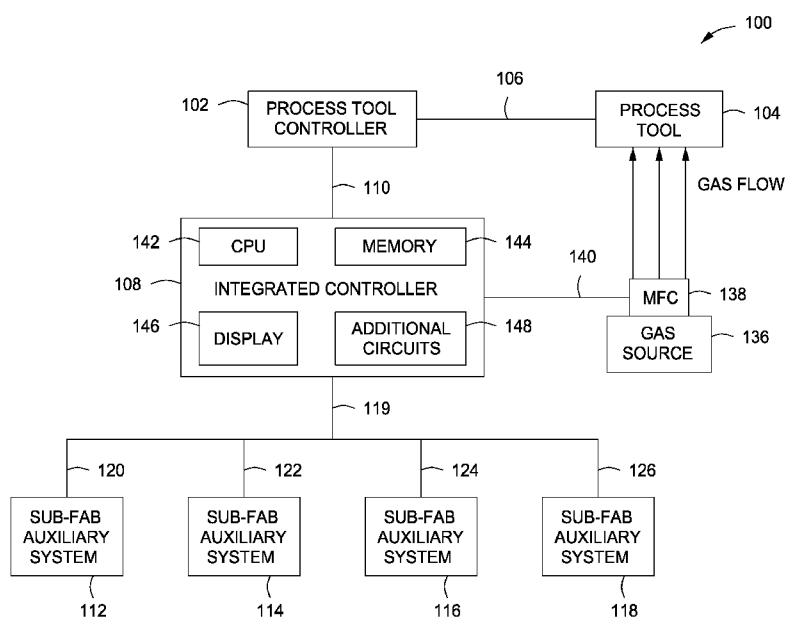




- (51) **International Patent Classification:**
G05B 23/02 (2006.01) *G05B 19/418* (2006.01)
- (21) **International Application Number:**
PCT/US2013/041799
- (22) **International Filing Date:**
20 May 2013 (20.05.2013)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
61/657,407 8 June 2012 (08.06.2012) US
13/895,978 16 May 2013 (16.05.2013) US
- (71) **Applicant:** APPLIED MATERIALS, INC. [US/US];
3050 Bowers Avenue, Santa Clara, California 95054 (US).
- (72) **Inventors:** CLARK, Daniel O.; 3657 Locke Court, Pleasanton, California 94566 (US). LOLDJ, Youssef A.; 614 Picasso Terrace, Sunnyvale, California 94087 (US). CRAWFORD, Shaun W.; 2827 Yarmouth Way, San Ramon, California 94583 (US). CAYER, Maxime; 1022 East Bartlett Way, Chandler, Arizona 85249 (US). TONG, Tony H.; 2708 Buena View Court, San Jose, California 95121 (US). RIESKE, Eric; 813 Tanager Road, Livermore, California 94551 (US).
- (74) **Agent:** LINARDAKIS, Leonard P.; Moser Taboada, 1030 Broad Street, Suite 203, Shrewsbury, New Jersey 07702 (US).
- (81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) **Title:** INTEGRATED CONTROLLER SOLUTION FOR MONITORING AND CONTROLLING MANUFACTURING EQUIPMENT



(57) **Abstract:** Methods and apparatus for controlling manufacturing equipment are provided herein. In some embodiments, a manufacturing system may include an integrated controller having one or more inputs to receive input values corresponding to operating information of at least one of a process tool, a mass flow controller or at least one sub-fab auxiliary system, wherein the integrated controller is configured to receive the input values, determine that an error condition is matched based on the received input values, and control the at least one sub-fab auxiliary system to operate at a fail-safe operating mode responsive to the determined error condition.



Published:

— *with international search report (Art. 21(3))*

INTEGRATED CONTROLLER SOLUTION FOR MONITORING AND CONTROLLING MANUFACTURING EQUIPMENT

FIELD

[0001] Embodiments of the present invention generally relate to control systems used in manufacturing electronic devices.

BACKGROUND

[0002] Electronic device manufacturing facilities, or "fabs", typically employ process tools which perform manufacturing processes in the production of electronic devices. Such processes may include physical vapor deposition, chemical vapor deposition, etch, cleaning and other electronic device manufacturing processes. It should be understood that the present invention is not limited to any particular electronic device manufacturing process. A fab is typically laid out with a clean room on one floor, and a room containing auxiliary systems and devices which support the clean room on a lower floor, herein referred to as a "sub-fab." For ease of reference, the phrases `auxiliary systems` and `auxiliary devices` may be used interchangeably herein to describe a sub-fab system and/or device. One important function of the sub-fab is to abate toxic, flammable, or otherwise potentially harmful substances which are common byproducts of electronic device manufacturing processes. The sub-fab may contain such auxiliary devices as abatement tools, AC power distributors, primary vacuum pumps, spare vacuum pumps, water pumps, chillers, heat exchangers, process cooling water supplies and delivery systems, electrical power supplies and delivery systems, inert gas dumps, valves, device controllers, clean dry air supplies and delivery systems, ambient air supplies and delivery systems, inert gas supplies and delivery systems, fuel supplies and delivery systems, touch screens, process logic controllers, reagent supplies and delivery systems, etc.

[0003] Controller systems used in electronic device manufacturing must utilize operating information, state information and other electronic signals from process tools and sub-fab auxiliary systems to determine operating parameters. However, if one or more of the fab or sub-fab systems are not operating properly, or if

information monitored by the integrated controller indicates a potential problem, unsafe operating conditions may result. For example, if pumps or abatement systems are not functioning properly, flow of toxic chemicals or global warming gases out of the electronic device manufacturing facilities may be released into the atmosphere without abatement. Other unsafe operating conditions from one or more of the fab or sub-fab systems not operating properly may include, for example, fire, equipment damage, etc.

[0004] Accordingly, the inventors have provided improved methods of monitoring, reporting and controlling process tools, gas flow controllers, and sub-fab auxiliary systems to facilitate safe and proper operation of this equipment.

SUMMARY

[0005] Methods and apparatus for controlling manufacturing equipment are provided herein. In some embodiments, a manufacturing system may include an integrated controller having one or more inputs to receive input values corresponding to operating information of at least one of a process tool, a mass flow controller or at least one sub-fab auxiliary system, wherein the integrated controller is configured to receive the input values, determine that an error condition is matched based on the received input values, and control the at least one sub-fab auxiliary system to operate at a fail-safe operating mode responsive to the determined error condition.

[0006] In some embodiments, a method of controlling a manufacturing system may include monitoring, by an integrated controller, operating information of at least one of a process tool, a mass flow controller or at least one sub-fab auxiliary system of the manufacturing system, determining, by the integrated controller, that an error condition is matched based on the monitored operating information; and controlling, by the integrated controller, the at least one sub-fab auxiliary system to operate at a fail-safe operating mode responsive to the determined error condition.

[0007] Other and further embodiments and variations of the invention are described in more detail, below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Embodiments of the present invention, briefly summarized above and discussed in greater detail below, can be understood by reference to the illustrative embodiments of the invention depicted in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0009] Figure 1 depicts a schematic view of a processing system having a control system in accordance with some embodiments of the present invention.

