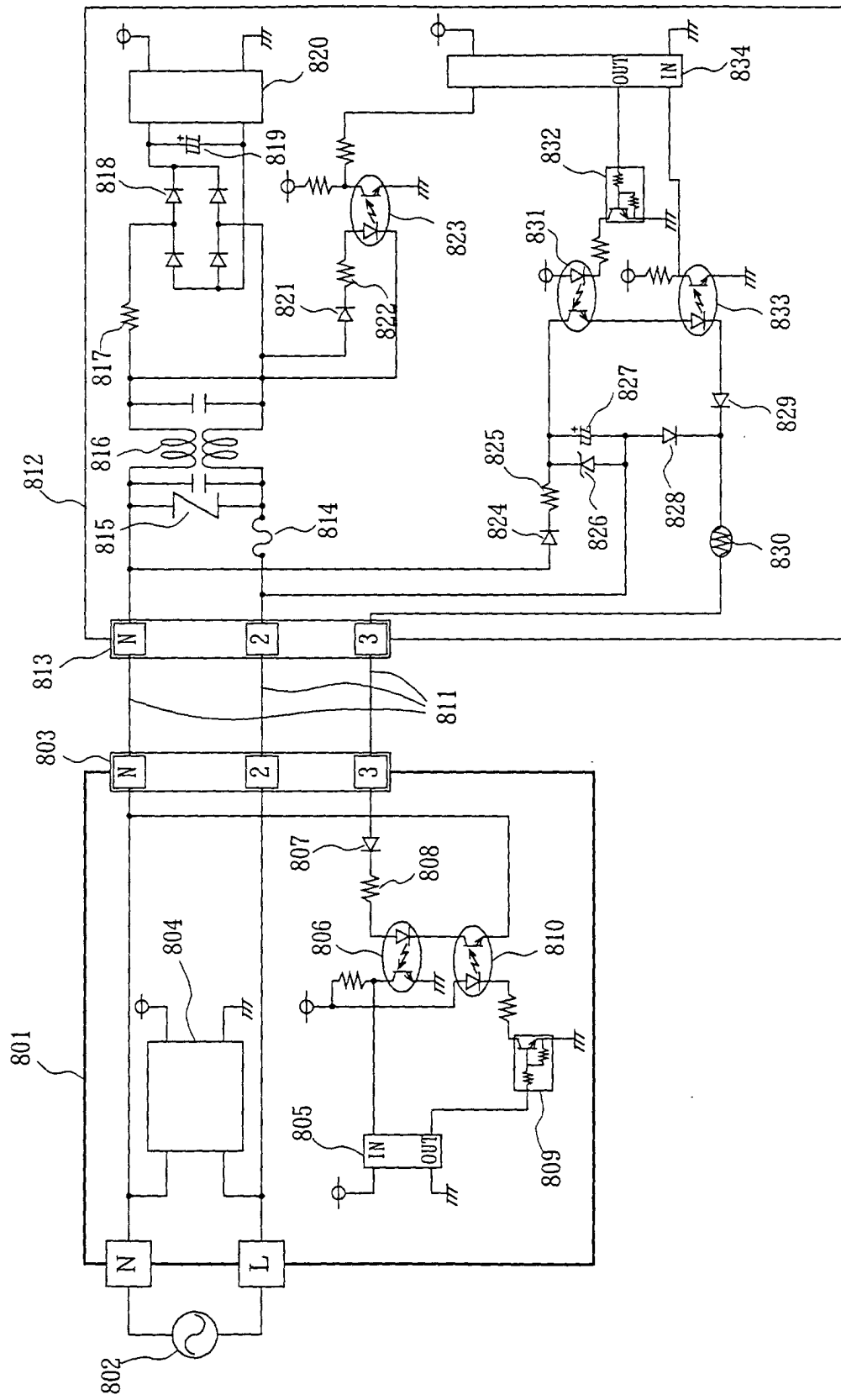


FIG. 11

