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(54) Title: MANUFACTURING SYSTEM AND METHOD FOR PROCESSING MATERIALS

(57) Abstract: A manufacturing system comprises materials (110, 120) to be processed, and processing tools (130, 140, 150) for processing said materials (110, 120). To each of said materials (110, 120) there are assigned means (111, 121) for directly exchanging information with said processing tools (130, 140, 150) and for deciding on the basis of said directly exchanged inormation which of said processing tools (130, 140, 150) is supposed to process a respective material (110, 120).

MANUFACTURING SYSTEM AND METHOD FOR PROCESSING MATERIALS

Field of the Invention

The present invention generally relates to factories having a high automation level, and more particularly to a manufacturing system and a method for processing materials.

Background of the Invention

To meet the automation challenges for example within a semiconductor factory, large computer integrated manufacturing (CIM) systems and legacy infrastructure have been developed. In manufacturing facilities in accordance with the prior art, CIM systems can for example support the following functions: tracking material flow through the factory, recording factory worker comments and/or relevant data pertaining to the products being manufactured, dispatching of material (in a semiconductor factory for example wafer lots), and scheduling and transportation of material within the factory.

A disadvantage of the factories and the manufacturing systems in accordance with the prior art is, for example, that factory employees must interact with the CIM host system prior to performing any operation on material. A further disadvantage is that the host system must be maintained and upgraded either through expensive external contracts with software suppliers or through expensive internal development.

Brief Description of the Drawings

FIG. 1 is a schematic block diagram showing a manufacturing system in accordance with an embodiment of the present invention; and

FIG. 2 is a flow chart showing an example for a direct information exchange between means assigned to a material to be processed and processing tools and for deciding which of the processing tools is supposed to process a respective material.

Detailed Description of a Preferred Embodiment

In accordance with the present invention a manufacturing system is provided, comprising:

materials 110, 120 to be processed, and processing tools 130, 140, 150 for processing said materials 110, 120, wherein to each of said materials 110, 120 there are assigned means 111, 121 for directly exchanging information with said processing tools 130, 140, 150 and for deciding on the basis of said directly exchanged information which of said processing tools 130, 140, 150 is supposed to process a respective material 110, 120.

In accordance with the present invention there is further provided a method for processing materials, said method comprising the following steps:

a) providing materials 110, 120 to be processed,

b) providing processing tools 130, 140, 150 for processing said materials 110, 120,

c) assigning to each of said materials 110, 120 to be processed means 111, 121 for directly exchanging information with said processing tools 130, 140, 150 and for deciding which of said processing tools 130, 140, 150 is supposed to process the respective material 110, 120,

d) directly exchanging information between said means 111, 121 and at least some of said processing tools 130, 140, 150, and

e) deciding on the basis of said exchanged information which of said processing tools 130, 140, 150 is supposed to process the respective material 110, 120.

With the present invention, for example, the need for a large and expensive centralized CIM system may be eliminated. Further more, delays in processing due to factory workers interacting with the CIM system may be avoided.

From the above it may be seen that the basic idea of the present invention is that material can be enabled to decide how and where it will be processed within a factory through direct communication with the processing tools and, if necessary, further automation equipment.

For transporting the materials 110, 120 between the processing tools 130, 140, 150 there may be provided suitable transport means 112, 122. If the materials to be processed are wafers, these transport means may for example may be pods 112, 122, for example FOUPs (Front Opening Unified Pods), capable of transporting and storing wafers and wafer lots, respectively. In this case respective means 111, 121 may be assigned to each pod 112, 122.

The means 111, 121 preferably comprise radio communication means 113, 123 for directly exchanging the information with the processing tools 130, 140, 150 via a radio link 170, 171, 172, 173, 174, 175. For example the BLUETOOTH protocol may be used for the respective radio links 170, 171, 172, 173, 174, 175. However, also high bandwidth local wireless networks may be used for the direct information exchange. At least a part of said means 111, 121 may, for example, be formed by PDAs (Personal Data Assistants). Onto these PDAs at least part, but preferably all of the product information can be downloaded. The product information may for example be directed to the process flow, the split requirements, the process recipes, and the tools which support the required process steps. Suitable PDAs may for example be JAVA enabled PDAs.

The means 111, 121, for making their decisions, may consider one or more of the following criteria: next processing step to be performed, types of the processing tools 130, 140, 150, distance between the respective material 110, 120 and at least some of the processing tools 130, 140, 150, operating conditions of at least some of the processing tools 130, 140, 150, number of other materials 111, 121 already waiting for respective processing tools 130, 140, 150, and/or expected duration of processing steps.

