INTEGRATED SYSTEM FOR TESTING ELECTRONIC DEVICES

A solution is proposed for testing electronic devices. A corresponding test system (100) includes at least one assembly station (105) for loading the electronic devices to be tested onto empty test boards (200) and for unloading the electronic devices being tested from the loaded test boards, and at least one test station (110) for testing the electronic devices on the loaded test boards. In the solution according to an embodiment of the invention, the test system further includes at least one storage station (115) for storing the test boards, at least one moving device (120) for moving the test boards among the at least one assembly station, the at least one test station and the at least one storage station, and control means (135) for controlling the moving of the test boards; each assembly station has an external assembly port (125e) for supplying the electronic devices to be tested to the test system and for collecting the tested electronic devices from the test system, and an internal assembly port (125i) for interfacing the assembly station with the at least one moving device, and each storage station has an external storage port (130e) for supplying the empty test boards to the test system and for collecting the empty test boards from the test system, and an internal storage port (130i) for interfacing the storage station with the at least one moving device.
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INTEGRATED SYSTEM FOR TESTING ELECTRONIC DEVICES

The solution according to one or more embodiments of the present invention generally relates to the test field. More specifically, this solution relates to the test of electronic devices.

The electronic devices (typically comprising one or more integrated circuits) generally undergo a test process to verify their correct operation; this is of the utmost importance for the quality of the production of the electronic devices. The test may be addressed to identify defects that are evident or potential (i.e., they might manifest after a short period of use). A typical example is the burn-in test, which consists in having the electronic devices work for some hours at very high or very low temperature (for example, from -50°C to +150°C); in this way, it is possible to simulate a long period of operation of the same electronic devices at room temperature (i.e., 25°C-50°C).

The test may be performed at the package level, wherein the electronic devices are tested once their production has been completed (i.e., the integrated circuits have been diced and embedded into corresponding packages). In this case, the electronic devices are mounted on test boards, which are used to access the electronic devices during the test. Particularly, each test board is provided with a matrix of sockets; the sockets block the electronic devices mechanically and contact them electrically, and at the same time allow removing the electronic devices without any substantial damage at the end of the test. The sockets are specifically configured for the different electronic devices; therefore, each type of electronic device requires sockets, and then test boards, of corresponding type.

The test of a generic batch of electronic devices of the same type involves the execution of a series of operations in a corresponding test system. First of all, the electronic devices to be tested (arranged in suitable trays) and the corresponding (empty) test boards are supplied to an assembly station; the assembly station is used to load the electronic devices onto the test boards. The (loaded) test boards are then transported from the assembly station to a test station (for example, an oven) and inserted therein; the test station conditions the electronic devices thermally, and controls the execution of their test at the desired temperature. Once the test of the electronic devices has been completed, the test boards are extracted from the test station and returned to the assembly station. The assembly station unloads the (tested) electronic devices from the test boards and places them into the same trays. At this point, the (empty) test boards and the trays with the
electronic devices may be collected from the assembly station. The same operations are repeated for every new batch of electronic devices to be tested.

However, most of the above-described operations are manual (for transporting the electronic devices and the test boards among the several stations of the test system). Therefore, these operations are expensive, slow, and prone to human errors.

Moreover, the test involves a number of dead times during which the test station and/or the assembly station are inactive. For example, this happens for both the stations while the electronic devices and the test boards are supplied to the assembly station, the test boards are transported from the assembly station to the test station and vice-versa, and the electronic devices and the test boards are collected from the assembly station; moreover, this happens for the assembly station while the electronic devices are tested, and for the test station while the electronic devices are loaded onto the test boards or are unloaded therefrom. Consequently, it is not possible to exploit the assembly station and the test station in an optimal way.

The above-described drawbacks increase the length and the cost of the test. This limits the widespread diffusion of the test of the electronic devices, with a detrimental effect on their level of quality and reliability.

In its general terms, the solution according to one or more embodiments of the present invention is based on the idea of providing an integrated test system.

Particularly, one or more aspects of the solution according to specific embodiments of the invention are set out in the independent claims, with advantageous features of the same solution that are set out in the dependent claims, whose wording is herein incorporated verbatim by reference (with any advantageous feature provided with reference to a specific aspect of the solution according to an embodiment of the invention that applies mutatis mutandis to every other aspect thereof).

More specifically, an aspect of the solution according to an embodiment of the invention proposes a test system for testing electronic devices. The system includes one or more assembly station for loading the electronic devices to be tested onto empty test boards and for unloading the electronic devices being tested from the loaded test boards.

One or more test stations are used for testing the electronic devices on the loaded test boards. In the solution according to an embodiment of the invention, the test system further includes one or more storage stations for storing the test boards. A moving device (or more) is used for moving the test boards among the assembly stations, the test stations
and the storage stations. Control means is then provided for controlling the moving of the test boards. Each assembly station has an external assembly port (for supplying the electronic devices to be tested to the test system and for collecting the tested electronic devices from the test system), and an internal assembly port (for interfacing the assembly station with the moving device); likewise, each storage station has an external storage port (for supplying the empty test boards to the test system and for collecting the empty test boards from the test system), and an internal storage port (for interfacing the storage station with the moving device).

Another aspect of the solution according to an embodiment of the invention proposes a corresponding method for testing electronic devices.

A further aspect of the solution according to an embodiment of the invention proposes a computer program for performing this method. Particularly, an aspect of the solution according to an embodiment of the invention provides a computer program product including a non-transitory computer readable medium embodying a computer program, the computer program including code means directly loadable into a working memory of a data-processing system thereby configuring the data-processing system to perform the same method.