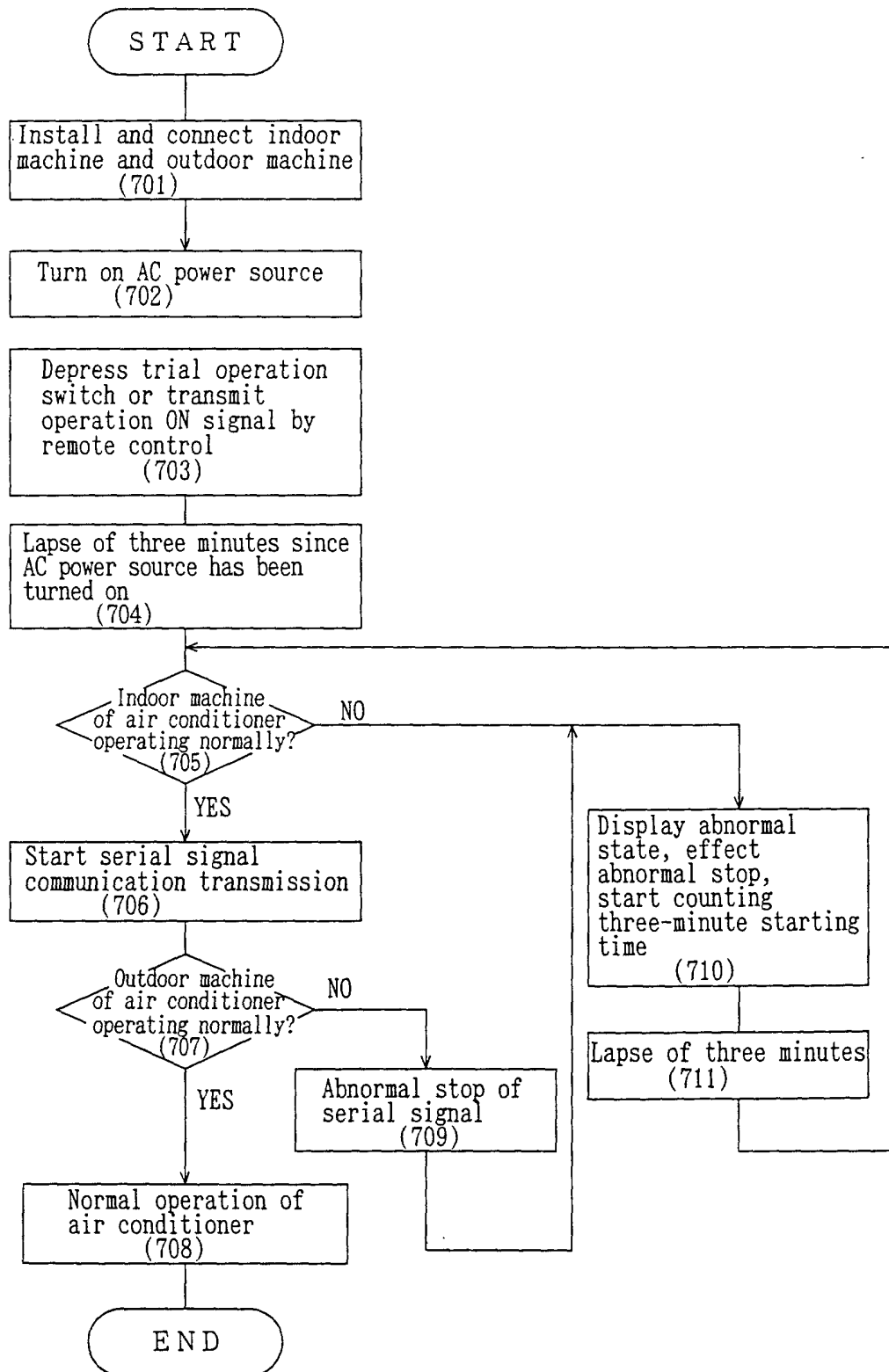


FIG. 12

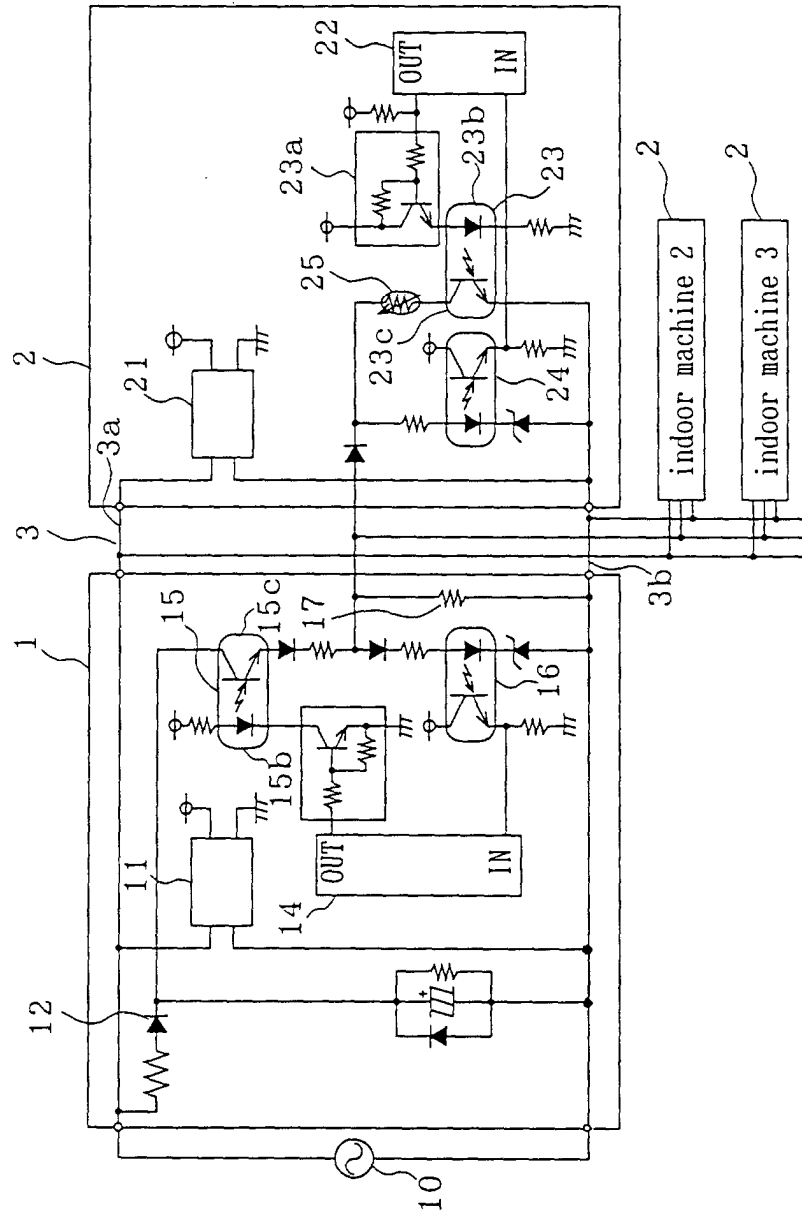