For making their decisions the means 111, 121 generally may be formed by any suitable hardware and software. However, in a preferred embodiment of the present invention the software means comprise JAVA applets running on

the hardware. A few advantages of using software written in the JAVA programming language are: JAVA enables "write once, run anywhere", JAVA classes, beans, and applets are modular so that small applets can be downloaded when needed. A further advantage of using JAVA applets is that the security demands may be met. Generally, the ability to improve a software module and distribute it throughout the factory or throughout factories is a powerful tool in reducing software development cycle times and in decreasing the dependence on external software windows with proprietary CIM implementations. No other language than JAVA presently allows for the distribution of applications across all of the various computing platforms found in manufacturing systems. JAVA libraries and virtual machines exist for all important operating systems and platforms. JAVA enabled browsers can be installed on all platforms. In connection with the use of JAVA applets it would be for example possible that employees "brows" the materials to be processed and the processing tools remotely to gain accessed to performance and to help with corrective action, if necessary. The modularity of JAVA applets allows small teams of software developers to generate code which can be distributed quickly without disrupting the operation of the manufacturing system and the factory, respectively. In theory, once an applet is tested on one piece of equipment for functionality, it can be distributed across remaining equipment with minimal risk. A further advantage is that the JAVA programming language provides "sandbox" security.

However, although JAVA is the presently preferred programming language, the present invention is not restricted to this programming language but may be used with any other suitable programming language.

The processing tools 130, 140, 150, for directly exchanging information with the means assigned to said materials 110, 120, comprise hardware and software means 131, 141, 151. Also in this case the software preferably comprises JAVA applets running on the hardware.

For providing the means 111, 121 and/or the processing tools 130, 140, 150 with JAVA applets, the manufacturing system in accordance with the present invention may comprise a JAVA applet server 160.

Furthermore, a database 165 may be provided, directly accessible by said means 111, 121 and/or by said processing tools 130, 140, 150 for reading and writing data. This data, for example, may comprise process flow and material information.

In accordance with one embodiment of the present invention, the materials to be processed are wafers 110, 120, the processing tools are wafer processing tools 130, 140, 150, and the manufacturing system further comprises pods 112, 122 for transferring said wafers 110, 120 to be processed between said wafer processing tools 130, 140, 150.

FIG. 1 is a schematic block diagram showing a manufacturing system in accordance with an embodiment of the present invention. With the manufacturing system of FIG. 1 the materials to be processed are wafer lots 110, 120. For transferring the wafer lots between wafer processing

tools 130, 140, 150, there are provided pods 112, 122. These pods for example may be FOUPs generally known in the art. To each of the pods 112, 122, and thereby to each of the wafer lots 110, 120, there are assigned means 111, 121 for directly exchanging information with said wafer processing tools 130, 140, 150 and for deciding on the basis of said directly exchanged information which of said wafer processing tools 130, 140, 150 is supposed to process the respective wafer lot 110, 120. The means 111, 121 comprise radio communication means 113, 123 for directly exchanging the information with said wafer processing tools 130, 140, 150 via radio links 170, 171, 172, 173, 174, 175. As already mentioned, the BLUETOOTH protocol may for example be used for these radio links 170, 171, 172, 173, 174, 175. The means 111, 121 comprise suitable hardware and software for deciding on the basis of the directly exchanged information which of the wafer processing tools 130, 140, 150 is supposed to process the respective wafer lot 110, 120. The software may comprise JAVA applets downloaded from a JAVA server 160 via suitable radio links 180, 182. The JAVA server 160 also serves the wafer processing tools 130, 140, 150 which are equipped with suitable hardware and software means for directly exchanging information with the pods 112, 122. The JAVA applets may be downloaded from the JAVA server 160 to the processing tools 130, 140, 150 via suitable links, preferably radio links. For the sake of clarity only one link 181 between the JAVA server 160 and the wafer processing tool 130 is shown. In accordance with FIG. 1 there is further provided a database 165. The pods 112,

122 are capable of exchanging data with this database 165 via respective radio links 190, 192. The wafer processing tools 130, 140, 150 are also capable of exchanging information with said database 165. For the sake of clarity only one link 191 between the wafer processing tool 150 and the database 165 is shown.