The solution according to one or more embodiments of the invention, as well as further features and the advantages thereof, will be best understood with reference to the following detailed description, given purely by way of a non-restrictive indication, to be read in conjunction with the accompanying drawings (wherein corresponding elements are denoted with equal or similar references, and their explanation is not repeated for the sake of brevity). In this respect, it is expressly intended that the figures are not necessary drawn to scale (with some details that may be exaggerated and/or simplified) and that, unless otherwise indicated, they are merely used to conceptually illustrate the structures and procedures described herein. Particularly:

FIG.1 is a schematic block diagram of a test system according to an embodiment of the invention,

FIG.2A and FIG.2B show a test board that may be used in this test system in perspective view and in bottom view, respectively,

FIG.3 is a schematic representation of an assembly station of the test system according to an embodiment of the invention,

FIG.4 is a schematic representation of a test station of the test system according to
an embodiment of the invention,

FIG. 5 is a schematic representation of a storage station of the test system according to an embodiment of the invention,

FIG. 6A is a schematic representation of a moving device of the test system according to an embodiment of the invention,

FIG. 6B and FIG. 6C show some details of this moving device,

FIG. 7 is a collaboration diagram that represents the roles of the main software components that may be used to implement the solution according to an embodiment of the invention, and

FIG. 8 is a diagram describing the flow of activity relating to a test process according to an embodiment of the invention.

With reference in particular to FIG. 1, a schematic block diagram of a test system 100 according to an embodiment of the invention is shown. The test system 100 is used to execute a burn-in test on electronic devices (at the package level), which are mounted on suitable test boards, or Burn-In Boards (BIBs), not shown in the figure; the electronic devices are tested in batches of the same type, which electronic devices are loaded on test boards of corresponding type.

Particularly, the test system 100 includes an assembly station 105 (or more); the assembly station 105 - shown in transparency in the figure - is used to load the electronic devices to be tested onto the (empty) test boards, and to unload the electronic devices being tested from the (loaded) test boards. The test system 100 also includes one or more test stations 110 (two ovens in the example in issue). The test stations 110 are used to condition the electronic devices to be tested being loaded on the test boards thermally, and to control the execution of their test at the desired temperature.

In the solution according to an embodiment of the invention, the test system 100 is provided with one or more storage, or parking, stations (two in the example in issue). The storage stations 115 are used to store the (empty and possibly loaded) test boards. A moving device 120 (or more) is provided for moving the test boards (either empty or loaded) among the assembly station 105, the test stations 110 and the storage stations 115.

Particularly, the assembly station 105 is provided with an external door 125e (which is accessible from the outside of the test system 100 - for example, by an operator); the external door 125e is used to supply the electronic devices to be tested and to collect the tested electronic devices. The assembly station 105 is also provided with an internal door
125i (which is not normally accessible from the outside of the test system 100); the internal door 125i is used to interface the assembly station 105 with the moving device 120 (for inserting and removing the test boards, either empty or loaded). Similarly, each storage station 115 is provided with an external door 130e (which is likewise accessible from the outside of the test system 100); the external door 130e is used to supply and to collect the empty test boards (for example, by the operator). The storage station 115 is also provided with an internal door 130i (which is not normally accessible from the outside of the test system 100); the internal door 130i is used to interface the storage station 115 with the moving device 120 (for inserting and removing the test boards, empty and possibly loaded). A control device 135 (for example, based on a Personal Computer) controls operation of the entire test system 100. Preferably, an internal zone of the test system 100 (along the moving device 120 onto which the assembly station 105, the test stations 110 and the storage station 115 open) is closed by protection barriers (not shown in the figure) to prevent its access in operation.

The proposed solution reduces the manual operations that are required during the test to the minimum; in this way, the test may be highly automated, thereby reducing its cost, execution time and risk of human errors (with an increase of the yield of the test system 100 of the order of 30-40%, with respect to a known test system with the same assembly station 105 and the same test stations 110 but managed manually).

Moreover, the storage stations 115 act as buffer allowing limiting the dead times of the assembly station 105 and the test stations 110. Indeed, while the electronic devices are loaded and/or unloaded in the assembly station 105 and the electronic devices are tested in the test stations 110, the test boards (for the electronic devices to be tested) may be supplied to the storage stations 115 and the test boards (for the tested electronic devices) may be collected from the storage stations 115. Moreover, while the electronic devices are tested in the test stations 110, the test boards may be transported from the storage stations 115 to the assembly station 105 (for loading the electronic devices to be tested) and vice-versa (once the tested electronic devices have been unloaded).

Particularly, the two (external and internal) doors of both the assembly station 105 and the stored stations 115 completely decouple the operations of supplying and collecting the electronic devices and the test boards, respectively, from the automatic moving of the test boards inside of the test system (through the moving device 120).

This solution allows reducing the length and the cost of the test. This fosters the
widespread diffusion of the test of the electronic devices on a large scale, with a positive impact on their level of quality and reliability. Moreover, the larger amount of information thus available allows implementing effective analysis statistics and test result diagnostics.

For example, in an embodiment of the invention, the electronic devices to be tested of each batch are supplied (on suitable trays) to the assembly station 105 (through its external door 125e); at the same time, the corresponding empty test boards are supplied to the storage stations 115 (through their external doors 130e). The moving device 120 transports the empty test boards from the storage stations 115 (through their internal doors 130i) to the assembly station 105 (through its internal door 125i). The assembly station 105 loads the electronic devices to be tested onto the empty test boards. The moving device 120 then transports the test boards loaded with the electronic devices to be tested from the assembly station 105 to the test stations 110 (if available) or to the storage stations 115 (otherwise). In the latter case, the moving device 120 will transport the same test boards (loaded with the electronic devices to be tested) later on from the storage stations 115 to the test stations 110 (when available). Once the test of the electronic devices has been completed, the moving device 120 transports the test boards loaded with the tested electronic devices from the test stations 110 to the assembly station 105 (if available) or to the storage stations 115 (otherwise). As above, in the latter case the moving device 120 will transport the same test boards (loaded with the tested electronic devices) later on from the storage stations 115 to the assembly station 105 (when available). The assembly station 105 unloads the tested electronic devices from the test boards and places them into the same trays. The moving device 120 then transports the empty test boards from the assembly station 105 to the storage stations 115. At this point, the tested electronic devices (in their trays) may be collected from the assembly station 105 (through its external door 125e); at the same time, the corresponding empty test boards may be collected from the storage stations 115 (through their external doors 130e).

