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(54) **PIN ELECTRONICS APPARATUS, TEST APPARATUS, AND METHOD**

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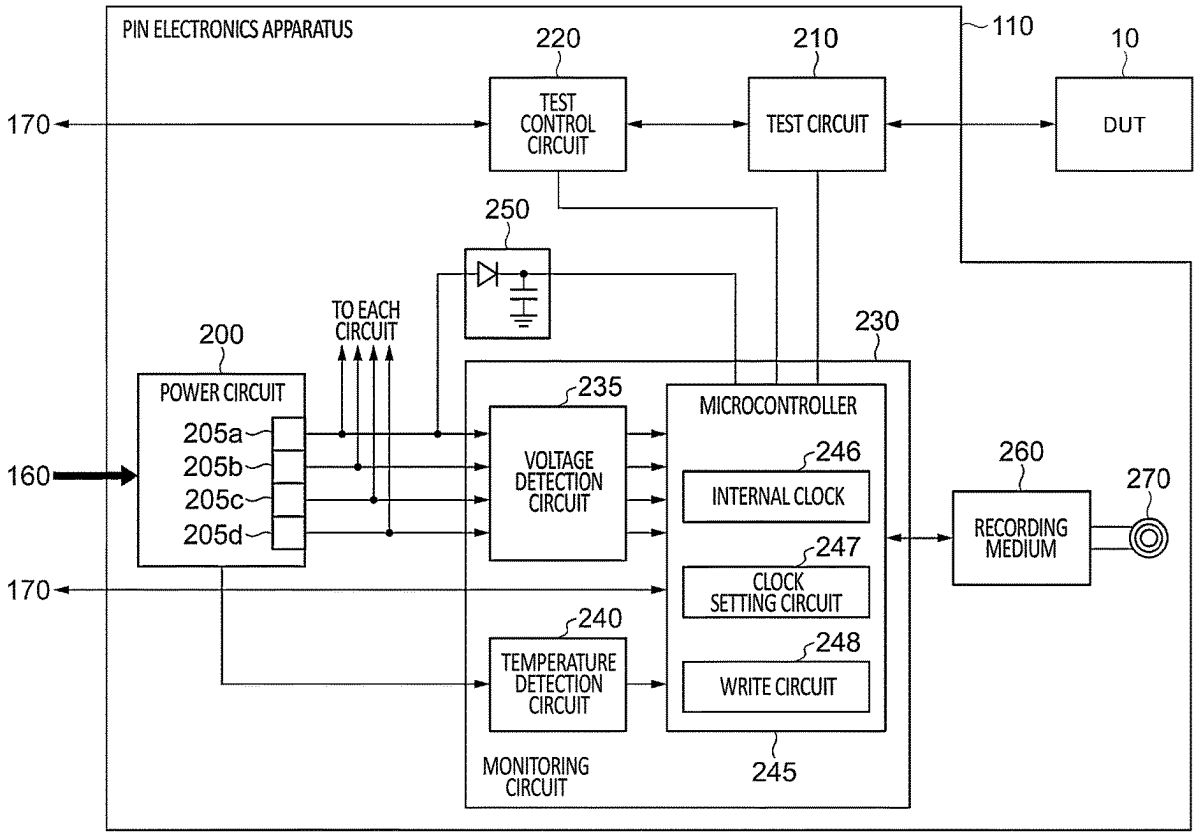
(57) **ABSTRACT**

Provided is a pin electronics apparatus including: a test circuit which is connected to a device under test and tests the device under test; a power circuit which includes a plurality of power sources; and a monitoring circuit which records, in response to detecting an abnormality in power supply from the power circuit, power identification information for identifying a power source, for which an abnormality in power supply is detected, among the plurality of power sources on a non-volatile recording medium.



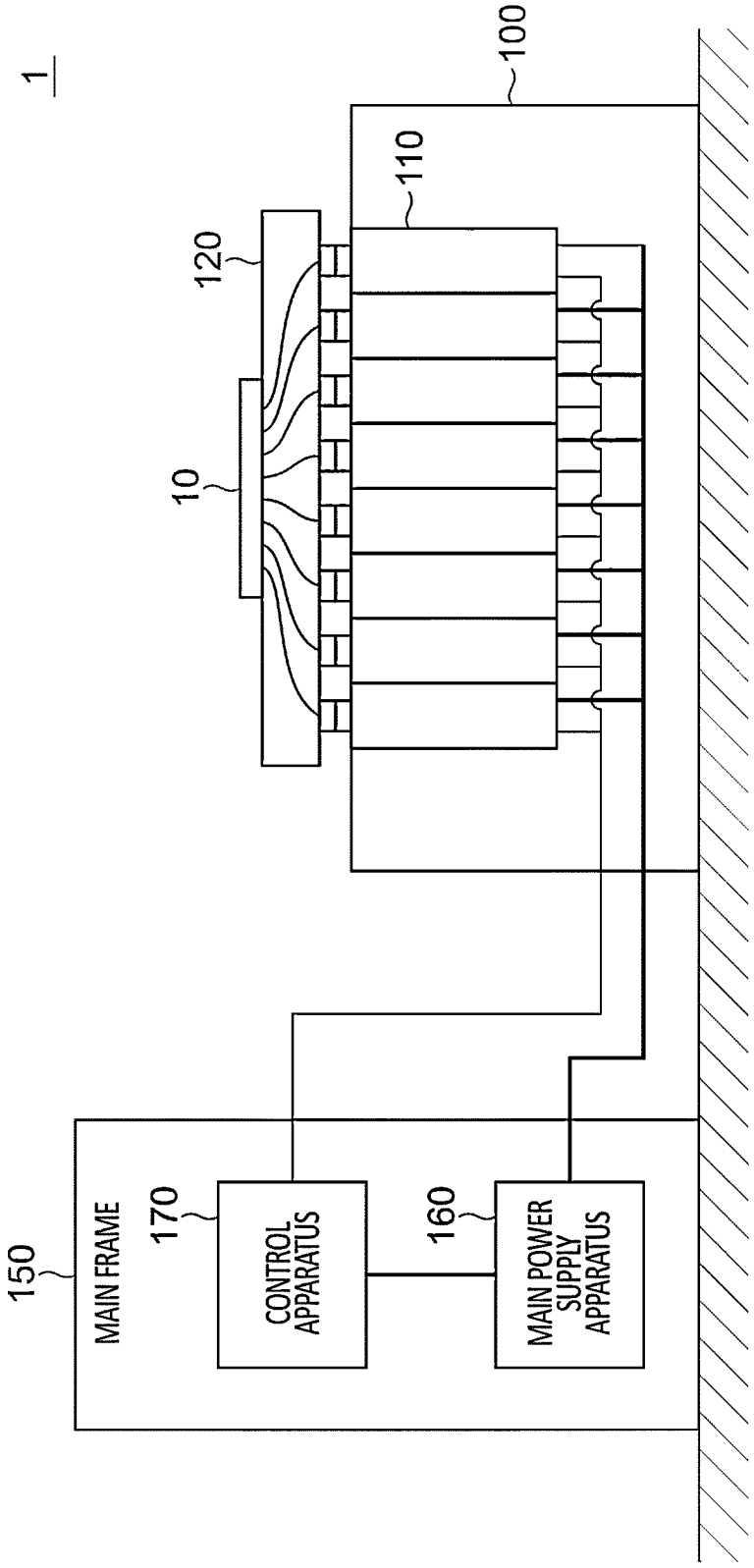

1
100
110
120
10
150
MAIN FRAME
170
CONTROL APPARATUS
160
MAIN POWER SUPPLY APPARATUS

FIG.1

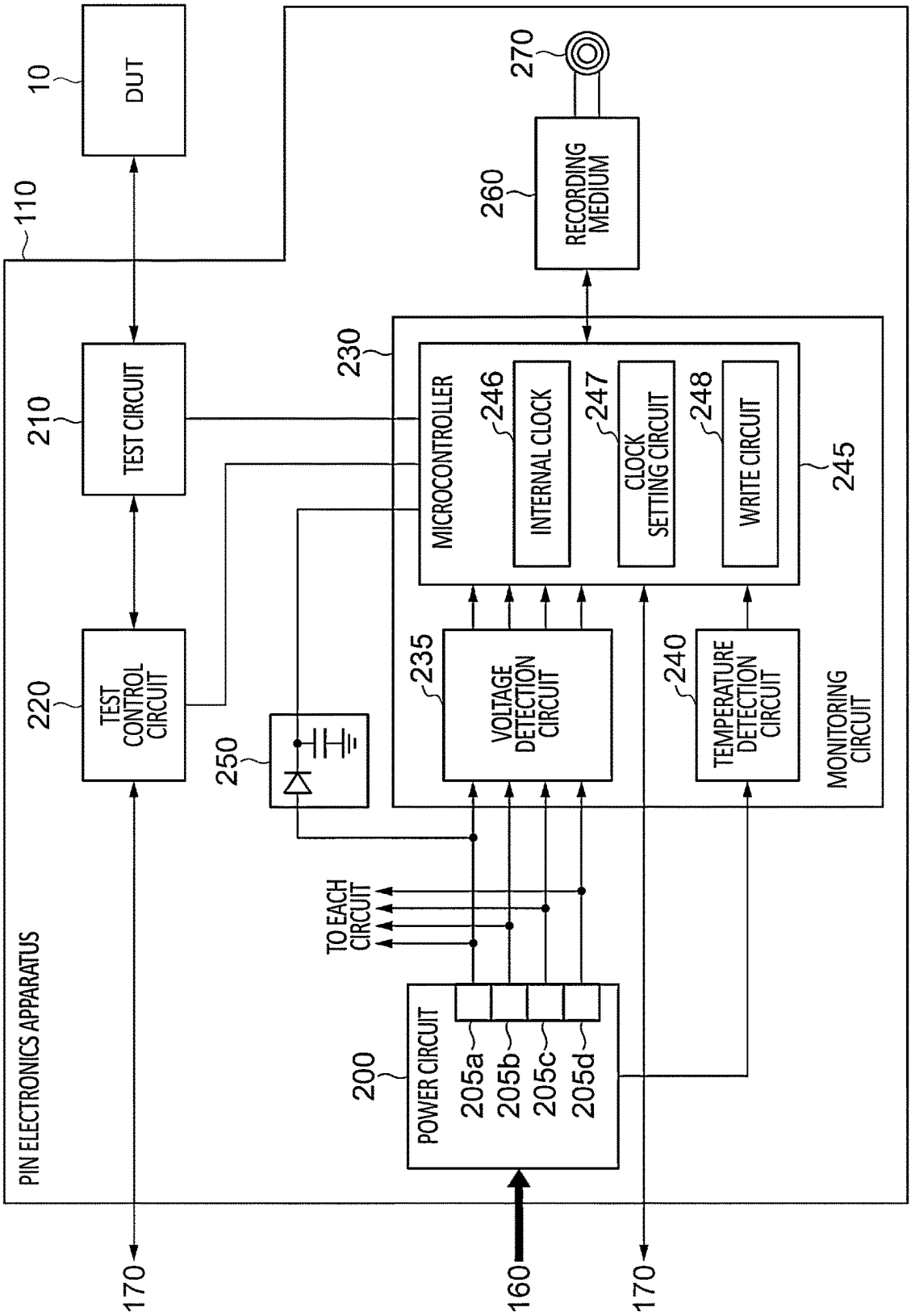

PIN ELECTRONICS APPARATUS
10
DUT
110
210
TEST CIRCUIT
220
TEST CONTROL CIRCUIT
250
230
MICROCONTROLLER
246
INTERNAL CLOCK
247
CLOCK SETTING CIRCUIT
248
WRITE CIRCUIT
245
235
VOLTAGE DETECTION CIRCUIT
240
TEMPERATURE DETECTION CIRCUIT
MONITORING CIRCUIT
270
260
RECORDING MEDIUM
TO EACH CIRCUIT
200
POWER CIRCUIT
205a
205b
205c
205d
170
160
170