FIG. 2 is a flow chart showing an example for a direct information exchange between means assigned to a material to be processed and processing tools and for deciding which of the processing tools is supposed to process a respective material. In block 201 the preceding process step is complete and the next processing tool has to be selected. In the blocks 202 through 204 it is checked whether the tools 1 through n are up. In block 205 it is checked which of the up tools (i.e. available tools) are idle. In block 206 it is checked which of the up tools are running the desired process. In block 207 it is checked which of the up tools has the smallest number of lots waiting to be processed by the respective tool. Finally, in block 208 it is checked which tool is closest to the lot to be processed. With block 209 the decision is made which of said processing tools is supposed to process the respective lot. In case that none of the processing tools is up, the respective wafer lot may be stored in a suitable temporary storage buffer, as indicated by block 210. It is clear for the person skilled in the art that the decision tree in accordance with FIG. 2 may be extended to a plurality of processing tools and to a plurality of decision criteria.

While the invention has been described in terms of particular structures, devices and methods, those of skill in the art will understand based on the description herein that it is not limited merely to such examples and that the full scope of the invention is properly determined by the claims that follow.

Claims

1. A manufacturing system, comprising:
materials to be processed, and
processing tools for processing said materials,
wherein to each of said materials there are assigned means for directly exchanging information with said processing tools and for deciding on the basis of said directly exchanged information which of said processing tools is supposed to process a respective material.

2. A manufacturing system according to claim 1, further comprising transport means for transporting said materials between said processing tools.

3. A manufacturing system according to claim 1, wherein said means comprise radio communication means for directly exchanging said information with said processing tools via a radio link.

4. A manufacturing system according to claim 1, wherein said means comprise radio communication means for exchanging said information with said processing tools via a radio link on the basis of the BLUETOOTH protocol.

5. A manufacturing system according to claim 1, wherein said means, when making their decisions, consider one or more of the following criteria: next processing step to be performed, types of said processing tools, distance between the respective material and at least

some of said processing tools, operating conditions of at least some of said processing tools, number of other materials already waiting for respective processing tools, expected duration of processing steps.

6. A manufacturing system according to claim 1, wherein said means comprise hardware and software means for making their decisions.

7. A manufacturing system according to claim 1, wherein said means comprise hardware and software means, and wherein said software means comprise JAVA applets running on said hardware means.

8. A manufacturing system according to claim 1, wherein said process tools, for directly exchanging information with said means assigned to said materials, comprise hardware and software means, and wherein said software means comprise JAVA applets running on said hardware means.

9. A manufacturing system according to claim 1, further comprising:

a JAVA applet server for providing said means and said processing tools with JAVA applets, and

a database directly accessible by said means and said processing tools for reading and writing data.

10. A manufacturing system according to claim 1, wherein said materials to be processed are wafers, wherein said processing tools are wafer processing tools, and wherein said manufacturing system further comprises pods for transferring said wafers to be processed between said wafer processing tools.

11. A method for processing materials, comprising the following steps:

a) providing materials to be processed,

b) providing processing tools for processing said materials,

c) assigning to each of said materials to be processed means for directly exchanging information with said processing tools and for deciding which of said processing tools is supposed to process the respective material,

d) directly exchanging information between said means and at least some of said processing tools, and

e) deciding on the basis of said exchanged information which of said processing tools is supposed to process the respective material.

12. The method according to claim 11, further comprising the following step:

f) transporting the respective material to the processing tool supposed to process the respective material.

13. The method according to claim 11, wherein said step d) is performed by setting up a radio link.

14. The method according to claim 11, wherein said step d) is performed by setting up a radio link on the basis of the BLUETOOTH protocol.

15. The method according to claim 11, wherein for making said decisions one or more of the following criteria are considered: next processing step to be performed, types of said processing tools, distance between the respective material and at least some of said processing tools, operating conditions of at least some of said processing tools, number of other materials already waiting for respective processing tools, expected duration of processing steps.

16. The method according to claim 11, wherein at least said step e) is performed by hardware and software means.

17. The method according to claim 11, wherein at least said step e) is performed by hardware and software means, and wherein said software means comprise JAVA applets running on said hardware means.

18. The method according to claim 11, wherein said process tools, for performing said step d), comprise hardware and software, and wherein said software means comprise JAVA applets running on said hardware means.

19. The method according to claim 11, wherein said means and said processing tools are provided with JAVA applets by a JAVA applet server, and

wherein said means and said processing tools write and read data into and out of a database.

20. The method according to claim 11, wherein said materials to be processed are wafers, wherein said processing tools are wafer processing tools, wherein said wafers to be processed are transferred between said wafer processing tools by pods, and wherein said pods comprise said means.