In this way, the storage stations 115 also act as buffer for the loaded test boards (with the electronic devices to be tested or the tested electronic devices). Consequently, it is possible to insert the test boards (with the electronic devices to be tested) in a fast way into the test stations 110 from the storage stations 115 (without the dead times caused by the assembly station 105 for loading the electronic devices to be tested onto the test
boards); likewise, it is possible to remove the test boards (with the tested electronic devices) in a fast way from the test stations 110 to the storage stations 115 (without the dead times caused by the assembly station 105 to unload the tested electronic devices from the test boards). This allows exploiting the assembly station 105 and test stations 110 in an optimal way.

Passing now to FIG.2A and FIG.2B, a generic test board 200 that may be used in the above-described test system (for physically interfacing the electronic devices under test with the test stations) is shown.

With reference in particular to FIG.2A (which shows the test board 200 in perspective), the test board 200 includes a circuitized insulating substrate 205 (for example, a printed circuit board with one or more layers of conductive tracks). A matrix of sockets 210 (of the order of some hundreds - for example, arranged on 16 rows and 16 columns in the figure) is fastened on an upper side of the substrate 205 (for blocking the electronic devices mechanically and connecting them to the substrate 205 electrically, at the same time allowing removing them without any damage at the end of the test). The test board 200 is provided with a bar-code 215 (for example, printed on a free portion of the upper side of the substrate 205, close to its front end); the bar-code 215 supplies identification information of the test board 200 (such as a unique code, a loading capability of the electronic devices equal to the number of sockets, its type for electronic devices of corresponding type that may be loaded thereon, and the like). The test board 200 also includes one or more edge connectors 220 (at its front end), which are used to implement every input/output function of the test board 200.

With reference now to FIG.2B (which shows the test board 200 in bottom view), control circuits 225 of the test board 200 are mounted on a lower side of the substrate 205. For example, the control circuits 225 include configuration components (for simulating a working condition of the electronic devices), supply components (for selecting a power supply voltage of the electronic devices), termination components (for reducing the interferences among electrical signals), and the like. The test board 200 is mounted on a frame (not shown in the figure), on which a protection plate 230 that covers the control circuits 225 is fastened. The plate 230 is provided with two slots 235a and 235b, which are arranged at opposite positions along a longitudinal axis of the test board 200 (close to the front end and a back end, respectively, of the substrate 205); these slots are commonly used to move the test board 200 automatically.
Continuing to FIG. 3, a schematic representation of the assembly station 105 according to an embodiment of the invention is shown. The external door 125e includes a support table for the trays (indicated with the reference 305) being used by the operator to transport the electronic devices (to be tested and tested). The internal door 125i instead includes an input door 310 (in solid line) and an output door 315 (in broken line). The input door 310 is used to receive the test boards 200 (either empty or loaded) from the moving device, not shown in the figure; the output door 315 is instead used to supply the test boards 200 (either empty or loaded) to the moving device. The internal door 125i is thus provided with an elevator, which conveys the input door 310 or the output door 315 to the height of a common door of the assembly station 105 (for either inserting or collecting the test boards 200). This solution makes the insertion (through the input door 310) and the collection (through the output door 315) of the test boards 200 in the assembly station 105 independent; consequently, the input door 310 and the output door 315 operate as buffers, so as to allow these operations without having to hold the assembly station 105 busy; this allows remarkably increasing the yield of the assembly station 105 (since it limits its dead times to the minimum). Moreover, this functionality may also be added to standard assembly stations (only provided with a single door).

In addition, the input door 310 is provided with a rotating platform 320 for the test board 200 inserted therein. The platform 320 allows rotating the test board 200 by 180° (around a vertical axis); in this way, it is possible to invert an orientation of the test board 200 (along its longitudinal axis). Advantageously, the input door 310 is bi-directional. In this way, the above-described operation may be performed even without further processing the test board 200 in the assembly station 105, by simply inserting the test board 200 into the input door 310, rotating it, and directly removing the test board 200 from the same input door 310; moreover, this also allows directly removing test boards 200 being identified as defective (before their loading).

The proposed solution allows arranging the test board 200 in the correct position for its management in the different stations of the test system (for example, to access the edge connectors and to read the bar-code). Consequently, the assembly station, the test stations and the storage stations may be arranged in any position along the moving device (at both sides thereof); in this way, it is possible to optimize the arrangement of these stations to minimize the space occupied by the test system.

The assembly station 105 thus includes an operative module 325 (which
implements the actual loading and unloading of the test boards 200). For this purpose, the
operative module 325 is generally provided with one or more pick-and-place heads, which are slidable along a mobile bar; each head is specific for a corresponding type of electronic devices to be picked and placed. A transport mechanism 330 manages the transport of the trays 305 and the test boards 200 inside the assembly station 105, among the external door 125e (for the trays 305), the input door 310 and the output door 315 (for the test boards 200), and the operative module 325. In detail, the operative module 325 (once manually equipped for the type of electronic devices to process) receives an empty test board 200 from the input door 310 and a tray 305 being loaded with electronic devices to be tested from the external door 125e. The operative module 315 picks each electronic device from the tray 305. Preferably, in this phase a preliminary direct-current (DC) test of the electronic device is also executed - to verify possible short circuits or current leakages; should the electronic device turn out to be defective, it is transported to a discard tray 335 directly. In this way, it is possible to remove the electronic devices affected by evident defects immediately; this allows avoiding useless tests and possible problems of interferences during them. On the contrary, the electronic device is inserted into a first free socket of the test board 200. Preferably, in this phase a functional test of the electronic device is also executed - to verify its correct insertion into the socket. In the event of negative result, the operative module 325 repositions the electronic device into the socket; after a maximum number of failed repositioning attempts (for example, 2-3), the socket is considered defective and a corresponding flag is set into a configuration map of the test board 200 (stored thereon to allow discarding the defective sockets during the test). In this way, it is possible to avoid errors during the test, however allowing using (at least temporarily) test boards being partially defective (in some sockets). Once the test board 200 has been loaded, it is transported to the output door 315; likewise, once the tray 305 has been emptied, it is returned to the external door 125e. Vice-versa, the operative module 325 receives a test board 200 loaded with tested electronic devices from the input door 310 and an empty tray 305 from the external door 125e. The operative module 315 picks each electronic device from the test board 200. Preferably, in this phase there is again executed the direct-current test of the electronic device, which is directly transported to the discard tray 335 if defective (so as to perform a preliminary screening of the tested electronic devices). On the contrary, the operative module 315 verifies whether the electronic device has passed the test (as indicated in the configuration map of
the test board 200). In the positive case, the electronic device (working correctly) is transported to the empty tray 305, whereas in the negative case the electronic device (defective) is transported to one or more failure trays 340 (three in the example in the figure). Once the test board 200 has been unloaded, it is transported to the output door 315; likewise, once the tray 305 has been loaded, it is returned to the external door 125e.