FIG.2

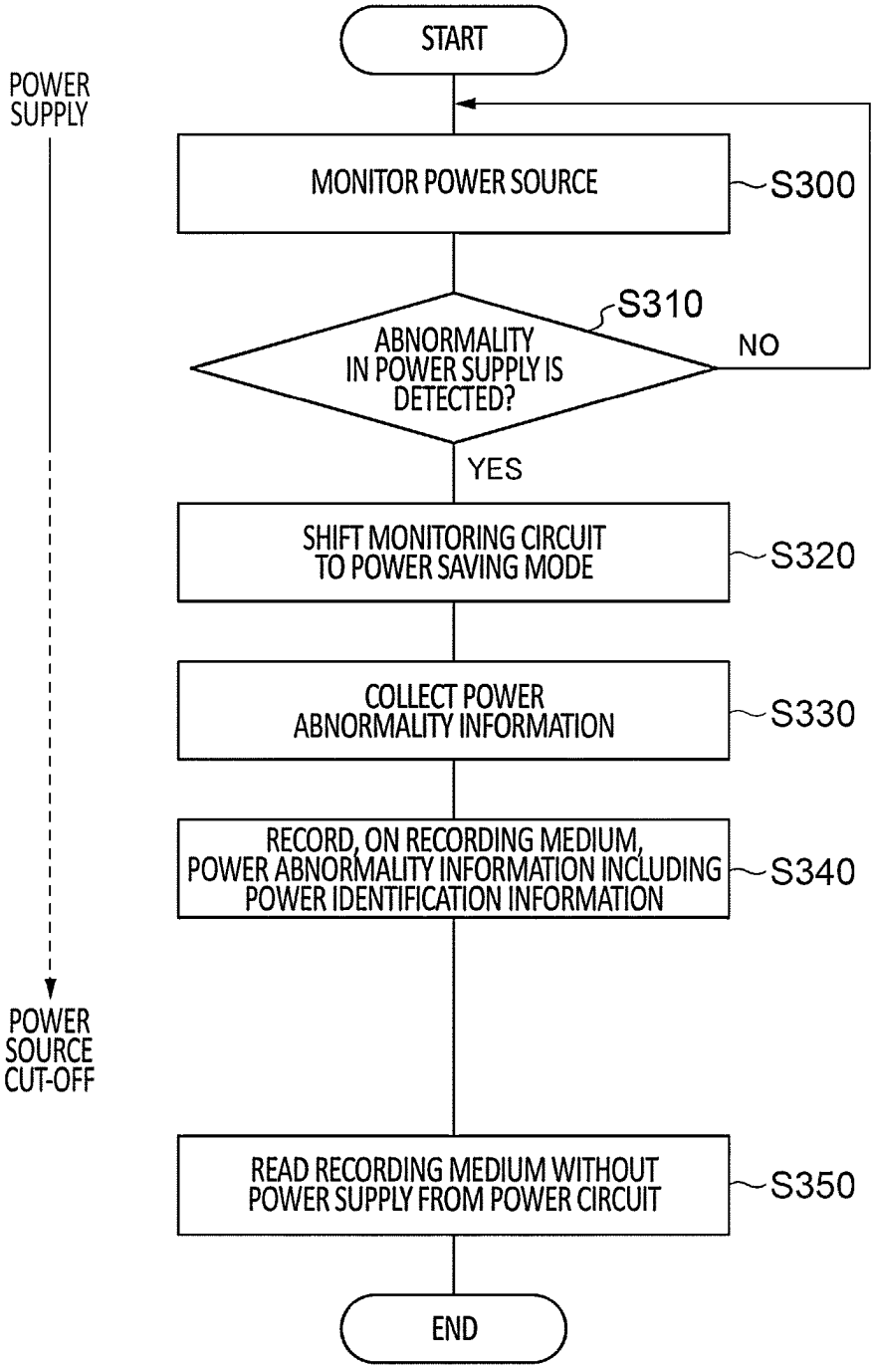

START
POWER SUPPLY
MONITOR POWER SOURCE
S300
S310
ABNORMALITY IN POWER SUPPLY IS DETECTED?
NO
YES
SHIFT MONITORING CIRCUIT TO POWER SAVING MODE
S320
COLLECT POWER ABNORMALITY INFORMATION
S330
RECORD, ON RECORDING MEDIUM, POWER ABNORMALITY INFORMATION INCLUDING POWER IDENTIFICATION INFORMATION
S340
POWER SOURCE CUT-OFF
READ RECORDING MEDIUM WITHOUT POWER SUPPLY FROM POWER CIRCUIT
S350
END

FIG.3

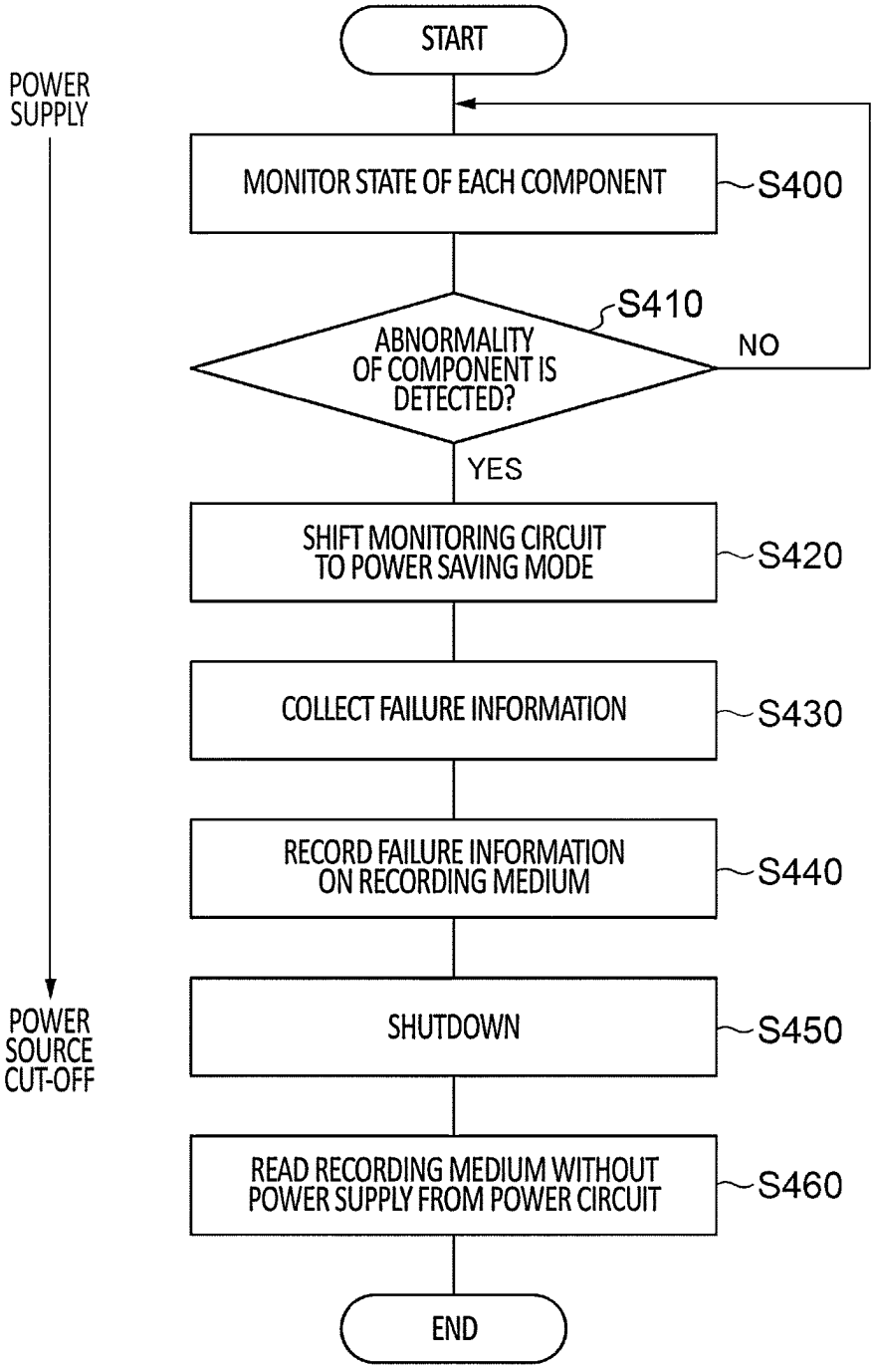

START
POWER SUPPLY
MONITOR STATE OF EACH COMPONENT
S400
S410
ABNORMALITY OF COMPONENT IS DETECTED?
NO
YES
SHIFT MONITORING CIRCUIT TO POWER SAVING MODE
S420
COLLECT FAILURE INFORMATION
S430
RECORD FAILURE INFORMATION ON RECORDING MEDIUM
S440
SHUTDOWN
S450
POWER SOURCE CUT-OFF
READ RECORDING MEDIUM WITHOUT POWER SUPPLY FROM POWER CIRCUIT
S460
END