[0010] Figure 2 depicts a flow chart of a method 200 for determining whether an error condition is matched in accordance with some embodiments of the present invention.

[0011] Figure 3 depicts a flow chart of a second method 300 for determining whether an error condition is matched in accordance with some embodiments of the present invention.

[0012] Figure 4 depicts a flow chart of a third method 400 for determining whether an error condition is matched in accordance with some embodiments of the present invention.

[0013] Figure 5 depicts a flow chart of a fourth method 500 for determining whether an error condition is matched in accordance with some embodiments of the present invention.

[0014] Figure 6 depicts a flow chart of other methods 600 for determining whether an error condition is matched in accordance with some embodiments of the present invention.

[0015] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. The figures are not drawn to scale and may be simplified for clarity. It is contemplated that elements and features of one embodiment may be beneficially incorporated in other embodiments without further recitation.

DETAILED DESCRIPTION

[0016] Embodiments of the present invention relate to controls systems for monitoring and controlling “fab” systems and “sub-fab” auxiliary systems used in the manufacture of electronic devices. Embodiments of the present invention provide an integrated control solution that utilizes process state and operating information from process tool sets, gas panels, and sub components to ensure that the fab and sub-fab systems are operating safely. For example, exemplary embodiments consistent with the present invention provide smarter and safer operation of fab and sub-fab systems by assuring that various error conditions (e.g., incorrect configuration information, loss of communication or power, the incorrect connection of signals to an integrated controller, and the like) do not result in an unsafe operating condition. If an error condition is detected, exemplary control systems consistent with the present invention may control the sub-fab equipment to operate in a fail-safe mode, show a warning lamp, display an error message, and/or defer control back to the local sub-fab controllers. In some embodiments consistent with the present application, the fail-safe modes for sub-fab components may include high capacity modes to accommodate the worst case process demands (e.g., the highest effluent load demands) of the process tool on abatement systems and pumps.

[0017] Although embodiments herein describe an integrated controller, the integrated controller may consist of multiple controllers which may be communicatively coupled. In addition, in some embodiments, there may be more than one control core per controller (*i.e.*, one controller can communicate with multiple tools and sub-fab components.) Furthermore, although discussed in terms of “control” of fab and sub-fab components, in some embodiments consistent with the present application, “control” may consist of providing control signals to the “independent controllers” of the sub-fab components.

[0018] Finally, although embodiments herein describe controls systems for manufacturing systems used in the manufacture of electronic devices such as substrate processing systems, embodiments of the present invention may be used in other industries where conservation of resources, reducing environmental impact

of waste products, and error reporting of manufacturing equipment are of concern, such as for example, but not limited to, the life science, food and agricultural industries.

[0019] FIG. 1 is a schematic depiction of a processing system 100 of an embodiment consistent with the present invention. Processing system 100 may include a process tool controller 102 which may be linked to a process tool 104 through communication link 106. Process tool controller 102 may be any microcomputer, microprocessor, logic circuit, a combination of hardware and software, or the like, suitable to control the operation of the process tool 104. For example, process tool controller 102 may be a PC, server tower, single board computer, and/or a compact PCI, etc. Process tool 104 may be any electronic device manufacturing process tool which requires effluent abatement and/or other resources from a sub-fab support system. Communication link 104 (and any other communication link described herein) may be hardwired or wireless and may use any suitable communication protocol.

[0020] The process tool controller 102 may be linked to the integrated controller 108 by means of communication link 110. The integrated controller 108 may comprise a central processing unit (CPU) 142, a memory 144, a display 146, and support circuits 148 for the CPU. The controller 108 may control each component of the processing system 100 directly, or via computers (or controllers) associated with particular process chamber and/or support system components. The controller 108 may be one of any form of general-purpose computer processor that can be used in an industrial setting for controlling various chambers and sub-processors. The memory, or computer-readable medium of the CPU may be one or more of readily available memory such as random access memory (RAM), read only memory (ROM), floppy disk, hard disk, flash, or any other form of digital storage, local or remote. The support circuits are coupled to the CPU for supporting the processor in a conventional manner. These circuits include cache, power supplies, clock circuits, input/output circuitry and subsystems, and the like. Inventive methods as described herein may be stored in the memory of the controller 108 as software routine that may be executed or invoked to control the operation of the substrate processing system 100 in the manner described herein. For example, each method step may

be stored as or in a module of the memory 144. The software routine may also be stored and/or executed by additional CPUs (not shown) that are remotely located from the hardware being controlled by the controller 108.

[0021] The integrated controller 108 may be linked to one or more mass flow controllers (MFC) 138 through communication links 140. The MFC may control a gas source 136 which provides gas to process tool 104. The MFC may provide operating information either directly to the integrated controller through communications link 140, or indirectly through the process tool controller 102.

[0022] The integrated controller 108 may in turn be linked to sub-fab auxiliary systems/devices 112, 114, 116 and 118 through communication links 120, 122, 124 and 126, respectively. The sub-fab auxiliary systems/devices may each have a local controller (not shown) which communicates with the integrated controller and controls the sub-fab auxiliary systems/devices. Alternatively, the integrated controller 108 may perform the functionality of a lower-level local controller for any or all of the sub-fab auxiliary systems/devices. Although four sub-fab auxiliary systems/devices are shown, it should be noted that more or fewer than four sub-fab auxiliary systems/devices may be linked to the integrated controller 108. Sub-fab auxiliary systems/devices may include abatement tools, AC power distributors, primary vacuum pumps, spare vacuum pumps, water pumps, chillers, heat exchangers, process cooling water supplies and delivery systems, electrical power supplies and delivery systems, inert gas dumps, valves, device controllers, clean dry air supplies and delivery systems, ambient air supplies and delivery systems, inert gas supplies and delivery systems, fuel supplies and delivery systems, touch screens, process logic controllers, reagent supplies and delivery systems, etc.

[0023] In operation, process tool controller 102 may control the process tool 104 by operating one or more of robots, doors, pumps, valves, plasma generators, power supplies, etc. As described above, process tool controller 102 may be constantly aware regarding the state of, and resource requirements of, each chamber in the process tool 104 and of the process tool 104 as a whole. Process tool controller 102 may have access to a database (not shown) which the process tool controller 102 may use to calculate the resource requirements of the chambers (not shown) and

the process tool 104 as a whole. Process tool controller 102 may send integrated controller 108 operating information regarding the state of each chamber in the process tool 104 and of the process tool 104 as a whole.

[0024] The integrated controller 108 may be linked to instruments in the sub-fab (not shown), calculate the resource requirements of the sub-fab auxiliary systems, and provide information regarding the resource requirements of the sub-fab auxiliary systems to the process tool controller 102.