With reference now to FIG.4, a schematic representation of a single test station 110 according to an embodiment of the invention is shown. The test station 110 is formed by a plurality of independent test modules 405, or ovens (four in the example in the figure). Each test module 405 includes a thermal room 410 for controlling the temperature of the electronic devices under test, loaded on the respective test boards (not shown in the figure); the thermal room 410 is provided with a series of entries for housing the test boards (for example, 12) - each one defined by a rail-based slot in the example in the figure. A door 420 (sliding in parallel to a front wall of the test module 405) allows opening the thermal room 410 (for inserting and removing the test boards by the moving device, not shown in the figure) and closing the same (for insulating it thermally from the outside during the tests).

The test module 405 thus includes control components 425, which are arranged in a zone being maintained at room temperature (insulated from the thermal room 410); for example, the control components 425 include an FPGA driving board (for supplying stimuli to the electronic circuits according to a pre-defined test pattern and receiving corresponding results), a power supply board (for supplying the electronic circuits), and the like. The control components 425 and the thermal room 410 communicate through a series of slits with insulating seals (one for every slot 415), which are provided on the bottom of the thermal room 410.

At the beginning of every test, the door 420 is opened. Each test board (with the electronic devices to be tested) is inserted by the moving device into a free slot 415, with the edge connectors turned inwards; the test board is made to slide on the rail of the slot 415 (for example, through suitable pushers, not shown in the figure), until the edge connectors fit into the corresponding slit (so as to connect the test board electrically to the control components 425). Once the thermal room 410 has been loaded, the door 420 is closed. The thermal room 410 is then brought to the desired temperature for executing the test of the electronic devices (whose results are stored into the configuration map of each test board). At the end of the test, the door 420 is opened and the test boards (with the
tested electronic devices) are removed from their slots 415 by the moving device.

Passing to FIG.5, a schematic representation of a single storage station 115 according to an embodiment of the invention is shown. The storage station 115 includes a plurality of storage modules 505 (two in the example at issue); each storage module 505 is formed by a rack 505, which is open both at the front side and at the back side to define the external door 130e and the internal door 130i, respectively. Each storage module 505 is provided with a series of entries 510 for housing the test boards, not shown in the figure (for example, 24) - each one formed by a rail-based through-slot in the example at issue; preferably, each slot 510 is associated with an optoelectronic sensor both on the side of the external door 130e and on the side of the internal door 130i (for verifying the correct insertion of the test boards), and with a bar-code reader (for verifying the correctness of the type of test board inserted through the external door 130e). Two signaling LEDs 515 for each slot 510 (for example, a green one and a red one) are arranged on the front wall of the test module 505 (besides the corresponding slot 510) for supplying information relating thereto to the operator; for example, the green LED 515 is turned on when an (empty) test board should be inserted through the external door 130e into the corresponding slot 510, while the red LED 515 is turned on when the (empty) test board in the corresponding slot 510 should be removed.

Continuing to FIG.6A, a schematic representation of the moving device 120 according to an embodiment of the invention is shown. The moving device 120 includes a linear rail 605 resting on the floor (besides which the assembly station, the test stations and the storage stations are arranged). A support tower 610 is slidable (horizontally) along the rail 605. The tower 610 supports a working head 615, which is slidable vertically along the tower 610. The head 615 is used to slide the test boards transversally to the rail 605 (either rightwards or leftwards). All the movements of the several components of the moving system 115 are controlled by suitable motors (for example, of brushless type, not shown in the figure).

Whenever a test board has to be moved, the tower 610 slides in front of the (source) station of the test system from which it should be picked up. Meantime, the head 615 slides to the height of the test board in the source station. At this point, the head 615 extracts the test board from the source station. The tower 610 then slides in front of the (target) station of the test system to which the test board should be supplied. Meantime, the head 615 slides to the height of the position in which the test board should be inserted
into the target station. The head 615 can now insert the test board into the target station.

The above-described structure of the moving device 120 is modular and readily expandable (by simply extending the rail 605 with further segments); therefore, it is possible to add new stations to the test system in a simple and fast way.

More in detail, as shown in FIG.6B, the head 615 includes a base 620 constrained to the tower transversally, so as to be capable of sliding only along it but not laterally. The base 620 supports an approaching group 625. The approaching group 625 includes a tray 630 with two lateral guides for supporting the test boards, under which a hooking mechanism 635 is mounted; the approaching group 625 is slidable with respect to the base 620 transversally to the rail, either leftwards or rightwards.

As shown in FIG.6C, the hooking mechanism 635 includes an inner arm 640, which is hinged to the approaching group; an external arm 645 is instead hinged to the arm 640, close to a free end thereof (opposite the one on which it is hinged). A coupling pin 650 extends upwards from a free end of the arm 645 (opposite the one on which it is hinged); the pin 650 is slidable vertically with respect to the arm 645.

With reference jointly to FIG.6B and FIG.6C, in a rest condition (not shown in the figure) the approaching group 625 is inside the base 620; at the same time, the arm 640 is arranged along a main moving direction of the moving device defined by its rail (so as to be contained within the space occupied by base 620), and the arm 645 is aligned with the pin 640 (so as to be contained within the space occupied by it). This allows limiting the space occupied by the head 615 when it is moving (sliding along the tower, which in turn slides along the rail); in this way, it is possible to maintain a sufficient distance between the head 615 and the several stations of the test system (in order to avoid any risk of interference).