FIG.4

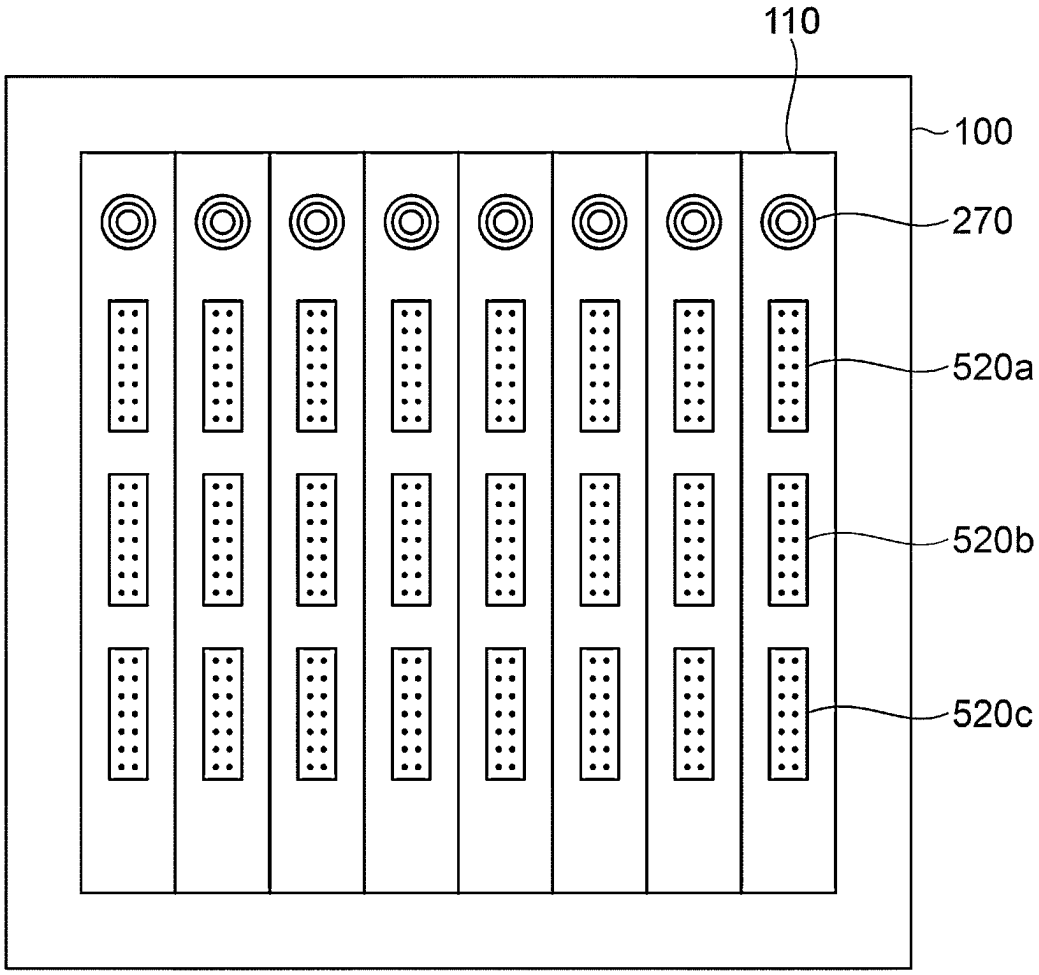


FIG.5

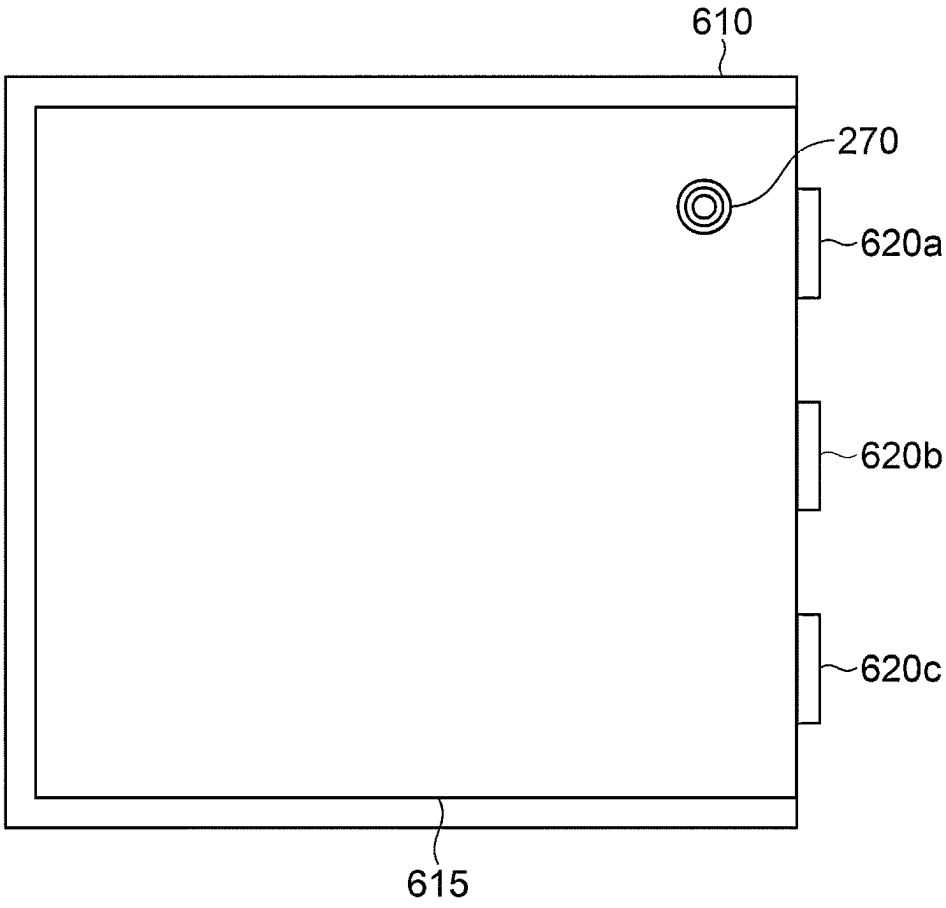


FIG.6

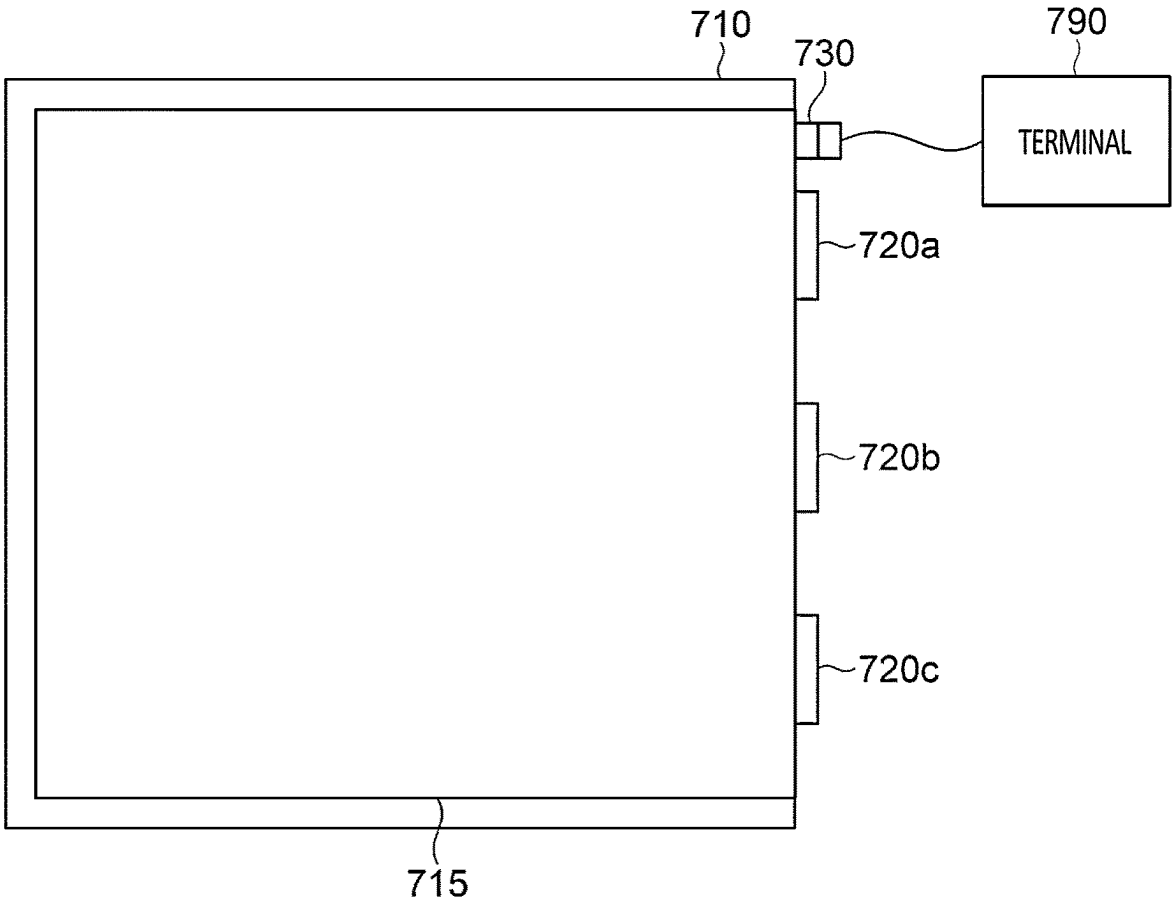


FIG.7

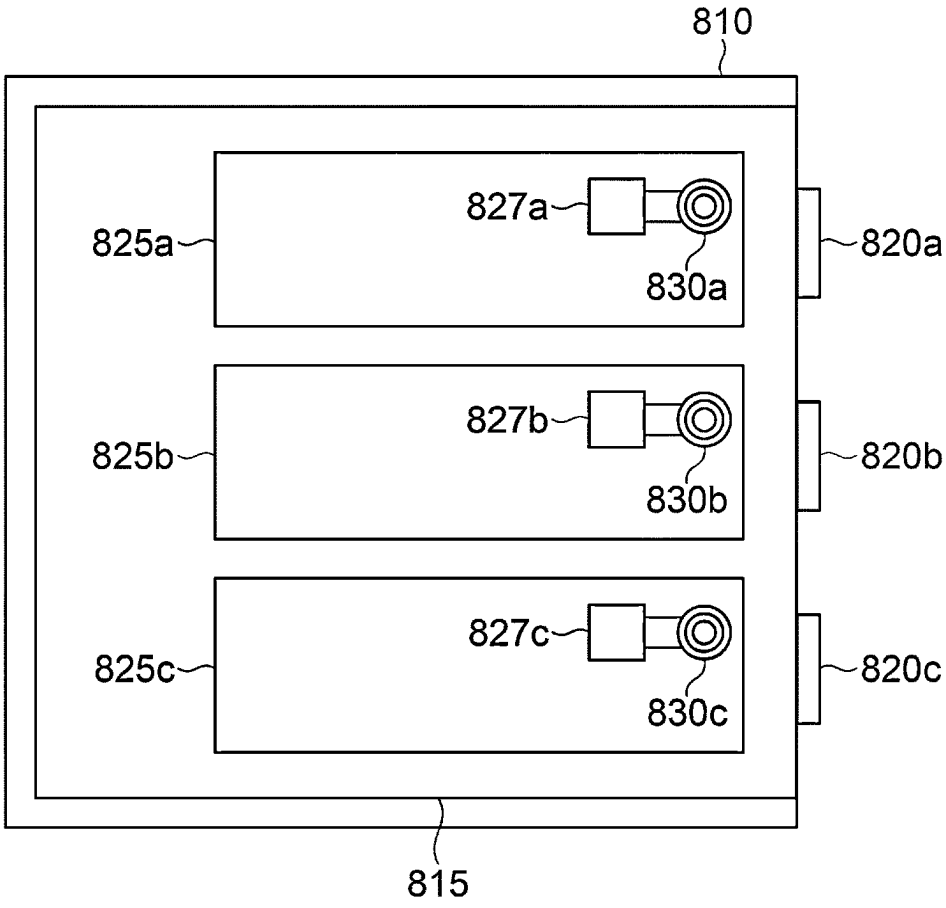

810
827a
825a
820a
830a
827b
825b
820b
830b
827c
825c
820c
830c
815

FIG.8

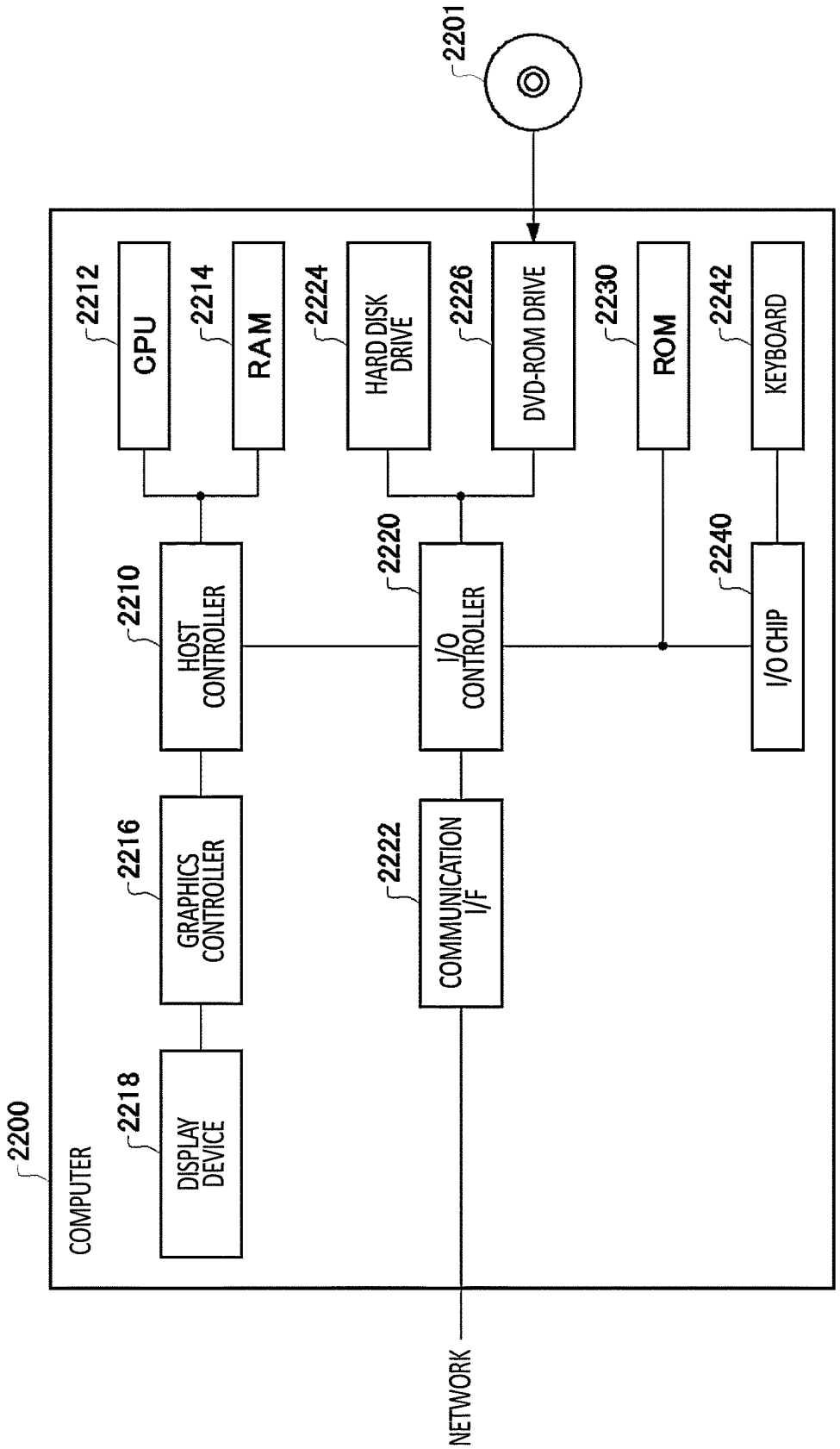

2201
2212
CPU
2214
RAM
2224
HARD DISK DRIVE
2226
DVD-ROM DRIVE
2230
ROM
2242
KEYBOARD
2210
HOST CONTROLLER
2220
I/O CONTROLLER
2240
I/O CHIP
2216
GRAPHICS CONTROLLER
2222
COMMUNICATION I/F
2218
DISPLAY DEVICE
2200
COMPUTER
NETWORK

FIG.9

PIN ELECTRONICS APPARATUS, TEST APPARATUS, AND METHOD

[0001] The contents of the following patent application(s) are incorporated herein by reference: NO. PCT/JP2022/044927 filed in WO on Dec. 6, 2022.