[0025] The process tool controller 102 and MFC 138 may communicate process state and operating information (which may include configuration information) to the integrated controller 108 which may in turn control one or more sub-fab auxiliary systems 112, 114, 116 and 118 by operating pumps, switches valves, power supplies, and/or other hardware through communication links 119, 120, 122, 124 and 126. In the alternative, integrated controller 108 may direct sub-fab auxiliary system local controllers (not shown) to perform these functions. The integrated controller may obtain state and operating information (which may include configuration information) from sub-fab auxiliary systems 112, 114, 116 and 118. Examples of process state and operating information may include, but are not limited to, electrical power use, fuel gas and purge gas compositions, temperatures of processing environments, status of data connections, and the like. The integrated controller 108 may use the operating information obtain to ensure proper and safe operation of the processing system.

[0026] In some embodiments consistent with the present invention, the integrated controller 108 is configured to receive input values corresponding to operating information of at least one of process tool 102, mass flow controller 138 or at least one sub-fab auxiliary system 112, 114, 116 and 118. The integrated controller 108 is further configured to determine whether an error condition is matched based on the received input values. The integrated controller may be further configured to control the at least one sub-fab auxiliary system 112, 114, 116 and 118 to operate at a fail-safe operating mode responsive to a determination that an error condition is matched.

[0027] In other embodiments consistent with the present invention a method of controlling a substrate processing system may include monitoring operating information of at least one of a process tool 102, a mass flow controller 138 or at least one sub-fab auxiliary system 112, 114, 116 and 118, determining whether an error condition is matched based on the monitored operating information, and controlling at least one sub-fab auxiliary system to operate at a fail-safe operating mode responsive to a determination that an error condition is matched. In some embodiments, this method may be performed by the integrated controller 108.

[0028] Figure 2 depicts a flow chart of a method 200 for controlling a processing system in accordance with some embodiments of the present invention. In some embodiments, the method 200 may be an example of a module of the memory 144 of the integrated controller and may be used to control the processing system as described herein. The method 200 depicts a method which may be performed by integrated controller 108 which may poll the process tool controller 102 and/or MFC 138 for MFC names in order to determine any changes to MFC 138. MFC names, consistent with some embodiments described herein, may refer to gas names and additional MFCs. When the name is not correct or an additional MFC is detected, there is a risk that somebody has changed the system physically and the old set-up could result in unsafe operating conditions. If changes to MFC 138 are detected, an error condition is matched and integrated controller 108 may signal at least one of the sub-fab auxiliary systems 112, 114, 116 and 118 to operate at fail-safe operation mode until the new MFC information can be physically verified and the system is reset.

[0029] Generally the method 200 begins at 202 where integrated controller 108 may send a request for MFC names to at least one of process tool 102 or MFC 138. At 204 a response may be received responsive to the request sent. Integrated controller 108 may determine whether there are any changes to MFC 138 based on the response received at 206. If there are no changes, the method terminates. If integrated controller 108 determines that there are changes to MFC 138 (*i.e.*, an error condition is matched), integrated controller 108 signals one or more of sub-fab auxiliary systems 112, 114, 116 and 118 to operate at fail-safe operation mode at 208. Additionally, integrated controller 108 may display a warning light and an error

message at 210 and 212. Alternatively, integrated controller 108 may signal one or more of the process tool controller 102, MFC 138, or sub-fab auxiliary systems 112, 114, 116 and 118 to display a warning light and an error message.

[0030] Figure 3 depicts a flow chart of a method 300 for controlling a processing system in accordance with some embodiments of the present invention. In some embodiments, the method 300 may be an example of a module of the memory 144 of the integrated controller and may be used to control the processing system as described herein. The method 300 depicts a method which may be performed by integrated controller 108.

[0031] Generally the method 300 begins at 302 where integrated controller 108 may receive an input signal from process tools, MFCs, or sub-fab auxiliary systems. Integrated controller 108 may determine if the received input signal is accompanied by a label at 304. For example, in some embodiments, the input signals may include specific information sent by process tool 104 or process tool controller 102 to integrated controller 108 such as status variable ID (SVID) information and collected event ID (CEID) information. SVID and CEID information may include, for example, gas names and flows, chamber status, recipe and lot start/stop information, and the like. If the received input signal is accompanied by a label identifying the source of the information, the method terminates. If integrated controller 108 determines the received input signal is not accompanied by a label (*i.e.*, an error condition is matched), integrated controller 108 signals one or more of sub-fab auxiliary systems 112, 114, 116 and 118 to operate at fail-safe operation mode at 306. Additionally, integrated controller 108 may display a warning light and an error message at 308 and 310. Alternatively, integrated controller 108 may signal one or more of the process tool controller 102, MFC 138, or sub-fab auxiliary systems 112, 114, 116 and 118 to display a warning light and an error message.

[0032] Figure 4 depicts a flow chart of a method 400 for controlling a processing system in accordance with some embodiments of the present invention. In some embodiments, the method 400 may be an example of a module of the memory 144 of the integrated controller and may be used to control the processing system as

described herein. The method 400 depicts a method which may be performed by integrated controller 108.

[0033] Generally the method 400 begins at 402 where integrated controller 108 may receive a label from process tools, MFCs, or other sub-fab auxiliary systems. Integrated controller 108 may determine if the received label is accompanied by an associated input signal at 404. A label may identify the source of the information (e.g., process tool, MFC, sub-fab auxiliary system). The input signals may include specific information sent by process tool 104 or process tool controller 102 to integrated controller 108 such as status variable ID (SVID) information and collected event ID (CEID) information. SVID and CEID information may include, for example, gas names and flows, chamber status, recipe and lot start/stop information, etc. If the received label is accompanied by an associated input signal, the method terminates. If integrated controller 108 determines the received label is not accompanied by an input signal (*i.e.*, an error condition is matched), integrated controller 108 signals one or more of sub-fab auxiliary systems 112, 114, 116 and 118 to operate at fail-safe operation mode at 406. Additionally, integrated controller 108 may display a warning light and an error message at 408 and 410. Alternatively, integrated controller 108 may signal one or more of the process tool controller 102, MFC 138, or sub-fab auxiliary systems 112, 114, 116 and 118 to display a warning light and an error message.

[0034] Figure 5 depicts a flow chart of a method 500 for controlling a processing system in accordance with some embodiments of the present invention. In some embodiments, the method 500 may be an example of a module of the memory 144 of the integrated controller and may be used to control the processing system as described herein. The method 500 depicts a method which may be performed by integrated controller 108.

[0035] Generally method 500 begins at 502 where integrated controller 108 may monitor the communication connection between integrated controller 108 and process tool 102, MFC 138, and sub-fab auxiliary systems 112, 114, 116 and 118. At 504, integrated controller 108 may determine if any one or more of a number of error conditions are matched. Specifically, error conditions may include:

- a) integrated controller 108 determines that communication of any of the data streams is lost between integrated controller 108 and process tool 102, MFC 138, and sub-fab auxiliary systems 112, 114, 116 and 118 at 506;
- b) integrated controller 108 determines that process tool 102, MFC 138, or sub-fab auxiliary systems 112, 114, 116 and 118 loses power at 508;
- c) integrated controller 108 determines that process tool 102, MFC 138, or sub-fab auxiliary systems 112, 114, 116 and 118 performs an emergency machine off (“EMO”) procedure at 510;
- d) a shutdown procedure is initiated by integrated controller 108 at 512; or
- e) integrated controller 108 determines that a monitored digital heartbeat is not available at 514. A digital heartbeat may include an electrical signal sent at discreet intervals by a fab or sub-fab system which indicates that the fab or sub-fab system is powered and functioning. In some embodiments, the signal may be generated and sent by integrated controller 108 with an ACK signal returned by the fab or sub-fab system.