Once the head 615 is in front of the source station at the desired height, the approaching group 625 slides towards the source station, so as to project from the base 620 (rightwards in the example in the figure). In this way, the tray 625 moves close to the test board to be picked up from the source station (dragging the hooking mechanism 635 integral therewith after it). The arm 640 then rotates towards the source station, so as to carry its free end towards it. The arm 645 as well rotates towards the source station, so as to project from the arm 640 thereby carrying its free end with the pin 650 inside the source station, under the outer slot of the test board in the source station (on the opposite side of the edge connectors for the test stations, on the side of the edge connectors for the
storage stations, and on both sides for the assembly station according to the target station). The pin 650 then slides upwards so as to hook the corresponding slot of the test board. At this point, the arm 640 rotates in the opposite direction away from the source station, so as to return aligned with the direction of the rail; the arm 645 as well rotates away from the source station, so as to project from the arm 640 thereby carrying its free end with the pin 650 to the end of the tray 630 opposite the source station. In this way, the pin 650 extracts the test board from the source station and inserts it into the tray 630. The approaching group 625 then slides away from the source station, so as to re-enter into the base 620; in this way, the tray 625 conveys the test board inside the head 615.

Vice-versa, when the head 615 is in front of the target station at the desired height, the approaching group 625 slides towards the target station, so as to project from the base 620. In this way, the tray 625 conveys the test board near the target station where it should be inserted (dragging the hooking mechanism 635 integral therewith after it). The arm 645 then rotates away from the target station, so as to project from the arm 640 thereby carrying its free end with the pin 650 to the end of the tray 630 opposite the target station (on the opposite side to the edge connectors for the test stations, on the side of the edge connectors for the storage stations, and on both sides for the assembly station according to the source station). The pin 650 then slides upwards so as to hook the corresponding slot of the test board. At this point, the arm 640 rotates towards the target station, so as to carry its free end towards it. The arm 645 as well rotates towards the target station, so as to project from the arm 640 thereby carrying its free end with the pin 650 inside the target station. In this way, the pin 650 extracts the test board from the tray 630 and inserts it into the target station. The hinge 650 now slides downwards so as to free the test board. The arms 640 and 645 then rotate in the opposite direction to return to their rest position (with the arm 640 along the direction of the rail and the arm 645 within the space occupied by it), and the approaching group 625 then slides away from the target station to re-enter into the base 620.

The above-described solution allows obtaining the desired result with a very compact structure. Particularly, the kinematic mechanism of the two arms makes it possible to limit the space occupied (in the rest condition), and at the same time to have a relatively high useful stroke (for inserting and removing the test boards); moreover, in this way it is possible to move the test boards in both the directions transversally to the direction of the rail, so as to be allow inserting and removing them from stations arranged
at both sides thereof.

A collaboration diagram representing the roles of the main software components that may be used to implement the solution according to an embodiment of the invention is illustrated in FIG. 7; particularly, the figure describes the static structure of the test system (by means of the corresponding components) and its dynamic behavior (by means of a series of exchanged messages, each one representing a corresponding action, denoted with sequence numbers preceded by the symbol "A"). These software components are denoted as a whole with the reference 700. The information (programs and data) is typically stored on a hard-disk and loaded (at least partially) into a working memory of the control system (not shown in the figure) when the programs are running, together with an operating system and several application programs (not shown in the figure). The programs are initially installed onto the hard disk, for example, from DVD-ROM.

In detail, the control system includes an input/output interface 705, which is used to provide a plan 710 of execution of the test - stored in a corresponding file (action "A1.Create"). The plan 710 indicates a sequence of test batches to be executed during a production period (for example, a day); for each test batch, the plan 710 also includes a corresponding descriptor, which specifies the characteristics of the test batch (for example, type of electronic devices to be tested, their number, type of required test boards, test pattern to be executed, and the like). An estimator 715 accesses the plan 710 and a log 720 of the preceding test batches - stored in a corresponding database; for example, the log 720 includes information relating to the average execution time of the test batches. The estimator 715 determines an expected execution time (start and completion) of each test batch in the plan 710, and a corresponding expected use of the test boards (action "A2.Estimate"). An optimizer 725 determines an optimal order of execution of the test batches in the plan 710, so as to limit the insertion and the removal of the test boards according to the information supplied by the estimator 715 (action "A3.Optimize"); for example, if different test batches use test boards of the same type, it is advisable to have their execution in short temporal succession (but generally not overlapped), so as to allow using the test boards released by a test batch (but still present in the test system) for a next test batch. The optimizer 725 then updates the plan 710 accordingly - for example, by changing the order of execution of some test batches (action "A4.Update"); this allows increasing the yield of the test system, since it reduces the operations of insertion and removal of the test boards in the storage stations.
A scheduler 730 forecasts the expected start of each test batch of the (modified) plan 710 according to the information supplied by the estimator 715 (action "A5.Forecast"). For each test batch to be executed, the scheduler 730 determines a corresponding advance on its expected start (for example, based on an estimated average time for supplying the test boards to the storage station, equipping the assembly station if necessary, and supplying the electronic devices to be tested to the assembly station). As soon as the expected start of each new test batch minus its advance is reached, the scheduler 730 determines the number of new test boards necessary for its execution (so as to optimize the use of the thermal rooms). The scheduler 730 then verifies whether these test boards are already available in the test system, according to system information 735 stored in a suitable file. In negative case, the scheduler 730 verifies whether the number of slots of the storage stations less the number of new test boards to be inserted therein is higher than a threshold level; the threshold level is set to a value (for example, 10-50) such as to guarantee that the test system is in a safe condition, in which its storage stations can always receive the test boards of every new test batch to be executed (from the outside) and/or the test boards of every test batch just executed (from the test stations). When the number of free slot of the storage stations falls below the threshold level, the scheduler 730 selects a number of test boards to be removed from the storage stations in order to restore the safe condition (action "A6.Select_occupied"). The selection is based on several optimization criteria; for example, first of all there are selected the slots occupied by test boards that will not be used any longer, and then the slots occupied by test boards that will be used at the latest. The scheduler 730 sends the corresponding information to the interface 705 (action "A7.Remove"); in response thereto, the interface 730 notifies the operator to remove the test boards from the selected slots of the storage stations (by turning on the corresponding red LEDs). Whenever the operator removes a test board from the storage station, the interface 705 turns off the corresponding red LED and updates the system information 735 accordingly (action "A8.Update").