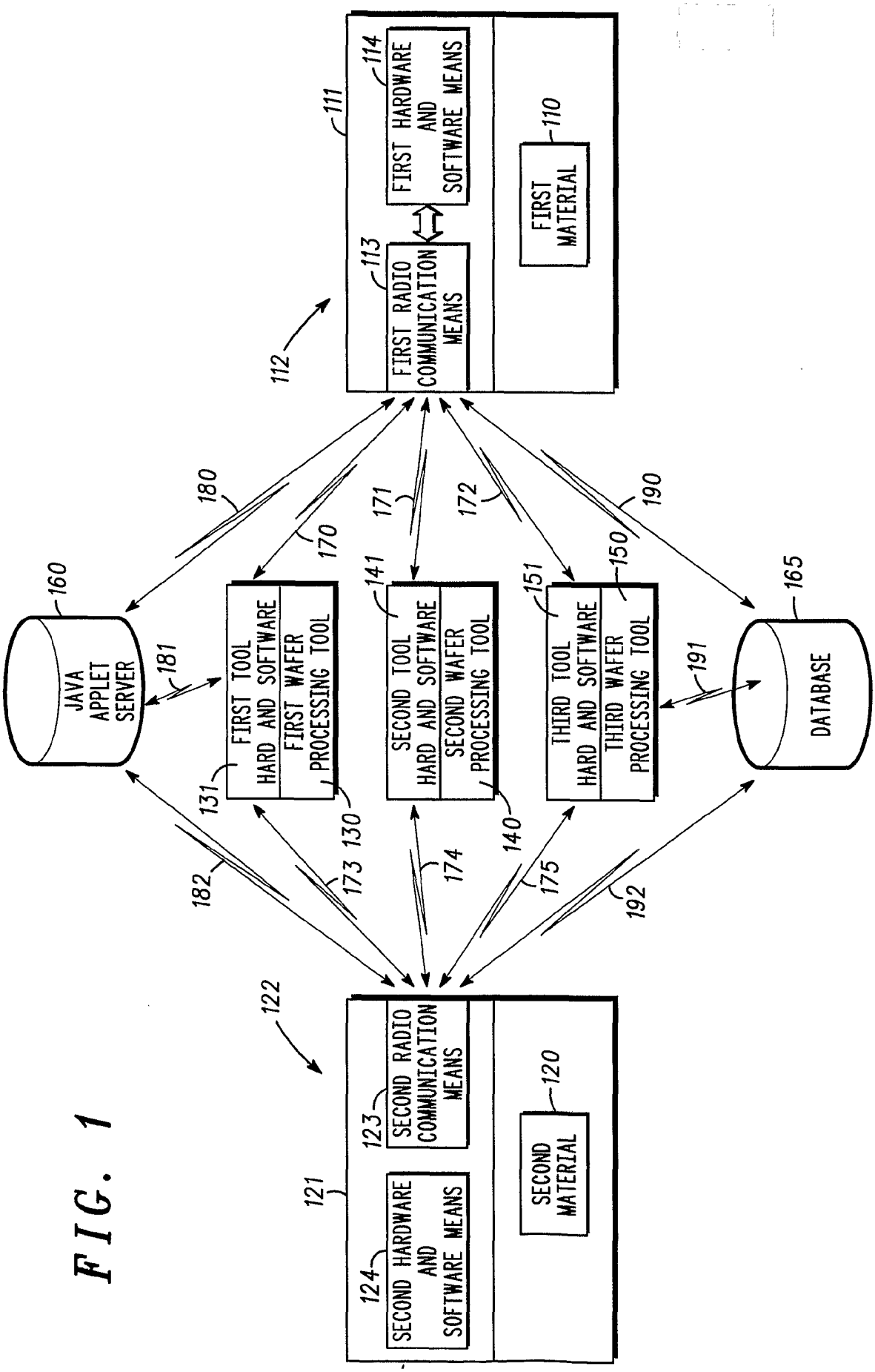

111
114
FIRST HARDWARE AND SOFTWARE MEANS
110
FIRST MATERIAL
113
FIRST RADIO COMMUNICATION MEANS
112
180
170
171
172
190
160
JAVA APPLET SERVER
181
FIRST TOOL HARD AND SOFTWARE
FIRST WAFER PROCESSING TOOL
141
SECOND TOOL HARD AND SOFTWARE
SECOND WAFER PROCESSING TOOL
151
THIRD TOOL HARD AND SOFTWARE
THIRD WAFER PROCESSING TOOL
150
165
DATABASE
191
131
130
140
182
173
174
175
192
122
121
123
SECOND RADIO COMMUNICATION MEANS
120
SECOND MATERIAL
124
SECOND HARDWARE AND SOFTWARE MEANS