[0036] If any of the aforementioned error conditions occur, integrated controller 108 signals one or more of sub-fab auxiliary systems 112, 114, 116 and 118 to operate at fail-safe operation mode at 516. Additionally, integrated controller 108 may display a warning light and an error message at 518 and 520. Alternatively or in combination, integrated controller 108 may signal one or more of the process tool controller 102, MFC 138, or sub-fab auxiliary systems 112, 114, 116 and 118 to display a warning light and an error message.

[0037] In embodiments consistent with Figure 5, if integrated controller 108 determines that process tool 102, MFC 138, or sub-fab auxiliary systems 112, 114, 116 and 118 loses power or performs an EMO procedure, additional processing may be performed in 522. Specifically, when a process is running and is abruptly shut down, gas may be trapped in the process tool gas chamber, pumps, and lines. When the process is restarted, abatement systems might not know gas was flowing and still remains in the system, and would remain in idle mode. However, embodiments consistent with the present invention may retain the knowledge that

gas was flowing prior to the last process interrupt and the abatement would start up in low fuel mode for a set period of time instead of starting up in pump run mode. This would assure that the gas from the process tool chamber, pump, and gas lines was abated. Knowledge that gas was flowing prior to the last process interrupt may be retained via an indicator stored in memory 144.

[0038] Figure 6 depicts a flow chart of a method 600 for controlling a processing system in accordance with some embodiments of the present invention. In some embodiments, the method 600 may be an example of a module of the memory 144 of the integrated controller and may be used to control the processing system as described herein. The method 600 depicts a method which may be performed by integrated controller 108.

[0039] Generally method 600 begins at 602 where integrated controller 108 may receive gas flow and/or gas composition information from at least one of the process tool controller 102 or MFC 138. Integrated controller 108 may determine if the received gas flow and/or gas composition information matches previously stored gas flow and/or gas composition information at 604. The gas flow and/or gas composition information may be stored in data structures in integrated controller memory 144 or in sub-fab auxiliary system memory (now shown). If the received gas flow and/or gas composition information matches stored gas flow and/or gas composition information, the method terminates. If integrated controller 108 determines that the received gas flow and/or gas composition information does not match stored gas flow and/or gas composition information (*i.e.*, an error condition is matched), integrated controller 108 signals one or more of sub-fab auxiliary systems 112, 114, 116 and 118 to operate at fail-safe operation mode at 606. Additionally, integrated controller 108 may display a warning light and an error message at 608 and 610. Alternatively, integrated controller 108 may signal one or more of the process tool controller 102, MFC 138, or sub-fab auxiliary systems 112, 114, 116 and 118 to display a warning light and an error message.

[0040] In each of the embodiments described above, in addition to warning lights and error messages, integrated controller 108 can produce standard reports including statistical analysis, details of the error conditions matched, change in

process capability based on the error conditions matched, and/or confidence level of failure or risk of not performing the recommended preventative maintenance activities (*i.e.*, not operating in fail-safe mode).

[0041] While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof.

Claims:

1. A manufacturing system, comprising:
 - an integrated controller having one or more inputs to receive input values corresponding to operating information of at least one of a process tool, a mass flow controller or at least one sub-fab auxiliary system, wherein the integrated controller is configured to (a) receive the input values, (b) determine that an error condition is matched based on the received input values, and (c) control the at least one sub-fab auxiliary system to operate at a fail-safe operating mode responsive to the determined error condition.
2. The manufacturing system of claim 1, wherein the integrated controller is communicatively coupled to:
 - a process tool controller linked to the process tool, wherein the process tool controller is adapted to control the process tool;
 - the mass flow controller, wherein the mass flow controller is linked to a gas source, the gas source being coupled to the process tool to provide one or more gasses to the process tool, wherein the one or more gasses provided to the process tool by the gas source are controlled by the mass flow controller; and
 - the at least one sub-fab auxiliary system.
3. A method of controlling a manufacturing system, comprising:
 - monitoring, by an integrated controller, operating information of at least one of a process tool, a mass flow controller (MFC) or at least one sub-fab auxiliary system of the manufacturing system;
 - determining, by the integrated controller, that an error condition is matched based on the monitored operating information; and
 - controlling, by the integrated controller, the at least one sub-fab auxiliary system to operate at a fail-safe operating mode responsive to the determined error condition.

4. The method of claim 3, wherein determining that an error condition is matched based on the monitored operating information includes:

 sending a request to at least one of the process tool controller, or the MFC, for MFC names;

 receiving a response to the request;

 determining that there were changes to the MFC based on the received response; and

 determining that the error condition is matched.

5. The method of claim 3, wherein determining that an error condition is matched based on the monitored operating information includes:

 receiving an input signal from at least one of the process tool controller, the mass flow controller or the at least one sub-fab auxiliary system;

 determining that the received input signal is not accompanied by an associated label of the process tool, the mass flow controller or the at least one sub-fab auxiliary system that sent the input signal; and

 determining that the error condition is matched.

6. The method of claim 3, wherein determining that an error condition is matched based on the monitored operating information includes:

 receiving a label of the process tool controller, the mass flow controller or the at least one sub-fab auxiliary system that sent the input signal;

 determining that the received label is not accompanied by an associated input signal of the process tool controller, the mass flow controller or the at least one sub-fab auxiliary system that sent the label; and

 determining that the error condition is matched.

7. The method of claim 3, wherein determining that an error condition is matched based on the monitored operating information includes:

 monitoring data streams of information between the integrated controller and at least one of the process tool controller, the mass flow controller or the at least one sub-fab auxiliary system;

determining that communication of at least one of the data streams monitored is lost; and

determining that the error condition is matched.

8. The method of claim 3, wherein determining that an error condition is matched based on the monitored operating information includes:

determining that the process tool, the mass flow controller or the at least one sub-fab auxiliary system loses power; and

determining that the error condition is matched.

9. The method of claim 3, wherein determining that an error condition is matched based on the monitored operating information includes:

determining that the process tool, the mass flow controller or the at least one sub-fab auxiliary system performs an emergency machine off (EMO) procedure; and

determining that the error condition is matched.

10. The method of claim 3, wherein determining that an error condition is matched based on the monitored operating information includes:

determining that a shutdown procedure of the integrated controller is initiated; and

determining that the error condition is matched.

11. The method of claim 3, wherein determining that an error condition is matched based on the monitored operating information includes:

monitoring a digital heartbeat of the process tool, the mass flow controller and each of the plurality of sub-fab auxiliary systems;

determining that a monitored digital heartbeat is not available; and

determining that the error condition is matched.