BACKGROUND

1. Technical Field

[0002] The present invention relates to a pin electronics apparatus, a test apparatus, and a method.

2. Related Art

[0003] Patent Document 1 describes "An abnormality of an internal voltage supplied to an internal circuit of a semiconductor integrated circuit apparatus during a burn-in test can be easily confirmed" (paragraph 0010), "The semiconductor integrated circuit apparatus 100D includes internal step-down power sources 3(1), 3(2), . . . , 3(n), an abnormality detection circuit 5D, and a logic circuit 9" (paragraph 0076), and "The internal memory 10 stores information indicating the internal step-down power source 3 in which the abnormality occurs, in addition to information indicating the abnormality" (paragraph 0079).

[0004] Patent Document 2 describes "The storage element 106 is a non-volatile rewritable memory in which the stored content does not disappear even when the power supply is lost, and use of a flash memory is assumed" (paragraph 0018), and "From the operation described above, in the storage element 106 in the semiconductor integrated circuit 100 of the present invention, in the course of the operation, a duration for which the operation is performed exceeding a warning temperature is recorded as a number of unit times in the "warning temperature excess duration" region, and a temperature value when a temperature becomes the highest during the operation is recorded in the "maximum detection temperature" region. If the individual semiconductor integrated circuit 100 fails and experiences an operational failure, the control circuit 103 reads information in the "warning temperature excess duration" or "maximum detection temperature" region of the storage element 106 via the input/output unit 104" (paragraph 0022).

[0005] Patent Document 3 describes "FIG. 1 illustrates an example of an abnormality notification system 1 of the present invention. The abnormality notification system 1 includes a bus 2, an upper module 3, and N (N is an integer of 2 or more) lower modules 4-1 to 4-N (collectively referred to as a lower module 4)" (Paragraph 0025), "Examples of the abnormality detected by the abnormality detection circuit 20 include an abnormality of a power supply voltage, an abnormality of a circuit temperature, or the like. The pin electronics card as the lower module 4 includes a power source and a circuit (for example, a field programmable gate array (FPGA)) for performing a test. The abnormality detection circuit 20 performs abnormality detection when the output voltage of the power source becomes abnormal, when the temperature of the circuit becomes abnormal, or the like" (Paragraph 0033), and "The abnormality information storage unit 22 is connected to the M abnormality detection circuits 20, and abnormality detection information indicating that the abnormality detection circuit 20 has detected an abnormality is input thereto. The abnormality detection information is 1-bit information, and the abnormality detection information is M bits in total. The M-bit abnormality detection information is stored as abnormality information in the abnormality information storage unit 22" (paragraph 0035).

[0006] Patent Document 4 describes "The circuit pack self-test system 10 (test system 10 herein), which is located on the circuit pack 18, consists of a microprocessor 20, a non-volatile memory 30 (NVM 30 herein), a volatile memory 42, a circuit under test 52 (on the circuit pack 18), and an interface circuit 60" (paragraph 0019), and "For example, when a specific test program cannot be completed due to a failure or error, this fault situation is immediately recorded in the non-volatile memory 30 to make this information available to repair personnel. This information is not lost in a power outage or power reset and is permanent in nature" (paragraph 0035).

[0007] Patent Document 5 discloses "According to the present invention, provided is an abnormality processing apparatus of an IC test apparatus in which when an abnormality which may develop into a fire occurs in the IC test apparatus, an abnormality sensor operates, an output of an abnormality monitoring circuit which has processed an detection output of the abnormality causes an interrupt in a control computer, and the control computer displays a factor of the abnormality on a terminal and operates a power control circuit to cut off power sources of the IC test apparatus and a control apparatus thereof, the abnormality processing apparatus including: various abnormality sensors of the IC test apparatus and the control apparatus which are classified according to a type of the abnormality factor; an abnormality monitoring circuit which processes the abnormality detection output and causes an interrupt in the control computer; an uninterruptible power supply apparatus which monitors an abnormality of supply power of the control apparatus, and when the abnormality occurs, supplies power to the control apparatus for a predetermined duration and notifies the abnormality monitoring circuit whether or not the control apparatus is in operation; a control computer which reads, from an abnormality monitoring circuit, an abnormality factor and whether the uninterruptible power supply apparatus is in operation and determines whether or not the IC test apparatus can be restored to an operating state; and a means in which an output of the control computer operates a power control circuit to cut off only the power source of the IC test apparatus while the power source of the control apparatus remains in an operating state and to start the power source of the IC test apparatus from a stop state" (paragraph 0009).

[0008] Patent Document 6 describes "FIG. 1 illustrates a semiconductor test apparatus 1 of the present invention. The semiconductor test apparatus 1 includes cards 2A to 2F (collectively referred to as a card(s) 2), a tester controller 3, a hard disk 4, and a connection path 5" (paragraph 0030), "The diagnosis unit 11 is provided in each card 2. The diagnosis unit 11 diagnoses whether or not a failure has occurred in its own card 2 (self-diagnosis) or diagnoses whether or not a failure has occurred in the connection path 5 as a connection unit to which the diagnosis unit 11 is connected (connection diagnosis)" (paragraph 0035), and "The diagnostic data storage unit 25 stores diagnostic data generated by the diagnostic data generation unit 24 as illustrated in FIG. 4" (paragraph 0055).

[0009] Patent Document 7 describes "The semiconductor test apparatus applies a signal to the DUT, and makes

determination by comparing an output signal from the DUT and an expected value to judge whether the DUT is a non-defective product or a defective product" (paragraph 0002), and "As a result, when a failure (fail) has occurred in the diagnosis of the fail memory unit 51, information on the failure region is stored in the information storage unit 61 of the address transfer unit, and an offset address is set in the offset setting unit 63" (paragraph 0042).

PRIOR ART DOCUMENTS

Patent Documents

[0010] Patent Document 1: Japanese Patent Application Publication No. 2021-052122
[0011] Patent Document 2: Japanese Patent Application Publication No. 2014-003078
[0012] Patent Document 3: Japanese Patent Application Publication No. 2012-063837
[0013] Patent Document 4: Japanese Patent Application Publication No. 2000-221238
[0014] Patent Document 5: Japanese Patent Application Publication No. H7-074224
[0015] Patent Document 6: Japanese Patent Application Publication No. 2012-117932
[0016] Patent Document 7: Japanese Patent Application Publication No. 2009-020934

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. **1** illustrates a configuration of a test apparatus **1** according to the present embodiment.
[0018] FIG. **2** illustrates a configuration of a pin electronics apparatus **110** according to the present embodiment.
[0019] FIG. **3** illustrates a power monitoring flow of the pin electronics apparatus **110** according to the present embodiment.
[0020] FIG. **4** illustrates a failure monitoring flow of the pin electronics apparatus **110** according to the present embodiment.
[0021] FIG. **5** illustrates a structure of a test head **100** according to the present embodiment as viewed from a mounting surface side of a connection apparatus **120**.
[0022] FIG. **6** illustrates a structure of a pin electronics apparatus **610** according to a first modification.
[0023] FIG. **7** illustrates a structure of a pin electronics apparatus **710** according to a second modification.
[0024] FIG. **8** illustrates a structure of a pin electronics apparatus **810** according to a third modification.
[0025] FIG. **9** illustrates an example of a computer **2200** in which a plurality of aspects of the present invention may be embodied entirely or partially.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0026] Hereinafter, the present invention will be described through embodiments of the invention, but the following embodiments do not limit the invention according to claims. In addition, not all combinations of features described in the embodiments are essential to a solution of the invention.
[0027] FIG. **1** illustrates a configuration of a test apparatus **1** according to the present embodiment together with a device under test (DUT) **10**. The DUT **10** is a device in which a circuit to be tested by the test apparatus **1** is formed. The DUT **10** may be a wafer on which a circuit is formed, IC/LSI chips which are singulated from a wafer, an IC/LSI package in which IC/LSI chips are packaged, or the like. In the example of this drawing, the test apparatus **1** is mounted with one DUT **10**, but instead of this, the test apparatus **1** may be mounted with a plurality of DUTs **10** and perform tests simultaneously.
[0028] The test apparatus **1** performs an electrical test on the DUT **10**. Alternatively or additionally, the test apparatus **1** may perform a light input/output test on the DUT **10**. In the present embodiment, a case where the test apparatus **1** performs the electrical test on the DUT **10** will be described as an example. When the test apparatus **1** performs the light input/output test on the DUT **10**, the test apparatus **1** and the DUT **10** are connected by optical connection instead of electrical connection.
[0029] The test apparatus **1** includes a test head **100**, a plurality of pin electronics apparatuses **110**, a connection apparatus **120**, and a main frame **150**. The test head **100** is a housing on which the plurality of pin electronics apparatuses **110** can be mounted. In an example of this drawing, the test head **100** includes a plurality of slots for inserting the plurality of pin electronics apparatuses **110**.
[0030] The plurality of pin electronics apparatuses **110** are inserted into the slots in the test head **100**, respectively, and detachably connected to a backplane of the test head **100**. The pin electronics apparatus **110** may also be referred to as a "pin electronics card," a "tester board," a "test module," or the like. Each pin electronics apparatus **110** is electrically connected to the DUT **10** via the connection apparatus **120**. Each pin electronics apparatus **110** inputs and outputs a signal to and from the DUT **10**, and tests the DUT **10** by inspecting the signal input from the DUT **10**.
[0031] The connection apparatus **120** is mounted on the test head **100** and is electrically connected to the plurality of pin electronics apparatuses **110**. The connection apparatus **120** is mounted with the DUT **10** and is electrically connected to a plurality of terminals included in the DUT **10**. The connection apparatus **120** serves as an interface between terminals of the plurality of pin electronics apparatuses **110** and the terminals of the DUT **10**, and electrically connects each terminal of one or more DUTs **10** and the corresponding terminal of the plurality of pin electronics apparatuses **110** by a signal cable, a board wiring, or the like.
[0032] The main frame **150** controls each unit in the test apparatus **1** in order to test the DUT **10**. In the present embodiment, the main frame **150** is a housing separate from a housing in which the test head **100** or the like are provided. Alternatively, each configuration in the main frame **150** may be provided in a same housing as that of the test head **100**. The main frame **150** includes a main power supply apparatus **160** and a control apparatus **170**.
[0033] The main power supply apparatus **160** receives power supply from a commercial power source or the like, and supplies power to each apparatus, each circuit, and the like in the test apparatus **1**. The control apparatus **170** is connected to the main power supply apparatus **160** and receives power supply from the main power supply apparatus **160**. The control apparatus **170** controls a test of the DUT **10**. When implemented by a computer, the control apparatus **170** may control the test of the DUT **10** by executing a test control program. The control apparatus **170** supplies a test program to each pin electronics apparatus **110** and causes each pin electronics apparatus **110** to execute the test program to test the DUT **10**. The control apparatus **170**

collects a test result of the DUT **10** from each pin electronics apparatus **110** and records the test result.