In this way, the test boards remain in the storage stations as far as possible (since they are removed only when the safe condition is not satisfied any longer); this allows minimizing the operations of insertion and removal of the test boards from the storage stations (of the order of 10-30 min. for each test batch).

In any case, the scheduler 730 at this point selects (for example, in order of position) the free slots of the storage stations for inserting the new test boards, always
available for what pointed out above (action "A9.Select_free"). The scheduler 730 sends the corresponding information to the interface 705 (action "AlO.Insert"); in response thereto, the interface 730 notifies the operator to supply the new electronic devices to be tested to the assembly station and the new test boards to the storage stations, to be inserted into the corresponding selected free slots (by turning on the corresponding green LEDs). Whenever the operator inserts a test board into the storage station, the interface 705 turns off the corresponding green LED and updates the system information 735 accordingly (same action "A8.Update"). In this way, such operations may be executed in advance with respect to the expected start of the new test batch; this allows avoiding the corresponding waiting times (of the order of 20-40 min.).

As soon as possible, the scheduler 730 submits the new test batch to an executor 740 (action "A11.Submit"). The executor 740 controls the execution of all the active test batches according to an optimization algorithm (described in detail in the following). For each operation executed on the test system (loading and unloading of test boards in the assembly station, test of the electronic devices in the test stations, insertion and removal of the test boards in the storage stations), the executor 740 updates the system information 735 accordingly (action "A12.Update"). At the end of each test batch, the executor 740 exports the corresponding results 745 into a dedicated database (action "A13.Exports"). At the same time, the executor 740 updates the log 720 accordingly (action "A14.Update").

The flow of activity relating to a test process according to an embodiment of the invention is represented in FIG.8 with a method 800.

The method 800 begins at the start black circle 802; as soon as a new test batch is to be executed, the activity flow enters a continuous loop at block 804; in this phase, the assembly station is at first selected (in the case of more assembly stations, they are selected with a round-robin policy).

A test is then executed at block 806 to determine whether the input door of the assembly station is free (for receiving a test board to be loaded or unloaded). In the affirmative case, the input door of the assembly station is set as target of the moving device at block 808. Continuing to block 810, the test stations are then selected. A test is executed at block 812 to determine whether the test stations include test boards of a batch in unloading phase (i.e., compatible with the equipment of the assembly station) to be removed (i.e., that they have already completed the test). In the affirmative case, a
thermal room is selected at block 814 (giving priority to the one that has ended the test by the longest time). An occupied slot of this thermal room (i.e., with a loaded test board still to be removed) is set as source of the moving device at block 816 (for example, in order of position). Continuing to block 818, the moving device is conveyed in front of the selected slot of the test stations to extract the corresponding test board; the test board is then transported to the input door of the assembly station and inserted therein (for being unloaded as soon as its operative module is available).

Returning to block 812, if the test stations do not include any test board of the batch in unloading phase to be removed, the storage stations are selected at block 820. A test is then executed at block 822 to determine whether the storage stations include test boards of the batch in unloading phase still to be unloaded (i.e., loaded with electronic devices already tested). In the affirmative case, a slot occupied by these test boards (giving priority to the one wherein the test board has been inserted by the longest time) it is set as origin of the moving device at block 824. The activity flow then passes to block 826, wherein the moving device is conveyed in front of the selected slot of the storage stations to extract the corresponding test board; the test board is then transported to the input door of the assembly station and inserted therein (for being unloaded as soon as its operative module is available).

On the contrary, if the storage stations do not include any test board of the batch in unloading phase still to be unloaded, the method descends from the block 822 to block 828; in this phase, there is verified whether at least one test board of the batch in unloading phase is present in the assembly station. In the negative case, this test batch is finally completed at block 830. The method then continues to block 832; the same point is instead reached directly from the block 828 if at least one test board of the batch in unloading phase is still present in the assembly station (to be unloaded).

In any case, a test is now executed to determine whether the storage stations include test boards of a batch in loading phase (i.e., compatible with the equipment of the assembly station) to be loaded (with the electronic devices of the corresponding type to be tested). In the affirmative case, a first slot occupied by these test boards is set as source of the moving device at block 834. The activity flow then passes to block 836, wherein the moving device is conveyed in front of the selected slot of the storage stations to extract the corresponding test board; the test board is then transported to the input door of the assembly station and inserted therein (for being loaded as soon as its operative module is
available). On the contrary, if the storage stations do not include any test board of the batch in loading phase still to be loaded, the activity flow returns from the block 832 to the block 806.

Considering the block 806 again, if the input door of the assembly station is not free, the method passes to block 838; in this phase, there is verified whether the output door of the assembly station contains a test board to be removed, either empty or loaded. In the affirmative case, the output door of the assembly station is set as source of the moving device at block 840 (selecting the one to which the test board has been supplied by the longest time in the case of more output doors available). The activity flow then branches at block 842 according to the condition of the test board in the output door of the assembly station.

If the test board is empty, the storage stations are selected as target at block 844. A first free slot of the storage stations is then set as target of the moving device at block 846. Continuing to block 848, the moving device is conveyed in front of the output door of the assembly station to extract the corresponding test board; the test board is then transported to the selected slot of the storage stations and inserted therein.

On the contrary, if the test board in the output door of the assembly station is loaded, the method passes from the block 842 to block 850; in this phase, a test is executed to determine whether test boards of a corresponding batch are in insertion phase into a thermal room of the test stations.

In the affirmative case, this thermal room of the test stations is selected as target at block 852. A first free slot of this thermal room is then set as target of the moving device at block 854. Continuing to block 856, the moving device is conveyed in front of the output door of the assembly station to extract the corresponding test board; the test board is then transported to the selected slot of the test stations and inserted therein.