12. The method of claim 3, wherein at least one of the at least one sub-fab auxiliary system is an abatement system, and wherein the fail-safe operating mode of the abatement system includes operating the abatement system in a high energy

mode which can accommodate a maximum process demand of the process tool on the abatement system.

13. The method of claim 12, wherein the abatement system has a local abatement controller which controls the abatement system, and wherein controlling the at least one sub-fab auxiliary system to operate at the fail-safe operating mode includes signaling the local abatement controller to operate at the fail-safe operating mode.

14. The method of any of claims 3 to 13, wherein responsive to the determined error condition, the integrated controller at least one of displays a warning light and an error message, or signals at least one of the process tool controller, the mass flow controller, or the at least one sub-fab auxiliary system, to display a warning light and an error message.

15. The method of claim 8, wherein at least one of the at least one sub-fab auxiliary system is an abatement system, and wherein the method further comprises:

- determining that gas was flowing in the manufacturing system prior to the process tool, the mass flow controller or the at least one sub-fab auxiliary system losing power;

- storing an indicator that gas was flowing in the manufacturing system; and

- operating the abatement system in low-fuel mode to abate the gas that was flowing in the manufacturing system prior to the process tool, the mass flow controller or the at least one sub-fab auxiliary system losing power.

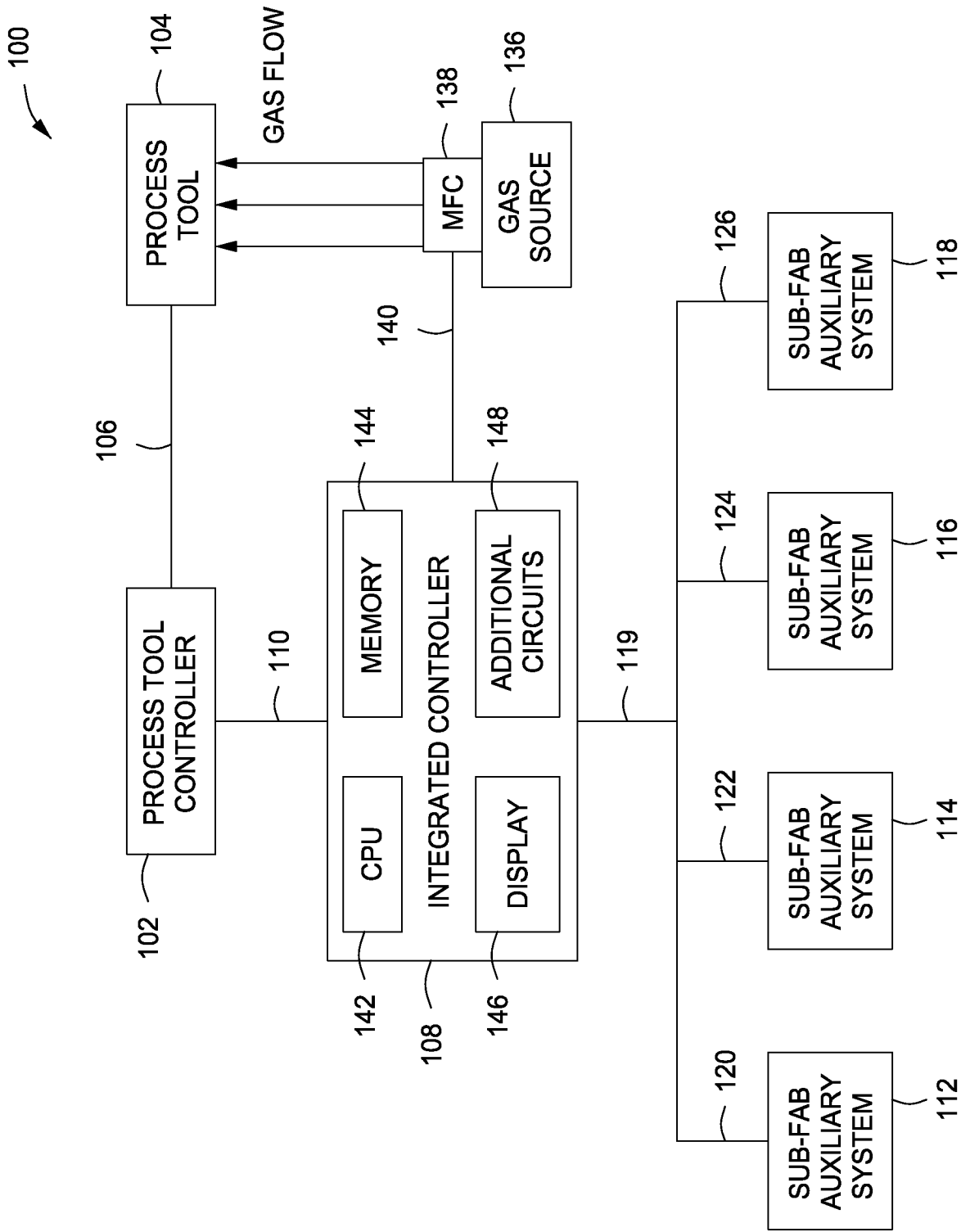


FIG. 1

2/6

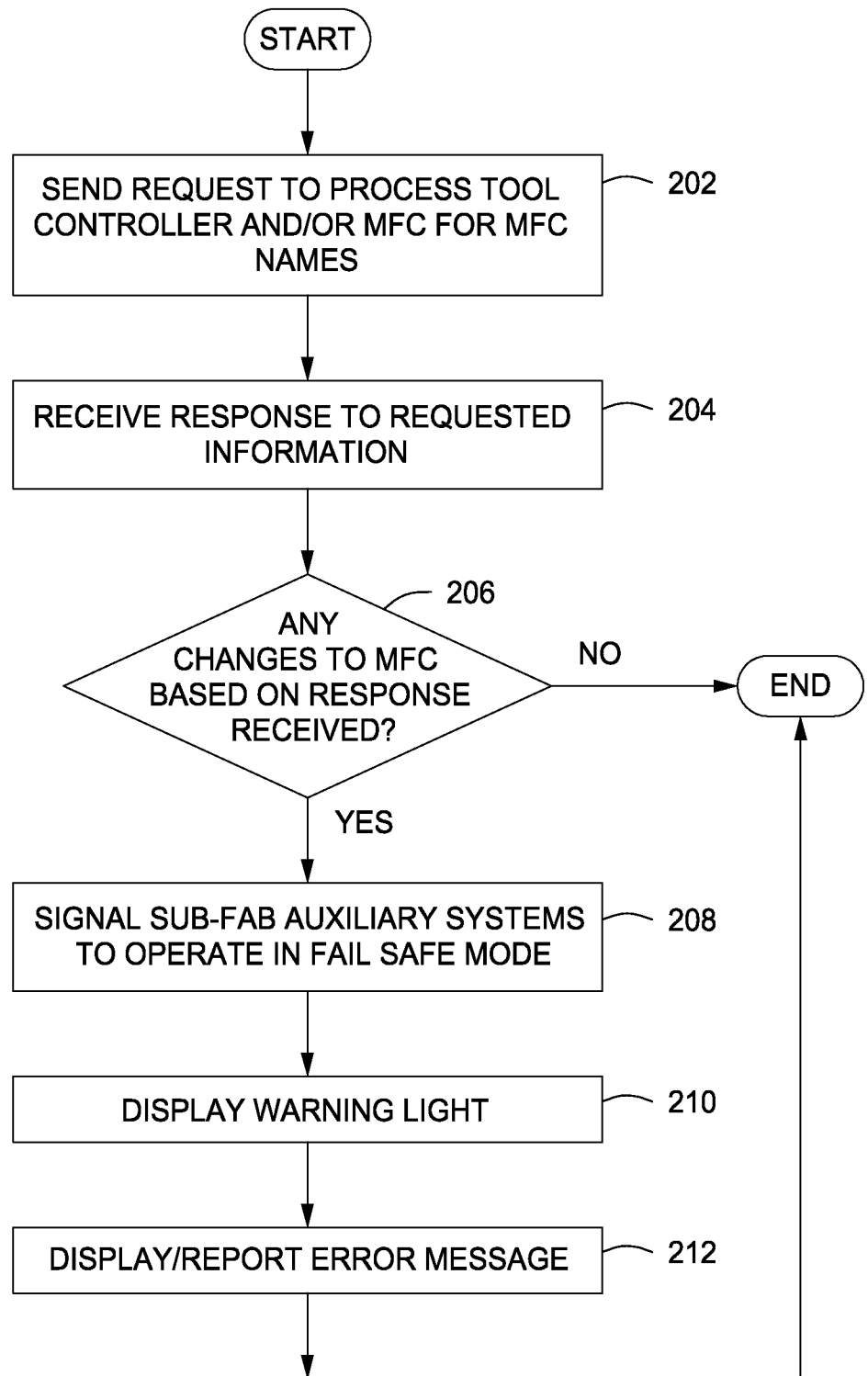
200

FIG. 2

3/6

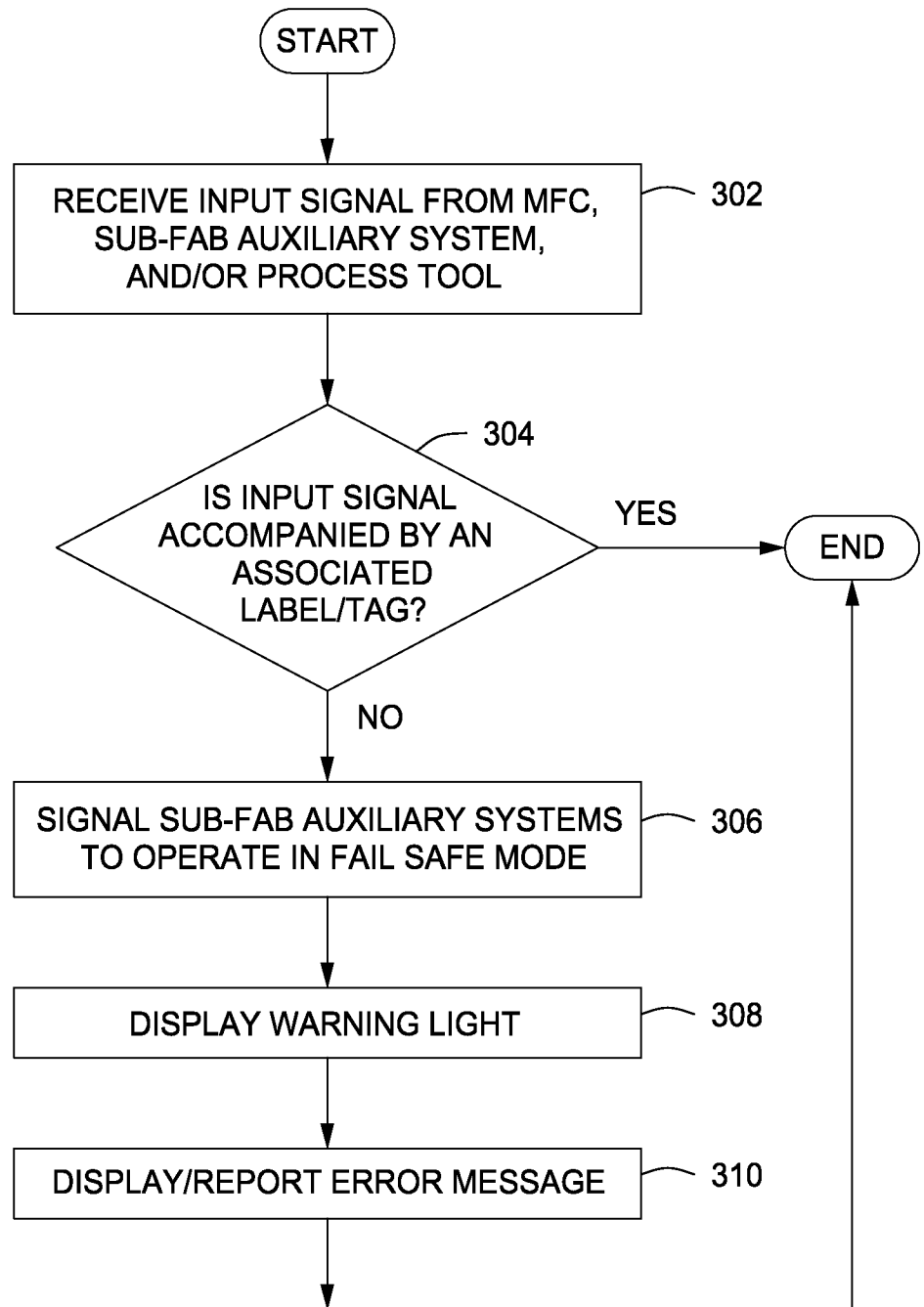
300

FIG. 3

4/6

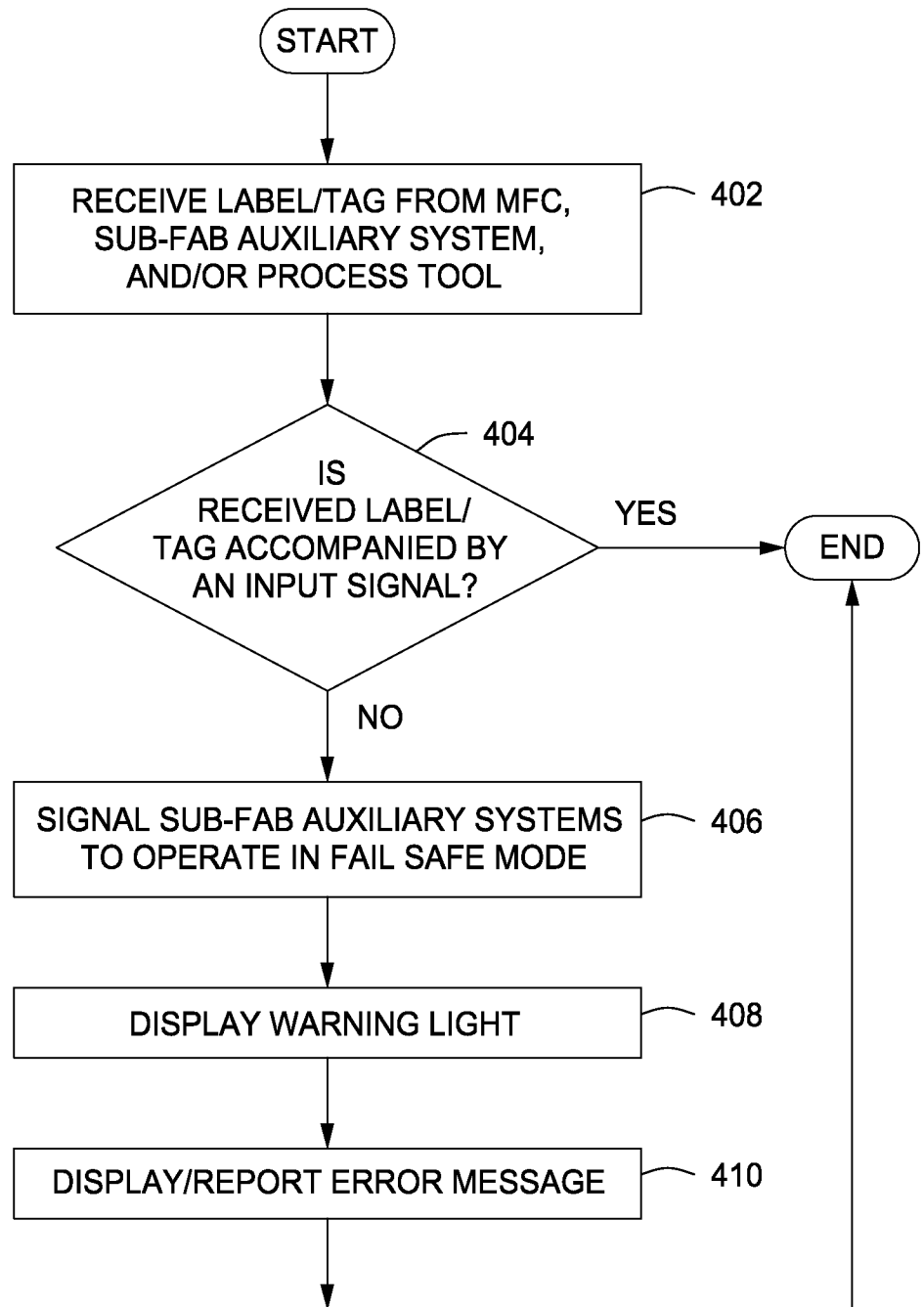
400

FIG. 4

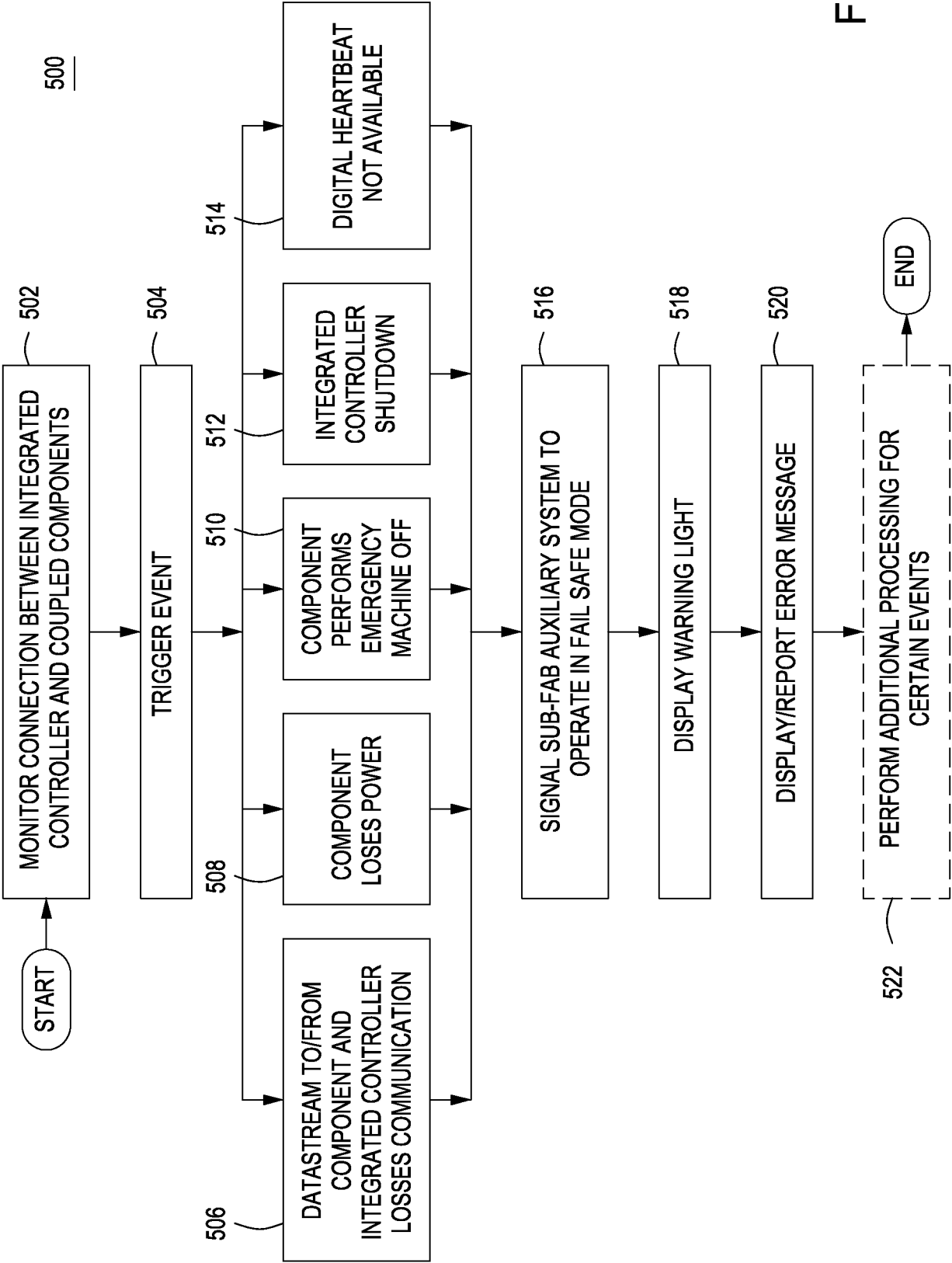


FIG. 5

6/6

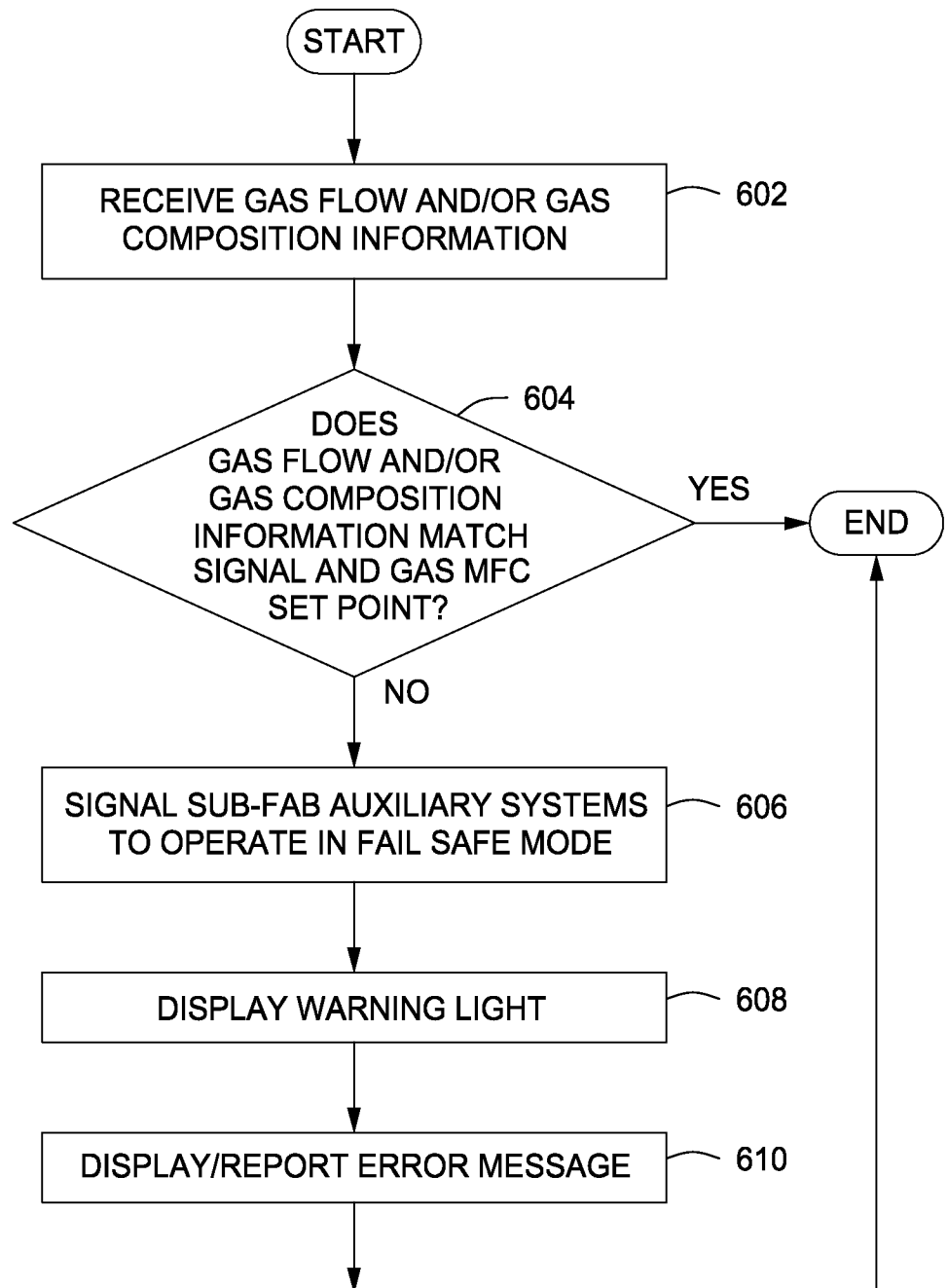
600

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/041799**A. CLASSIFICATION OF SUBJECT MATTER****G05B 23/02(2006.01)i, G05B 19/418(2006.01)i**

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G05B 23/02; H04M 5/00; G06F 19/00; G05B 11/01; G05B 9/02; G06F 1/26; G05B 9/03; G05B 19/418