[0034] FIG. **2** illustrates a configuration of the pin electronics apparatus **110** according to the present embodiment. The pin electronics apparatus **110** includes a power circuit **200**, a test circuit **210**, a test control circuit **220**, a monitoring circuit **230**, a storage battery **250**, a recording medium **260**, and an antenna **270**.

[0035] The power circuit **200** receives power supply from the main power supply apparatus **160**, generates power to be supplied to each circuit in the pin electronics apparatus **110**, and supplies the power to each circuit in the pin electronics apparatus **110**. The power circuit **200** may include a plurality of power sources **205***a* to **205***d* (also referred to as a "power source(s) **205**"). The plurality of power sources **205** may output power having different rated voltages, rated currents, or the like. In addition, when the pin electronics apparatus **110** uses a large amount of power having a same rated voltage, a same rated current, or the like, two or more power sources **205** may output the power having the same rated voltage, the same rated current, or the like.

[0036] The test circuit **210** is connected to the DUT **10** via the connection apparatus **120** and tests the DUT **10**. The test circuit **210** for an operation test of the DUT **10** may include various circuits for determining a quality of the DUT **10** by transmitting and receiving a signal to and from the DUT **10**, various circuits including at least one of a pattern generator which generates a test pattern, a timing generator which generates a timing, a waveform shaper which shapes the test pattern by using the timing generated by the timing generator and outputs a test signal, a driver circuit which amplifies the test signal and outputs a result to the DUT **10**, a comparator which compares a response signal from the DUT **10** with a target value, or a determiner which determines the quality of the DUT **10** by using a result of comparison by the comparator. In addition, the test circuit **210** for a parametric test of the DUT **10** may include various circuits including at least one of a voltage generator which generates a voltage to be supplied to the DUT **10**, a current generator which generates a current to be supplied to the DUT **10**, a voltage measurer which measures a voltage output by the DUT **10**, a current measurer which measures a current output by the DUT **10**, a frequency measurer which measures a frequency of a signal output by the DUT **10**, or the like. The test control circuit **220** controls the test of the DUT **10** performed by the test circuit **210**. The test control circuit **220** may also be referred to as a "site controller". The test control circuit **220** executes a test program supplied from the control apparatus **170** to control each unit in the test circuit **210**, thereby causing the test circuit **210** to execute a test such as the operation test or the parametric test of the DUT **10**.

[0037] The monitoring circuit **230** is connected to the power circuit **200**, the test circuit **210**, and the test control circuit **220**. The monitoring circuit **230** monitors each component including each electronic device (ASIC, LSI, IC, or the like), each circuit, discrete components, mechanical components, and the like in the pin electronics apparatus **110**, such as the power circuit **200**, the test circuit **210**, and the test control circuit **220** in the pin electronics apparatus **110**. In response to detecting a failure of the pin electronics apparatus **110**, the monitoring circuit **230** records failure information regarding the failure on the recording medium **260**. In response to detecting a failure of the power circuit **200**, that is, an abnormality in the power supply from the power circuit **200**, the monitoring circuit **230** records, on the recording medium **260**, failure information including power identification information before power supply to the monitoring circuit **230** is cut off. Here, the monitoring circuit **230** records, on the recording medium **260**, the failure information including the power identification information for identifying the power source **205**, for which the abnormality in power supply has been detected, among the plurality of power sources **205**.

[0038] Note that, in the present specification, the "abnormality in power supply" can include both a case where an output of the power circuit **200** (or each power source **205**) does not satisfy a power specification (a voltage specification, a current specification, or the like) and a case where a temperature of the power circuit **200** (or each power source **205**) does not satisfy a temperature specification (an upper limit temperature or the like).

[0039] The monitoring circuit **230** includes a voltage detection circuit **235**, a temperature detection circuit **240**, and a microcontroller **245**. The voltage detection circuit **235** is connected to each of the plurality of power sources **205**. For each power source **205** of the plurality of power sources **205***a* to **205***d*, the voltage detection circuit **235** detects whether or not an output voltage of the power source **205** is outside a reference voltage range predetermined for each power source **205**. The voltage detection circuit **235** may include a comparison circuit which compares the output voltage of the power source **205** with each of a rated upper limit voltage and a rated lower limit voltage of the output voltage of the power source **205**. The voltage detection circuit **235** may detect an abnormality of the power source **205** when the output voltage of the power source **205** is outside the reference voltage range from the rated lower limit voltage to the rated upper limit voltage.

[0040] The temperature detection circuit **240** is connected to the power circuit **200**. The temperature detection circuit **240** detects whether or not a temperature associated with each power source **205** exceeds a predetermined reference temperature. The temperature detection circuit **240** may detect the abnormality of the power source **205** when a temperature indicated by a temperature detection signal from a temperature sensor such as a thermal diode provided in a vicinity of each power source **205** exceeds a rated upper limit temperature.

[0041] In addition, the temperature detection circuit **240** may detect whether or not a temperature of each component in the pin electronics apparatus **110** exceeds a predetermined reference temperature. Such a reference temperature may be individually determined for each component, or may be commonly determined for two or more components.

[0042] The microcontroller **245** is connected to each circuit or component to be monitored, such as the power circuit **200**, the test circuit **210**, and the test control circuit **220**, the voltage detection circuit **235**, and the temperature detection circuit **240**. The microcontroller **245** may include a central processing unit (CPU) for control or general purpose. The microcontroller **245** executes a monitoring program to monitor (including temperature monitoring) a failure of each component in the pin electronics apparatus **110**, monitor the plurality of power sources **205**, and write the failure information to the recording medium **260**.

[0043] The microcontroller **245** includes an internal clock **246**, a clock setting circuit **247**, and a write circuit **248**. The internal clock **246** outputs a current date and time. For

example, the internal clock **246** may indicate the current time by being set to a certain date and time and updating an internal time every time a predetermined duration elapses from the date and time. In addition, the internal clock **246** may include a timer counter which is reset to a certain date and time and increments each time a predetermined duration elapses, and may calculate the current date and time by using an elapsed duration from the reset date and time indicated by the timer counter.

[0044] The clock setting circuit **247** sets, in internal clock **246**, the current date and time received from an apparatus external to the pin electronics apparatus **110**. The clock setting circuit **247** may receive writing of the current date and time from the control apparatus **170** at a time of activation of the test apparatus **1** or periodically and set the current date and time. Note that, when the microcontroller **245** does not record a failure detection date and time on the recording medium **260** in association with the failure information, the microcontroller may not include the internal clock **246** and the clock setting circuit **247**.

[0045] In response to detecting the failure of the pin electronics apparatus **110**, the write circuit **248** records, on the recording medium **260**, the failure information regarding the failure. In response to the voltage detection circuit **235** or the temperature detection circuit **240** detecting the abnormality in the power supply from the power circuit **200**, the write circuit **248** records the failure information on the recording medium **260**, the failure information including the power identification information for identifying the power source **205** for which the abnormality is detected. In addition, in response to detecting a failure of the test circuit **210**, the test control circuit **220**, or another component of the pin electronics apparatus **110**, the write circuit **248** records, on the recording medium **260**, the failure information including component identification information for identifying a failed component.

[0046] Note that the monitoring circuit **230** may include, instead of the microcontroller **245**, dedicated hardware which implements, by a dedicated circuit, an operation to be performed by the microcontroller **245**. In addition, the monitoring circuit **230** may perform only one or two of failure detection of each component in the pin electronics apparatus **110**, failure detection of each power source **205** by the voltage detection circuit **235**, or failure detection of each power source **205** by the temperature detection circuit **240**. The monitoring circuit **230** may not include the voltage detection circuit **235** when the failure detection of each power source **205** by the voltage detection circuit **235** is not performed, and may not include the temperature detection circuit **240** when the failure detection of each power source **205** by the temperature detection circuit **240** is not performed.

[0047] The storage battery **250** is connected to the power circuit **200**. The storage battery **250** accumulates power from at least one of the plurality of power sources **205**. The storage battery **250** may include a capacitor which accumulates power, and may include a small capacity battery which can be charged.

[0048] The storage battery **250** may accumulate power from the power source **205**, which supplies power to the monitoring circuit **230**, among the plurality of power sources **205** and provide the power to the monitoring circuit **230**. Accordingly, the monitoring circuit **230** can record the power identification information on the non-volatile recording medium **260** after the power supply from the power circuit **200** is cut off and before the power supply from the storage battery **250** is interrupted.

[0049] The recording medium **260** is connected to the monitoring circuit **230**. The recording medium **260** receives a write request of the failure information from the monitoring circuit **230** and stores the failure information. The recording medium **260** may be capable of storing one set of failure information or may be capable of storing a plurality of sets of failure information. The recording medium **260** may be a non-volatile recording medium such as a flash memory, so that the stored failure information is not lost even after the power supply from the power circuit **200** is cut off.

[0050] In addition, the recording medium **260** may be a recording medium which is readable without receiving power supply from a power source, such as the power circuit **200**, provided in the pin electronics apparatus **110**. For example, the recording medium **260** may be implemented by using an RFID or the like which is connected to the antenna **270** and is readable by near field communication. The antenna **270** is used to access information (data) recorded on the recording medium **260** by near field communication. The antenna **270** may receive, by wireless power supply from an external terminal or the like, power for operating the recording medium **260**, supply the power to the recording medium **260**, and operate the recording medium **260** by the power. Then, the antenna **270** supplies, to the recording medium **260**, a read request from an external terminal or the like according to a protocol of near field communication, and returns, to the external terminal or the like, information read from the recording medium **260**.

[0051] Note that the recording medium **260** may be built in the monitoring circuit **230**. In addition, the microcontroller **245** may use, as recording medium **260**, at least a partial region of a non-volatile memory built in the microcontroller **245**.

[0052] FIG. **3** illustrates a power monitoring flow of the pin electronics apparatus **110** according to the present embodiment. The pin electronics apparatus **110** starts the power monitoring flow of this drawing in a state where the power circuit **200** is normally supplying power to each circuit in the pin electronics apparatus **110**.

[0053] In S**300**, the microcontroller **245** in the monitoring circuit **230** monitors the state of the power circuit **200**. In S**310**, the microcontroller **245** determines whether or not the abnormality in the power supply by the power circuit **200** is detected. In response to output voltage of each power source **205** becoming outside the reference voltage range defined for the power source **205** or the temperature of each power source **205** exceeding the reference temperature defined for the power source **205**, the microcontroller **245** detects the abnormality of the power source **205**. The microcontroller **245** acquires, as the failure detection date and time, date and time which are indicated by the internal clock **246** at a timing when the abnormality in power supply is detected.

[0054] If the power supply is normal, the microcontroller **245** advances the processing to S**300** to continue monitoring the state of the power circuit **200** ("NO" in S**310**). If the power supply is abnormal, the microcontroller **245** advances the processing to S**320** ("YES" in S**310**).

[0055] In S**320**, in response to cut-off of the power supply from the power circuit **200** and reception of the power supply from the storage battery **250**, the monitoring circuit

230 shifts to a power saving mode in which a power consumption is smaller than that in a case of performing a normal operation. For example, the monitoring circuit 230 may reduce the power consumption, for example, by stopping power supply to at least one of the voltage detection circuit 235 or the temperature detection circuit 240, by shifting the microcontroller 245 to the power saving mode to cut off power supply to some circuits in the microcontroller 245, or by reducing an operating frequency of the microcontroller 245. Note that even in a normal operation mode, the monitoring circuit 230 may not execute S320 when the failure information can be written to the recording medium 260 until the power supply to the monitoring circuit 230 is cut off after the power supply from the power circuit 200 is cut off.

[0056] In S330, the monitoring circuit 230 collects power abnormality information used as the failure information in a case of power abnormality. The power abnormality information as the failure information may include the power identification information as the component identification information, and may include failure type information indicating a type of failure, detailed component information (a product model number, a serial number, a date of manufacture, a manufacturer, or the like) of a failed component (the power circuit 200, the power source 205, or the like), or various types of information regarding a failure in the output voltage of each power source 205 measured by the voltage detection circuit 235 or the power source 205 in which a failure has occurred, the temperature of each power source 205 detected by the temperature detection circuit 240 or the power source 205 in which a failure has occurred, or the like. Note that the component identification information may include more detailed information including at least one of the product model number, the serial number, the date of manufacture, the manufacturer, or the like, in addition to information sufficient to identify a component in which a failure has occurred in the pin electronics apparatus 110 (for example, a component ID unique in the pin electronics apparatus 110).