FIG. 1

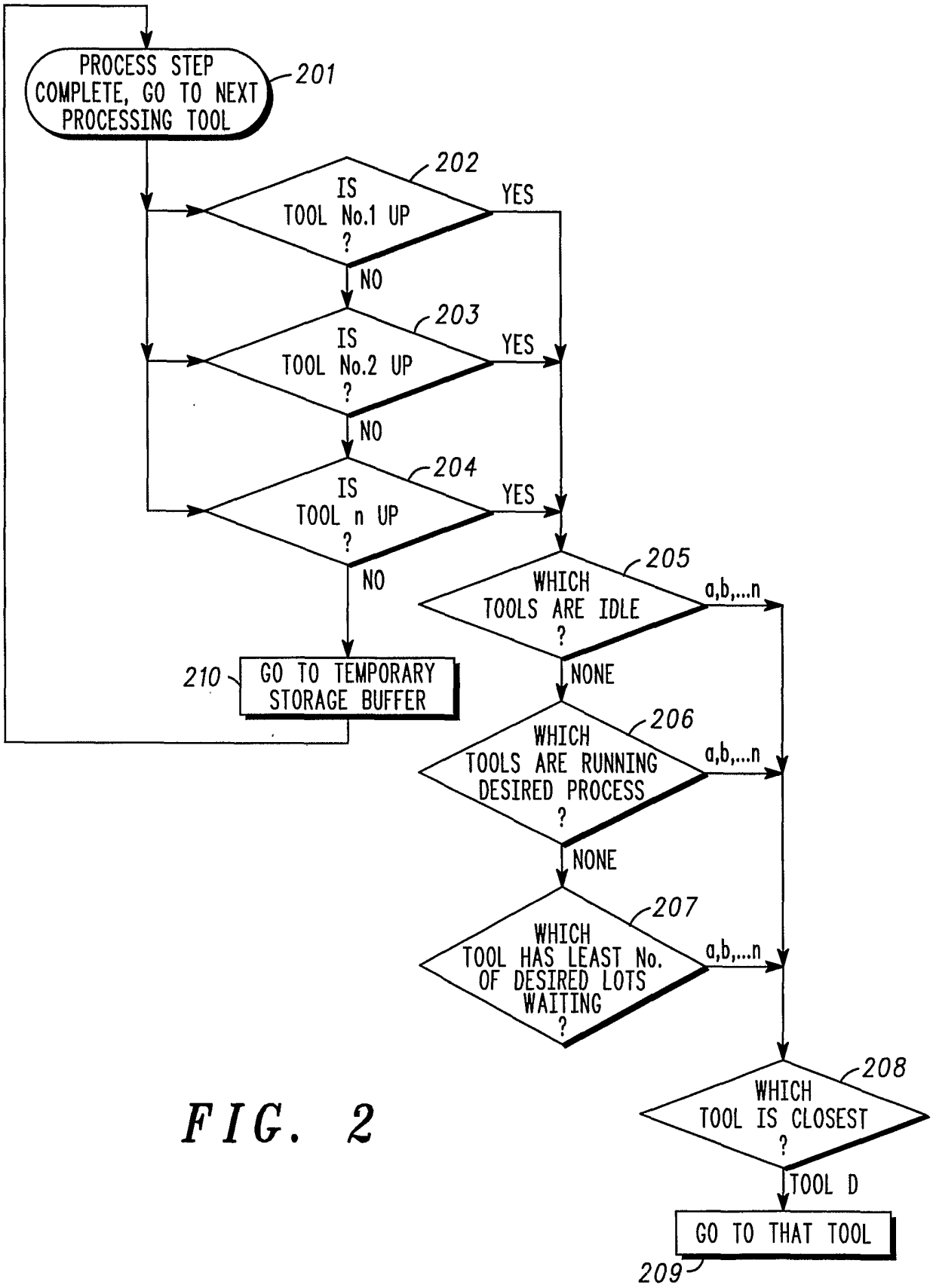

PROCESS STEP COMPLETE, GO TO NEXT PROCESSING TOOL
201
IS TOOL No.1 UP ?
202
YES
NO
IS TOOL No.2 UP ?
203
YES
NO
IS TOOL n UP ?
204
YES
NO
WHICH TOOLS ARE IDLE ?
205
a,b,...n
NONE
WHICH TOOLS ARE RUNNING DESIRED PROCESS ?
206
a,b,...n
NONE
WHICH TOOL HAS LEAST No. OF DESIRED LOTS WAITING ?
207
a,b,...n
GO TO TEMPORARY STORAGE BUFFER
210
WHICH TOOL IS CLOSEST ?
208
TOOL D
GO TO THAT TOOL
209

FIG. 2