If instead no batch corresponding to the test board in the output door of the assembly station is in insertion phase in the test stations, the method passes from the block 850 to block 858; in this phase, the storage stations are selected as target. A first free slot of the storage stations is then set as target of the moving device at block 860. Continuing to block 862, the moving device is conveyed in front of the output door of the assembly station to extract the corresponding test board; the test board is then transported to the selected slot of the storage stations and inserted therein.

Returning to the block 838, if the output door of the assembly station does not
contain any test board to be removed, the test stations are selected at block 864. A test is then executed at block 866 to determine whether a batch of test boards is in insert phase into a thermal room of the test stations. In the affirmative case, a first free slot of this thermal room (giving priority to the one that has begun the insertion by the longest time) is set as target of the moving device at block 868. A first slot of the storage stations containing a corresponding test board loaded with the electronic devices to be tested (always available for the priority being given to the assembly station for its loading) is selected at block 870. Continuing to block 872, the moving device is conveyed in front of this slot of the storage stations to extract the corresponding test board; the test board is then transported to the selected slot of the test stations and inserted therein.

On the contrary, if no batch of test boards is in insertion phase in the test stations, the method passes from the block 866 to block 874; in this phase, a test is executed to determine whether a batch of test boards is in removal phase from a thermal room of the test stations. In the affirmative case, a first free slot of this thermal room (giving priority to the one that has ended it by the longest time) is set as source of the moving device at block 876. A first free slot of the storage stations (always available in the safe condition of the test system) is selected at block 878. Continuing to block 880, the moving device is conveyed in front of this slot of the test stations to extract the corresponding test board; the test board is then transported to the selected slot of the storage stations and inserted therein.

In any case, the activity flow reaches the block 882 from the block 818 (loaded test board transported from the test stations to the assembly station), from the block 826 (loaded test board transported from the storage stations to the assembly station), from the block 836 (empty test board transported from the storing stations to the assembly station), from the block 848 (empty test board transported from the assembly station to the storage stations), from the block 856 (loaded test board transported from the assembly station to the test stations), from the block 862 (loaded test board transported from the assembly station to the storage stations), from the block 872 (loaded test board transported from the storage stations to the test stations), and from the block 880 (loaded test board transported from the test stations to the storage stations); the same point is also reached directly from the block 874 if no operations has to be executed by the moving device. In this phase, a test is executed to verify whether all the batches of the plan have been completed. In the negative case, the activity flow returns to the block 804 to repeat the same operations as
above. On the contrary, the method ends at the concentric white/black stop circles 884.

In this way, it is possible to minimize the dead times of the stations of the test system according to their cost; particularly, the proposed algorithm assigns a higher priority to the assembly station with respect to the test stations (since generally it is the most critical resource of the test system).

Naturally, in order to satisfy local and specific requirements, a person skilled in the art may apply to the solution described above many logical and/or physical modifications and alterations. More specifically, although this solution has been described with a certain degree of particularity with reference to one or more embodiments thereof, it should be understood that various omissions, substitutions and changes in the form and details as well as other embodiments are possible (for example, with respect to numerical values and compositions). Particularly, the same solution may even be practiced without the specific details set forth in the preceding description to provide a more thorough understanding thereof; conversely, well-known features may have been omitted or simplified in order not to obscure the description with unnecessary particulars. Moreover, it is expressly intended that specific elements and/or method steps described in connection with any embodiment of the disclosed solution may be incorporated in any other embodiment as a matter of general design choice.

For example, similar considerations apply if the test system has a different structure or includes equivalent components, or it has other operative characteristics. In any case, every component thereof may be separated into more elements, or two or more components may be combined together into a single element; moreover, each component may be replicated to support the execution of the corresponding operations in parallel. It is also pointed out that (unless specified otherwise) any interaction between different components generally does not need to be continuous, and it may be either direct or indirect through one or more intermediaries. Particularly, it is possible to provide any number (one or more) of assembly stations, test stations, storage stations and/or moving devices (arranged in any position), with the test stations and the storage stations that may include any number of test modules and storage modules, respectively (down to only one).

More generally, the test system may be used in whatever test process in the broadest meaning of the term (even not of thermal type - for example, in reliability tests during a preliminary phase of development of the electronic devices, in functional tests, in
parametric tests). Moreover, the same solution lends itself to be applied to any type of electronic devices (for example, of optical type, based on discreet components, and so on); likewise, the test boards may have any other structure or include equivalent components (for blocking the electronic devices mechanically and contacting them electrically).

The internal and external doors of the assembly stations and the storage stations described above are merely exemplificative; for example, the external doors as well may be not accessible to the operators (for example, when they interface with additional automatic devices that integrate the proposed test system with other systems in a complex test plant).

Similar considerations apply if the control system is replaced with an equivalent structure (for example, based on a network of computers).

Nothing prevents controlling the moving of the test boards in a different way; for example, the storage stations may also be used to extract defective test boards that need maintenance. Obviously, the above-described optimization algorithm is not to be interpreted in a limitative manner; alternatively, it is possible to implement more sophisticated techniques - for example, based on weights assigned to the different resources of the test system according to their cost (so as to minimize the dead times of the resources with higher weight), giving priority to the removal of a possible test board in the output door of the storage stations after the insertion of a test board into its input door (in order to exploit the moving device already in position), and the like.

Each moving device may have different structure or may include equivalent components. For example, it is possible to provide a rail with different arrangement, an elevator system of the head of other type, and the like; moreover, nothing prevents using a different number of arms in the working head (down to only one), even without any approaching group. More generally, the proposed solution lends itself to be implemented with moving devices of any other type (also active on a single side of their moving direction).

Each assembly station may include any number of input doors and output doors; in any case, a simplified embodiment with standard assembly stations (i.e., without the input doors and the output doors) is not excluded.

The inversion of the orientation of the test boards may be implemented in another way; alternatively, there is not excluded the possibility of implementing this function in a
different position - for example, in the output door (in addition or in alternative to the input door). In any case, this characteristic is not strictly necessary, and it may be omitted in some embodiments (wherein the arrangement of the stations of the test system does not require any rotation of the test boards), or it may be implemented directly by the moving device.