[0057] In S340, the monitoring circuit 230 records, as the failure information, the power abnormality information including the power identification information on the recording medium 260 before the power supply to the monitoring circuit 230 is cut off. The monitoring circuit 230 may record the failure detection date and time on the recording medium 260 in association with the power abnormality information.

[0058] The monitoring circuit 230 may encrypt at least a part of the failure information and record a result on the recording medium 260. For example, the monitoring circuit 230 may encrypt at least one of the power identification information included in the failure information, the detailed component information of the failed power circuit 200 or power source 205, the failure type information, or the like. Accordingly, the monitoring circuit 230 can prevent the pin electronics apparatus 110 from being further damaged due to improper component replacement of a third party who is not familiar with the pin electronics apparatus 110.

[0059] After the power supply from the power circuit 200 is cut off, in S350, the recording medium 260 is read by near field communication or the like without the power supply from the power circuit 200. Note that, for example, when there is a power abnormality to such an extent that the power source 205 which supplies power to the monitoring circuit 230 does not need to be cut off or when the test apparatus 1 is reactivated, the control apparatus 170 may read the recording medium 260 to acquire the failure detection date and time and the failure information.

[0060] According to the pin electronics apparatus 110 described above, the recording medium 260 can maintain the written failure information or the like even when the power circuit 200 fails and the power supply from the power circuit 200 is cut off. Therefore, the pin electronics apparatus 110 can provide the failure information or the like to a user such as a maintenance worker of the test apparatus 1 or an external apparatus such as the control apparatus 170 even after shutdown of the test apparatus 1 or power supply cut-off of the power circuit 200.

[0061] In addition, since the recording medium 260 records, on the recording medium 260, the failure information including the power identification information for identifying the power source 205 for which the abnormality in power supply has been detected, it is possible to easily specify the failed power source 205 among the plurality of power sources 205. In addition, even when an abnormality occurs intermittently in the power source 205 or when an abnormality occurs in the power source 205 only under a certain condition, the pin electronics apparatus 110 records, on the recording medium 260, the power source 205 for which an abnormality is detected, in an identifiable manner, and thus it is possible to improve repairability, product quality, or mean time to repair (MTTR) of the pin electronics apparatus 110. In addition, by recording the failure detection date and time on the recording medium 260 in association with the failure information, the pin electronics apparatus 110 can provide the user of the test apparatus 1 with information that makes it easier to investigate a cause of a component in the pin electronics apparatus 110, such as a constant failure, an intermittent abnormality, or a temporary abnormality due to external noise such as a lightning strike.

[0062] Note that the control apparatus 170 or the pin electronics apparatus 110 may be configured to control the power circuit 200 to cut off the power source of the pin electronics apparatus 110 in a predetermined power cut-off sequence. In this case, in response to detecting the abnormality in power supply, the power circuit 200 cuts off the plurality of power sources 205*a* to 205*d* in order of the predetermined power cut-off sequence. In such a configuration, the monitoring circuit 230 may receive the power supply from the power source 205 to be cut off after at least one other power source 205 among the plurality of power sources 205*a* to 205*d* is cut off.

[0063] For example, when the power circuit 200 cuts off the power supply every 400 ms in order of the power source 205*d*, the power source 205*c*, the power source 205*b*, and the power source 205*a*, there is a delay of 1200 ms from cut-off of the power supply from the power source 205*d* to cut-off of the power supply from the power source 205*a*. By receiving the power supply from the power source 205*a*, the monitoring circuit 230 can start writing the failure information to the recording medium 260 after start of the cut-off of the power supply and finish writing the failure information before the cut-off of the power supply from the power source 205*a*. As described above, the monitoring circuit 230 may be configured to receive the power supply from the power source 205 from which the power supply is cut off after the writing of the failure information is completed after detection of the abnormality in the power supply. The monitoring circuit 230 may receive the power supply from the power

source **205**, which is cut off last in the power cut-off sequence, among the plurality of power sources **205**.

[0064] FIG. **4** illustrates a failure monitoring flow of the pin electronics apparatus **110** according to the present embodiment. The pin electronics apparatus **110** starts the failure monitoring flow of this drawing in a state where each circuit in the pin electronics apparatus **110** is operating normally. The pin electronics apparatus **110** may start the failure monitoring flow of this drawing in self-diagnosis performed, for example, when the test apparatus **1** is powered on. Note that, since the failure of the power circuit **200** is a type of failure of components in the pin electronics apparatus **110**, the power monitoring flow illustrated in FIG. **3** may be one form or a subset of the failure monitoring flow in this drawing.

[0065] In S**400**, the microcontroller **245** in the monitoring circuit **230** monitors the state of each component in the pin electronics apparatus **110**. In S**410**, the microcontroller **245** determines whether or not an abnormality of the component in the pin electronics apparatus **110** is detected. Each component in the pin electronics apparatus **110** includes various error detectors which detect abnormalities such as parity/ECC errors, queue overflows/underflows, or detections of undefined instructions, for example. In response to receiving an error detection signal indicating that an abnormality has occurred from the error detector, the microcontroller **245** detects the abnormality of the component including the error detector. The microcontroller **245** may detect the abnormality of the component in response to the temperature detection circuit **240** detecting that a temperature of the component exceeds a reference temperature defined for the component.

[0066] In addition, in the self-diagnosis of the test apparatus **1**, the pin electronics apparatus **110** performs a self-diagnosis test of each internal component. The microcontroller **245** may detect the abnormality of the component according to a result of the self-diagnosis test. The microcontroller **245** acquires, as the failure detection date and time, a date and time which is indicated by the internal clock **246** at a timing when the failure of the pin electronics apparatus **110** is detected.

[0067] If all the components are normal, the microcontroller **245** advances the processing to S**400** to continue monitoring the state of each component ("NO" in S**410**). If any of the components is abnormal, the microcontroller **245** advances the processing to S**420** ("YES" in S**410**).

[0068] In S**420**, in response to detecting the abnormality of the component, the monitoring circuit **230** shifts to the power saving mode in which the power consumption is smaller than that in a case of performing the normal operation. For example, the monitoring circuit **230** may reduce the power consumption, for example, by stopping power supply to at least one of the voltage detection circuit **235** or the temperature detection circuit **240**, by shifting the microcontroller **245** to the power saving mode to cut off power supply to some circuits in the microcontroller **245**, or by reducing the operating frequency of the microcontroller **245**. Note that the monitoring circuit **230** may shift to the power saving mode when the power supply to the monitoring circuit **230** is stopped due to occurrence of a severe abnormality, which requires emergency shutdown of the test apparatus **1**, such as a power short circuit or a mechanical failure, and may not execute S**420** when a minor abnormality that allows the operation of the test apparatus **1** to continue occurs.

[0069] In S**430**, the monitoring circuit **230** collects the failure information. The failure information may include the component identification information, and may include the failure type information, the detailed component information, and various types of information regarding the failure, such as a state value of each component or a failed component, or internal data.

[0070] In S**440**, the monitoring circuit **230** records the failure information on the recording medium **260** before the power supply to the monitoring circuit **230** is cut off. The monitoring circuit **230** may record the failure detection date and time in the recording medium **260** in association with the failure information.

[0071] The monitoring circuit **230** may encrypt at least a part of the failure information and record a result on the recording medium **260**. For example, the monitoring circuit **230** may encrypt at least one of the component identification information for identifying the failed component, the detailed component information of the failed component, the failure type information, or the like.

[0072] When a severe abnormality occurs, the test apparatus **1** is shut down in S**450**. Thus, the power circuit **200** in the pin electronics apparatus **110** stops the power supply to each circuit in the pin electronics apparatus **110**. After the power supply from the power circuit **200** is stopped, in S**460**, the recording medium **260** is read by near field communication or the like without the power supply from the power circuit **200**. For example, when there is a power abnormality to such an extent that the power source **205** which supplies power to the monitoring circuit **230** does not need to be cut off or when the test apparatus **1** is reactivated, the control apparatus **170** may read the recording medium **260** to acquire the failure detection date and time and the failure information.

[0073] According to the pin electronics apparatus **110** described above, the recording medium **260** can maintain the written failure information even when a circuit or a component in the pin electronics apparatus **110** fails and the test apparatus **1** is shut down. Therefore, the pin electronics apparatus **110** can provide the failure information to the user of the test apparatus **1** or an external apparatus such as the control apparatus **170** even after the shutdown of the test apparatus **1** or the power supply cut-off of the power circuit **200**.

[0074] In addition, since the recording medium **260** records, on the recording medium **260**, the failure information including the component identification information for identifying the failed component, it is possible to easily specify the failed component among the plurality of components. For example, the ASIC/LSI/IC in the pin electronics apparatus **110** may be attached with a heat sink for cooling or enclosed in a water jacket for liquid cooling. When the recording medium **260** records, as the component identification information, at least one of the product model number, the serial number, the date of manufacture, the manufacturer, or the like of such a component, the user of the test apparatus **1** can obtain the detailed component identification information without removing the heat sink or the like.

[0075] In addition, according to the pin electronics apparatus **110** described above, by using, as the recording medium **260**, a recording medium which is readable without receiving the power supply from the power circuit **200**, the failure information can be provided to the user of the test

apparatus **1** or an external apparatus without powering on the pin electronics apparatus **110** even after the shutdown of the test apparatus **1** or the power supply cut-off of the power circuit **200**.

[0076] Note that the monitoring circuit **230** may write in advance, to the recording medium **260**, the component information for each of the plurality of components mounted on the pin electronics apparatus **110**, in association with the component identification information, before the detection of the abnormality in the power supply or the failure of the pin electronics apparatus **110**. In addition, the monitoring circuit **230** may write in advance, to the recording medium **260**, other information that can be written to the recording medium **260** in advance, before the detection of the abnormality in the power supply or the failure of the pin electronics apparatus **110**. By writing as much information as possible to the recording medium **260** before the detection of the abnormality in the power supply or the failure of the pin electronics apparatus **110**, the monitoring circuit **230** can reduce a size of information to be written to the recording medium **260** after the detection of the abnormality in the power supply or the failure of the pin electronics apparatus **110**, and can reduce a duration for writing to the recording medium **260**.

[0077] FIG. **5** illustrates a structure of the test head **100** according to the present embodiment as viewed from a mounting surface side of the connection apparatus **120** (an upper surface side of the test head **100** in the test apparatus **1** of FIG. **1**). Each of the plurality of pin electronics apparatuses **110** is inserted into the slot of the test head **100**, and an edge thereof on a side of the connection apparatus **120** and the DUT **10** is exposed to an outer surface of the test head **100**. The pin electronics apparatus **110** includes one or more connectors **520***a* to **520***c* (also referred to as a "connector(s) **520**") and the antenna **270** at the edge on the side of the connection apparatus **120** and the DUT **10**.

[0078] Each connector **520** is connected to a corresponding connector arranged on a surface of the connection apparatus **120** on the test head **100** side. Accordingly, the pin electronics apparatus **110** is electrically connected to the DUT **10** via the connection apparatus **120**.

[0079] The antenna **270** is provided on an outer surface of the pin electronics apparatus **110**, the outer surface being externally exposed in a state where the pin electronics apparatus **110** is mounted on the test head **100**. In an example of this drawing, the antenna **270** is provided on an outer surface, on which the connectors **520***a* to **520***c* electrically connected to the DUT **10** are equipped, of the pin electronics apparatus **110**. Accordingly, by removing the connection apparatus **120** mounted on the test head **100**, the antenna **270** is externally exposed without removing the pin electronics apparatus **110** from the test head **100**. In this state, the recording medium **260** is readable by near field communication using the antenna **270**.

[0080] The recording medium **260** can read the failure information by receiving power supply by near field wireless power supply via the antenna **270** from a terminal apparatus that reads the failure information, and supply the failure information to the terminal apparatus by the near field communication via the antenna **270**. The recording medium **260** may operate by receiving the power supply from the terminal apparatus by the near field wireless power supply via the antenna **270**, and supply the failure information to the terminal apparatus by the near field communication.