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & keywords: fail-safe, controller, monitor, error, sub-fab auxiliary, mass flow controller, and similar terms.**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2005-0113942 A1 (RANDY J. LONGSDORF et al.) 26 May 2005 See paragraphs 43-44, 55-57; figure 5; and claims 1-15.	1-3, 7, 11-14
A		4-6, 8-10, 15
Y	US 2011-0118893 A1 (YOUSSEF A. LOLDJ et al.) 19 May 2011 See paragraphs 21-46; and figures 1-5.	1-3, 7, 11-14
Y	US 2009-0018688 A1 (PHIL CHANDLER et al.) 15 January 2009 See paragraphs 30-38; and figure 1.	2
A	US 2004-0182574 A1 (SARMAD ADNAN et al.) 23 September 2004 See paragraphs 20, 44-49; figure 1; and claims 16, 22-37.	1-15
A	US 2009-0132061 A1 (SCOTT STUBBS et al.) 21 May 2009 See paragraphs 16-20; figures 2-3; and claim 1.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

26 August 2013 (26.08.2013)

Date of mailing of the international search report

26 August 2013 (26.08.2013)

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
189 Cheongsu-ro, Seo-gu, Daejeon Metropolitan City,
302-701, Republic of Korea

Facsimile No. +82-42-472-7140

Authorized officer

BYUN Sung Cheal

Telephone No. +82-42-481-8262



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2013/041799