FIG. 13

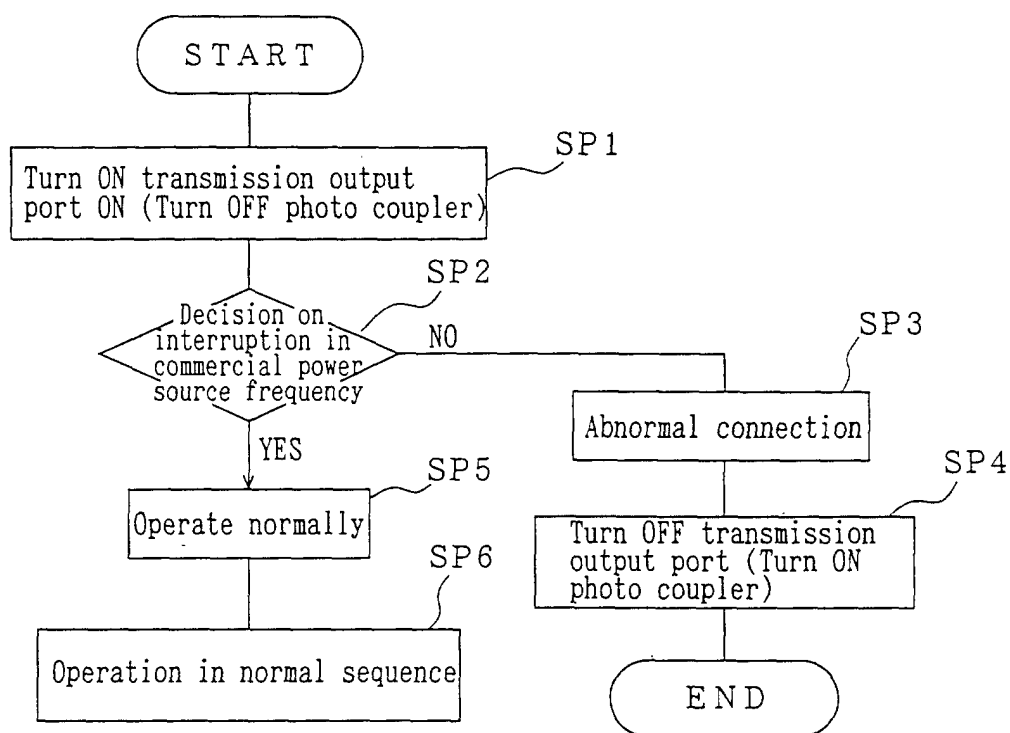


FIG. 14