[0081] Therefore, the user of the test apparatus **1** can read and confirm a failure occurrence date and time and the failure information recorded on the recording medium **260** in each pin electronics apparatus **110**, by bringing a terminal carried by the user close to the antenna **270** of each pin electronics apparatus **110**. The user can confirm the failure information read from each pin electronics apparatus **110** to specify the pin electronics apparatus **110**, in which the abnormality has occurred, from among the plurality of pin electronics apparatuses **110**, and can remove the pin electronics apparatus **110**, in which the abnormality has occurred, from the test head **100** to inspect or replace the pin electronics apparatus **110**.

[0082] In addition, the terminal which has read the failure information or the like of the pin electronics apparatus **110** via the antenna **270** may upload the failure information or the like to a server apparatus (for example, a cloud server) on the Internet or an intranet via a wireless communication network. Accordingly, the server apparatus can perform unified management of the failure information or the like of the pin electronics apparatuses **110** mounted on a plurality of test apparatuses **1** installed in various places, and can allow a producer or maintenance provider of the test apparatus **1** to confirm the state of each test apparatus **1**.

[0083] Note that the recording medium **260** may be readable under control of the microcontroller **245** without receiving the power supply from the power circuit **200**. In this case, the microcontroller **245** receives power supply by the near field wireless power supply via the antenna **270** from the terminal apparatus which reads the failure information, and reads the failure information from the recording medium **260**. Then, the microcontroller **245** supplies the failure information to the terminal apparatus by the near field communication via the antenna **270**.

[0084] More specifically, after the power supply is started and activation is performed, when the power supply from the power circuit **200** is not received and power supply is received by the near field wireless power supply, the microcontroller **245** transitions to a mode of processing an external read request for the recording medium **260**. In this mode, in response to receiving, via the antenna **270**, the read request for the recording medium **260**, the microcontroller **245** reads requested information (data) from the recording medium **260** and returns the information by the near field communication via the antenna **270**.

[0085] FIG. **6** illustrates a structure of a pin electronics apparatus **610** according to a first modification. The test apparatus **1** may include the pin electronics apparatus **610** instead of the pin electronics apparatus **110** illustrated in FIGS. **1** to **5**. Since the pin electronics apparatus **610** is a modification of the pin electronics apparatus **110**, description thereof will be omitted below except for differences.

[0086] The pin electronics apparatus **610** includes a main board **615** and one or more connectors **620***a* to **620***c* (also referred to as a "connector(s) **620**"). The main board **615** is equipped with each circuit and each component illustrated in FIG. **2**. This drawing illustrates the structure of the pin electronics apparatus **610** when the pin electronics apparatus **610** is viewed from a component equipping surface side of the main board **615**. Here, the component equipping surface side of the pin electronics apparatus **610** is an upper surface side when the pin electronics apparatus **610** taken out from the test head **100** is placed on a desk or the like. The antenna **270** is provided in a side portion, on which the one or more

connectors **620** connected to the DUT **10** are equipped, of an upper surface of the pin electronics apparatus **610**. The antenna **270** may be provided in a corner of the upper surface of the pin electronics apparatus **610** on a side on which the one or more connectors **620** are equipped. Since the one or more connectors **620** are similar to the one or more connectors **520** illustrated in FIG. **5**, description thereof will be omitted.

[0087] Since the pin electronics apparatus **610** has the antenna **270** in the side portion, on which each connector **620** is equipped, of the upper surface, it is possible to enable the recording medium **260** to be read by the near field communication using the antenna **270** without bringing the terminal close to a central portion or the like where the circuits in the pin electronics apparatus **610** are densely equipped. Accordingly, the pin electronics apparatus **610** can reduce a risk of damage to the pin electronics apparatus **610** due to the terminal falling or the like.

[0088] In addition, the main board **615** may have a structure in which wiring is concentrated on each connector **620** in the side portion on which each connector **620** is equipped, and a region having no wiring pattern is easily secured outside a vicinity of each connector **620**. In such a case, the main board **615** has an antenna pattern of the antenna **270** in the side portion on which each connector **620** is equipped, so that it is possible to prevent other wiring patterns from being included in a layer provided with the antenna **270** and upper and lower layers thereof and to suppress interference with the near field communication. Note that depending on arrangement of components or wiring patterns of the main board **615**, the antenna **270** may be provided at another location on the upper surface of the pin electronics apparatus **110**.

[0089] FIG. **7** illustrates a structure of a pin electronics apparatus **710** according to a second modification. The test apparatus **1** may include the pin electronics apparatus **710** instead of the pin electronics apparatus **110** illustrated in FIGS. **1** to **5** and the pin electronics apparatus **610** illustrated in FIG. **6**. Since the pin electronics apparatus **710** is a modification of the pin electronics apparatus **110** and the pin electronics apparatus **610**, description thereof will be omitted below except for differences.

[0090] The pin electronics apparatus **710** includes a main board **715** and one or more connectors **720***a* to **720***c* (also referred to as a "connector(s) **720**") and a monitoring connector **730**. The main board **715** is equipped with each circuit and each component illustrated in FIG. **2**. This drawing illustrates the structure of the pin electronics apparatus **710** when the pin electronics apparatus **710** is viewed from a component equipping surface side of the main board **715**. Here, the component equipping surface side of the pin electronics apparatus **710** is an upper surface side when the pin electronics apparatus **710** taken out from the test head **100** is placed on a desk or the like. Since the one or more connectors **720** are similar to the one or more connectors **520** illustrated in FIG. **5** or the one or more connectors **620** illustrated in FIG. **6**, description thereof will be omitted.

[0091] The monitoring connector **730** is provided instead of the antenna **270**, and is used to connect a terminal **790**, which reads the failure information, to the recording medium **260** in a wired manner. The recording medium **260** may receive power supply from the terminal **790** via the monitoring connector **730**. The recording medium **260** reads the failure information in response to a read request from the terminal **790**, and supplies the failure information to the terminal **790** by wired communication via the monitoring connector **730**.

[0092] The monitoring connector **730** may be provided on an outer surface, on which the connectors **720***a* to **720***c* electrically connected to the DUT **10** are equipped, of the pin electronics apparatus **710**. Accordingly, by removing the connection apparatus **120** mounted on the test head **100**, the monitoring connector **730** is externally exposed without removing the pin electronics apparatus **110** from the test head **100**. In this state, the recording medium **260** is readable by wired communication using the monitoring connector **730**.

[0093] Alternatively, the monitoring connector **730** may be provided in a side portion, on which the one or more connectors **720** connected to the DUT **10** are equipped, of the upper surface of the pin electronics apparatus **710** or the like. In this case, the monitoring connector **730** becomes accessible in a state where the pin electronics apparatus **710** is removed from the test head **100** and placed on a desk or the like.

[0094] Note that the recording medium **260** may be readable under the control of the microcontroller **245** without receiving the power supply from the power circuit **200**. In this case, the microcontroller **245** receives power supply from the terminal **790** via the monitoring connector **730**, and reads the failure information from the recording medium **260**. Then, the microcontroller **245** supplies the failure information to the terminal apparatus via the monitoring connector **730**.

[0095] FIG. **8** illustrates a structure of a pin electronics apparatus **810** according to a third modification. The test apparatus **1** may include the pin electronics apparatus **810** instead of the pin electronics apparatus **110** illustrated in FIGS. **1** to **5**, the pin electronics apparatus **610** illustrated in FIG. **6**, and the pin electronics apparatus **710** illustrated in FIG. **7**. Since the pin electronics apparatus **810** is a modification of the pin electronics apparatus **110**, the pin electronics apparatus **610**, and the pin electronics apparatus **710**, description thereof will be omitted below except for differences.

[0096] The pin electronics apparatus **810** includes a main board **815**, one or more sub boards **825***a* to **825***c* (also referred to as a "sub board(s) **825**"), and one or more connectors **820***a* to **820***c* (also referred to as a "connector(s) **820**"). The main board **815** is mounted with the one or more sub boards **825**. This drawing illustrates the structure of the pin electronics apparatus **810** when the pin electronics apparatus **810** is viewed from a surface side of the main board **815** where the sub board **825** is mounted. Here, the surface side of the main board **815** where the sub board **825** is mounted is an upper surface side when the pin electronics apparatus **810** taken out from the test head **100** is placed on a desk or the like.

[0097] The one or more sub boards **825** are mounted on the main board **815**. Each sub board **825** may be equipped with each circuit or component included in the pin electronics apparatus **110** illustrated in FIG. **2**. Accordingly, in the one or more sub boards **825**, a monitoring circuit **827** and an antenna **830** may be mounted on each sub board **825**. Therefore, the pin electronics apparatus **810** includes one or more monitoring circuits **827***a* to **827***c* (also referred to as a "monitoring circuit(s) **827**"), each mounted on the corresponding sub board **825**, and one or more antennas **830***a* to

830*c* (also referred to as an "antenna(s) **830**"). Here, each monitoring circuit **827** may have a function and a configuration similar to those of the monitoring circuit **230** illustrated in FIG. **1**. In addition, each antenna **830** may have a function and a configuration similar to those of the antenna **270** illustrated in FIG. **1**.

[0098] By providing the monitoring circuit **827** and the antenna **830** on each sub board **825**, the pin electronics apparatus **810** can read the failure information or the like recorded on the recording medium **260** mounted on each of the one or more sub boards **825** by the near field communication. Therefore, the user of the test apparatus **1** can read and confirm the failure occurrence date and time and the failure information recorded on the recording medium **260** in each sub board **825**, by bringing the terminal carried by the user close to the antenna **830** of each sub board **825**. The user can confirm the failure information read from each sub board **825** to specify the sub board **825**, in which the abnormality has occurred, from the one or more sub boards **825**, and can remove the sub board **825**, in which the abnormality has occurred, from the pin electronics apparatus **810** to inspect or replace the sub board **825**.

[0099] Various embodiments of the present invention may be described with reference to flowcharts and block diagrams, where blocks may represent (1) stages of processes in which operations are executed or (2) sections of apparatuses responsible for executing operations. Certain stages and sections may be implemented by a dedicated circuit, a programmable circuit supplied together with computer-readable instructions stored on computer-readable media, and/or processors supplied together with computer-readable instructions stored on computer-readable media. The dedicated circuit may include digital and/or analog hardware circuits, and may include integrated circuits (IC) and/or discrete circuits. The programmable circuit may include a reconfigurable hardware circuit including logical AND, logical OR, logical XOR, logical NAND, logical NOR, and other logical operations, a memory element or the like such as a flip-flop, a register, a field programmable gate array (FPGA) and a programmable logic array (PLA), or the like.

[0100] A computer-readable medium may include any tangible device that can store instructions to be executed by a suitable device, and as a result, the computer-readable medium having instructions stored thereon includes a product including instructions that can be executed in order to create means for executing operations specified in the flowcharts or block diagrams. Examples of the computer-readable medium may include an electronic storage medium, a magnetic storage medium, an optical storage medium, an electromagnetic storage medium, a semiconductor storage medium, and the like. More specific examples of the computer-readable medium may include a FLOPPY (registered trademark) disk, a diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or flash memory), an electrically erasable programmable read-only memory (EEPROM), a static random access memory (SRAM), a compact disc read-only memory (CD-ROM), a digital versatile disk (DVD), a BLU-RAY (registered trademark) disk, a memory stick, an integrated circuit card, and the like.

[0101] The computer-readable instruction may include: an assembler instruction, an instruction-set-architecture (ISA) instruction; a machine instruction; a machine dependent instruction; a microcode; a firmware instruction; state-setting data; or either a source code or an object code described in any combination of one or more programming languages, including an object oriented programming language such as SMALLTALK (registered trademark), JAVA (registered trademark), C++, or the like, and a conventional procedural programming language such as a "C" programming language or a similar programming language.

[0102] The computer-readable instructions may be provided for a processor or programmable circuit of a general purpose computer, special purpose computer, or other programmable data processing apparatuses such as a computer locally or via a wide area network (WAN) such as a local area network (LAN), the Internet, or the like, and execute the computer-readable instructions in order to create means for executing the operations designated in flowcharts or block diagrams. Examples of the processor include a computer processor, a processing unit, a microprocessor, a digital signal processor, a controller, a microcontroller, and the like.