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005-0113942 A1	26/05/2005	CA 2545129 A1	09/06/2005
		CN 102339059 A	01/02/2012
		CN 1882890 A	20/12/2006
		EP 1685545 A2	02/08/2006
		JP 04785747 B2	05/10/2011
		JP 2007-512625 A	17/05/2007
		RU 2006121993 A	27/12/2007
		RU 2395830 C2	27/07/2010
		US 8180466 B2	15/05/2012
		WO 2005-052881 A2	09/06/2005
		WO 2005-052881 A3	02/02/2006
US 2011-0118893 A1	19/05/2011	CN 102667644 A	12/09/2012
		KR 10-2012-0096513 A	30/08/2012
		WO 2011-060415 A2	19/05/2011
		WO 2011-060415 A3	25/08/2011
US 2009-0018688 A1	15/01/2009	TW 200910035 A	01/03/2009
		WO 2008-156687 A1	24/12/2008
US 2004-0182574 A1	23/09/2004	CA 2519111 A1	30/09/2004
		CA 2519111 C	17/04/2012
		EA 007346 B1	25/08/2006
		EP 1606677 A2	21/12/2005
		MX PA05009762 A	26/10/2005
		NO 20054354 A	23/11/2005
		NO 20054354 D0	20/09/2005
		US 6968905 B2	29/11/2005
		WO 2004-083970 A2	30/09/2004
		WO 2004-083970 A3	26/05/2005
US 2009-0132061 A1	21/05/2009	AT 523223 T	15/09/2011
		EP 1888169 A1	20/02/2008
		EP 1888169 B1	07/09/2011
		JP 05102199 B2	05/10/2012
		JP 2008-539900 A	20/11/2008
		US 2006-0253163 A1	09/11/2006
		US 7483744 B2	27/01/2009
		US 8170670 B2	01/05/2012
		WO 2006-121898 A1	16/11/2006