[0103] FIG. **9** illustrates an example of a computer **2200** in which a plurality of aspects of the present invention may be embodied entirely or partially. A program installed in the computer **2200** can cause the computer **2200** to function as an operation associated with the apparatuses according to the embodiments of the present disclosure or as one or more sections of the apparatuses, or can cause the operation or the one or more sections to be executed, and/or can cause the computer **2200** to execute a process according to the embodiments of the present disclosure or a stage of the process. Such programs may be executed by a CPU **2212** to cause the computer **2200** to perform specific operations associated with some or all of the blocks in the flowcharts and block diagrams described in the present specification.

[0104] The computer **2200** according to the present embodiment includes the CPU **2212**, an RAM **2214**, a graphics controller **2216**, and a display device **2218**, which are mutually connected by a host controller **2210**. The computer **2200** also includes input/output units such as a communication interface **2222**, a hard disk drive **2224**, a DVD-ROM drive **2226**, and an IC card drive, which are connected to the host controller **2210** via an input/output controller **2220**. The computer also includes legacy input/output units such as an ROM **2230** and a keyboard **2242**, which are connected to the input/output controller **2220** via an input/output chip **2240**.

[0105] The CPU **2212** operates according to programs stored in the ROM **2230** and the RAM **2214**, thereby controlling each unit. The graphics controller **2216** acquires image data generated by the CPU **2212** in a frame buffer or the like provided in the RAM **2214** or in itself, such that the image data is displayed on the display device **2218**.

[0106] The communication interface **2222** communicates with other electronic devices via a network. The hard disk drive **2224** stores programs and data used by the CPU **2212** in the computer **2200**. The DVD-ROM drive **2226** reads a program or data from a DVD-ROM **2201** and provides the program or data to the hard disk drive **2224** via the RAM **2214**. The IC card drive reads the programs and the data from the IC card, and/or writes the programs and the data to the IC card.

[0107] The ROM **2230** stores therein boot programs and the like executed by the computer **2200** at the time of activation, and/or programs that depend on the hardware of

the computer **2200**. The input/output chip **2240** may also connect various input/output units to the input/output controller **2220** via a parallel port, a serial port, a keyboard port, a mouse port, or the like.

[0108] The program is provided by a computer-readable medium such as the DVD-ROM **2201** or the IC card. The program is read from a computer-readable medium, installed in the hard disk drive **2224**, the RAM **2214**, or the ROM **2230** which are also examples of the computer-readable medium, and executed by the CPU **2212**. The information processing described in these programs is read by the computer **2200** and provides cooperation between the programs and the above-described various types of hardware resources. The apparatus or method may be configured by implementing operations or processing of information according to use of the computer **2200**.

[0109] For example, when communication is performed between the computer **2200** and an external device, the CPU **2212** may execute a communication program loaded in the RAM **2214** and instruct the communication interface **2222** to perform communication processing based on processing described in the communication program. Under the control of the CPU **2212**, the communication interface **2222** reads transmission data stored in a transmission buffer processing region provided in a recording medium such as the RAM **2214**, the hard disk drive **2224**, the DVD-ROM **2201**, or the IC card, transmits the read transmission data to the network, or writes reception data received from the network in a reception buffer processing region or the like provided on the recording medium.

[0110] In addition, the CPU **2212** may cause the RAM **2214** to read all or a necessary part of a file or database stored in an external recording medium such as the hard disk drive **2224**, the DVD-ROM drive **2226** (DVD-ROM **2201**), the IC card, or the like, and may execute various types of processing on data on the RAM **2214**. Then, the CPU **2212** writes the processed data back in the external recording medium.

[0111] Various types of information such as various types of programs, data, tables, and databases may be stored in a recording medium and subjected to information processing. The CPU **2212** may execute, on the data read from the RAM **2214**, various types of processing including various types of operations, information processing, conditional judgement, conditional branching, unconditional branching, information retrieval/replacement, or the like described throughout the present disclosure and specified by instruction sequences of the programs, and writes the results back to the RAM **2214**. In addition, the CPU **2212** may retrieve information in a file, a database, or the like in the recording medium. For example, when a plurality of entries, each having an attribute value of a first attribute associated with an attribute value of a second attribute, is stored in the recording medium, the CPU **2212** may retrieve, out of the plurality of entries, an entry with the attribute value of the first attribute specified that meets a condition, read the attribute value of the second attribute stored in said entry, and thereby acquiring the attribute value of the second attribute associated with the first attribute meeting a predetermined condition.

[0112] The programs or software modules described above may be stored in a computer-readable medium on or near the computer **2200**. In addition, a recording medium such as a hard disk or an RAM provided in a server system connected to a dedicated communication network or the Internet can be used as a computer-readable medium, thereby providing a program to the computer **2200** via the network.

[0113] While the present invention has been described by way of the embodiments, the technical scope of the present invention is not limited to the above-described embodiments. It is apparent to persons skilled in the art that various alterations or improvements can be made to the above described embodiments. It is also apparent from the described scope of the claims that the embodiments to which such alterations or improvements are made can be included in the technical scope of the present invention.

[0114] It should be noted that the operations, procedures, steps, stages, or the like of each process performed by an apparatus, system, program, and method shown in the claims, the specification, or the drawings can be performed in any order as long as the order is not indicated by "prior to," "before," or the like and as long as the output from a previous process is not used in a later process. Even if the process flow is described using phrases such as "first" or "next" in the claims, the specification, or the drawings for the sake of convenience, it does not necessarily mean that the process must be performed in this order.

EXPLANATION OF REFERENCES

[0115] **1**: test apparatus;
[0116] **10**: DUT;
[0117] **100**: test head;
[0118] **110**: pin electronics apparatus;
[0119] **120**: connection apparatus;
[0120] **150**: main frame;
[0121] **160**: main power supply apparatus;
[0122] **170**: control apparatus;
[0123] **200**: power circuit;
[0124] **205***a* to **205***d*: power source;
[0125] **210**: test circuit;
[0126] **220**: test control circuit;
[0127] **230**: monitoring circuit;
[0128] **235**: voltage detection circuit;
[0129] **240**: temperature detection circuit;
[0130] **245**: microcontroller;
[0131] **246**: internal clock;
[0132] **247**: clock setting circuit;
[0133] **248**: write circuit;
[0134] **250**: storage battery;
[0135] **260**: recording medium;
[0136] **270**: antenna;
[0137] **520***a* to **520***c*: connector;
[0138] **610**: pin electronics apparatus;
[0139] **615**: main board;
[0140] **620***a* to **620***c*: connector;
[0141] **710**: pin electronics apparatus;
[0142] **715**: main board;
[0143] **720***a* to **720***c*: connector;
[0144] **730**: monitoring connector;
[0145] **790**: terminal;
[0146] **810**: pin electronics apparatus;
[0147] **815**: main board;
[0148] **820***a* to **820***c*: connector;
[0149] **825***a* to **825***c*: sub board;
[0150] **827***a* to **827***c*: monitoring circuit;
[0151] **830***a* to **830***c*: antenna;
[0152] **2200**: computer;
[0153] **2201**: DVD-ROM;

[0154] **2210**: host controller;
[0155] **2212**: CPU;
[0156] **2214**: RAM;
[0157] **2216**: graphics controller;
[0158] **2218**: display device;
[0159] **2220**: input/output controller;
[0160] **2222**: communication interface;
[0161] **2224**: hard disk drive;
[0162] **2226**: DVD-ROM drive;
[0163] **2230**: ROM;
[0164] **2240**: input/output chip; and
[0165] **2242**: keyboard.

What is claimed is:

1. A pin electronics apparatus comprising:
a test circuit which is connected to a device under test and tests the device under test;
a power circuit which includes a plurality of power sources; and
a monitoring circuit which records, in response to detecting an abnormality in power supply from the power circuit, power identification information for identifying a power source, for which an abnormality in power supply is detected, among the plurality of power sources on a non-volatile recording medium.

2. The pin electronics apparatus according to claim **1**, wherein in response to detecting an abnormality in power supply from the power circuit, the monitoring circuit records the power identification information on the non-volatile recording medium before power supply to the monitoring circuit is cut off.

3. The pin electronics apparatus according to claim **2**, wherein
in response to detecting an abnormality in power supply, the power circuit cuts off the plurality of power sources in order of a predetermined power cut-off sequence, and
the monitoring circuit receives power supply from a power source to be cut off after at least one other power source among the plurality of power sources is cut off.

4. The pin electronics apparatus according to claim **3**, wherein the monitoring circuit records the power identification information on the non-volatile recording medium during a period from start of cut-off of the plurality of power sources based on the power cut-off sequence to cut-off of a power source which supplies power to the monitoring circuit.

5. The pin electronics apparatus according to claim **1**, further comprising
a storage battery which accumulates power from at least one of the plurality of power sources, wherein
the monitoring circuit records the power identification information on the non-volatile recording medium after cut-off of power supply from the power circuit and before interruption of power supply from the storage battery.

6. The pin electronics apparatus according to claim **5**, wherein the storage battery includes a capacitor which accumulates power.

7. The pin electronics apparatus according to claim **5**, wherein in response to receiving power supply from the storage battery, the monitoring circuit shifts to a power saving mode in which power consumption is smaller than that in a case of performing a normal operation.

8. The pin electronics apparatus according to claim **1**, wherein for each power source of the plurality of power sources, the monitoring circuit detects an abnormality in the power source in response to at least one of a fact that an output voltage of the power source is outside a reference voltage range predetermined for each power source or a fact that a temperature associated with the power source exceeds a predetermined reference temperature.

9. The pin electronics apparatus according to claim **1**, wherein the monitoring circuit includes a microcontroller which performs monitoring the plurality of power sources and writing on the non-volatile recording medium by executing a monitoring program.

10. The pin electronics apparatus according to claim **1**, wherein the non-volatile recording medium is readable without receiving power supply from the power circuit.

11. The pin electronics apparatus according to claim **10**, wherein the non-volatile recording medium is readable by near field communication.

12. The pin electronics apparatus according to claim **11**, comprising
an antenna which is provided on an outer surface of the pin electronics apparatus, the outer surface being externally exposed in a state where the pin electronics apparatus is mounted on a test head, wherein
the non-volatile recording medium is readable by near field communication using the antenna.

13. The pin electronics apparatus according to claim **12**, wherein the antenna is provided on an outer surface, on which a connector connected to the device under test is equipped, of the pin electronics apparatus.

14. The pin electronics apparatus according to claim **11**, comprising
an antenna which is provided on a side portion, on which a connector connected to the device under test is equipped, of an upper surface of the pin electronics apparatus, wherein
the non-volatile recording medium is readable by near field communication using the antenna.

15. A test apparatus comprising:
one or more pin electronics apparatuses including the pin electronics apparatus according to claim **1**;
a control apparatus which controls the one or more pin electronics apparatuses; and
a connection apparatus which connects the one or more pin electronics apparatuses to one or more devices under test.

16. A test apparatus comprising:
one or more pin electronics apparatuses including the pin electronics apparatus according to claim **2**;
a control apparatus which controls the one or more pin electronics apparatuses; and
a connection apparatus which connects the one or more pin electronics apparatuses to one or more devices under test.

17. A test apparatus comprising:
one or more pin electronics apparatuses including the pin electronics apparatus according to claim **3**;
a control apparatus which controls the one or more pin electronics apparatuses; and
a connection apparatus which connects the one or more pin electronics apparatuses to one or more devices under test.

18. A test apparatus comprising:
one or more pin electronics apparatuses including the pin electronics apparatus according to claim **4**;
a control apparatus which controls the one or more pin electronics apparatuses; and
a connection apparatus which connects the one or more pin electronics apparatuses to one or more devices under test.

19. A test apparatus comprising:
one or more pin electronics apparatuses including the pin electronics apparatus according to claim **5**;
a control apparatus which controls the one or more pin electronics apparatuses; and
a connection apparatus which connects the one or more pin electronics apparatuses to one or more devices under test.

20. A method comprising:
testing, by a pin electronics apparatus connected to a device under test, the device under test; and
in response to detecting an abnormality in power supply from a power circuit including a plurality of power sources, recording, by the pin electronics apparatus, power identification information for identifying a power source, for which an abnormality in power supply is detected, among the plurality of power sources on a non-volatile recording medium.

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