The scheduler may manage the batches of the plan according to any other algorithm (for example, by assigning different priorities to the batches, managing critical batches that should be completed within a time limit, and the like).

Alternatively, the storage stations may also be managed with other policies; for example, it is possible to remove the test boards already used immediately (so as to maximize the space available for possible exceptions or urgencies).

Moreover, the safe condition of the test system may be based on a different threshold level, also defined dynamically - for example, as a percentage (for example, from 110% to 130%) of the maximum number of test boards of the different test batches of the plan still not completed; in any case, it is possible to select the test boards to be removed from the storage stations according to different criteria (for example, simply giving priority to the test boards unloaded by the longest time).

Similar considerations apply if the plan is updated with different techniques (for example, based on the expected use of all the resources of the test system) - even if this characteristic may be omitted in some simplified implementations of the proposed solution.

Likewise, the advance for requiring the test devices and the corresponding test boards of the next batch to be executed may be calculated dynamically (for example, according to an estimated equipment time of the assembly station); in this case as well, however, a simplified implementation wherein the requests are submitted at the same time as the corresponding batches in not excluded.

The proposed solution lends itself to be implemented with an equivalent method (by using similar steps with the same functions of more steps or portions thereof, removing some steps being non-essential, or adding further optional steps); moreover, the steps may be performed in a different order, concurrently or in an interleaved way (at least in part).

The proposed solution may be implemented as a stand-alone module, as a plug-in for the control device of the test system, or even directly in the control device itself.
Similar considerations apply if the program (which may be used to implement each embodiment of the invention) is structured in a different way, or if additional modules or functions are provided; likewise, the memory structures may be of other types, or may be replaced with equivalent entities (not necessarily consisting of physical storage media).

The program may take any form suitable to be used by any data-processing system or in connection therewith (for example, within a virtual machine), thereby configuring the system to perform the desired operations; particularly, the program may be in the form of external or resident software, firmware, or microcode (either in object code or in source code - for example, to be compiled or interpreted). Moreover, it is possible to provide the program as an article of manufacture implemented on any transitory computer usable medium; the medium may be any element suitable to contain, store, communicate, propagate, or transfer the program. For example, the medium may be of the electronic, magnetic, optical, electromagnetic, infrared, or semiconductor type; examples of such medium are fixed disks (where the program can be pre-loaded), removable disks, tapes, cards, wires, fibers, wireless connections, networks, broadcast waves, and the like. In any case, the solution according to an embodiment of the present invention lends itself to be implemented even with a hardware structure (for example, integrated in a chip of semiconductor material), or with a combination of software and hardware suitably programmed on otherwise configured.
CLAIMS

1. A test system (100) for testing electronic devices, the test system including at least one assembly station (105) for loading the electronic devices to be tested onto empty test boards (200) and for unloading the electronic devices being tested from the loaded test boards, and at least one test station (110) for testing the electronic devices on the loaded test boards, characterized by:

   at least one storage station (115) for storing the test boards, at least one moving device (120) for moving the test boards among the at least one assembly station, the at least one test station and the at least one storage station, and control means (135) for controlling the

   moving of the test boards, each assembly station having an external assembly port (125e) for supplying the electronic devices to be tested to the test system and for collecting the tested electronic devices from the test system, and an internal assembly port (125i) for interfacing the assembly station with the at least one moving device, and each storage station having an external storage port (130e) for supplying the empty test boards to the test system and for collecting the empty test boards from the test system, and an internal storage port (130i) for interfacing the storage station with the at least one moving device.

2. The test system (100) according to claim 1, wherein the control means (135) includes means (740) for controlling the moving of the loaded test boards with the electronic devices to be tested from the at least one assembly station to the at least one test station (110) when available or to the at least one storage station otherwise, of the loaded test boards with the electronic devices to be tested from the at least one storage station to the at least one test station once available, of the loaded test boards with the tested electronic devices from the at least one test station to the at least one assembly station when available or to the at least one storage station otherwise, and of the loaded test boards with the tested electronic devices from the at least one storage station to the at least one assembly station once available.

3. The test system (100) according to claim 1 or 2, wherein the control means (135) includes means (740) for controlling the moving of the empty test boards (200) to be loaded with the electronic devices to be tested from the at least one storage station (115) to the at least one assembly station (105), of the loaded test boards with the electronic devices to be tested from the at least one assembly station to the at least one
storage station or the at least one test station (110), of the loaded test boards with the
electronic devices to be tested from the at least one storage station to the at least one test
station, of the loaded test boards with the tested electronic devices from the at least one
test station to the at least one storage station or the at least one assembly station, of the
loaded test boards with the tested electronic devices from the at least one storage station
to the at least one assembly station, and of the empty test boards from the at least one
assembly station to the at least one storage station according to an optimization algorithm
for optimizing a use of the at least one assembly station and the at least one test station.

4. The test system (100) according to any claim from 1 to 3, wherein each moving
device (120) includes support means (625) for supporting the test boards (200), a first arm
(640) with a first free end and a first constrained end being hinged at the support means
for rotating the first arm between a first rest position wherein the first arm extends along a
moving direction of the moving device and a first working position wherein the first arm
extends transversally to the moving direction towards a first side or a second side thereof,
and a second arm (645) with a second free end and a second constrained end being hinged
at the first arm for rotating the second arm between a second rest position wherein the
second arm is within a space being occupied by the first arm and a second working
position wherein the second arm projects from the first arm inside a station facing the
moving device at one of the sides thereof or a further second working position wherein
the second arm projects from the first arm away from the facing station, and engaging
means (650) arranged at the second free end for engaging a test board in the facing station
when the second arm is in the second working position or a test board in the support
means when the second arm is in the further second working position.

5. The test system (100) according to any claim from 1 to 4, wherein each
assembly station (105) includes an operative module (325) for loading and unloading the
test boards, the internal assembly port (125i) including at least one input port (310) for
receiving the test boards (200) from the at least one moving device (120) and at least one
output port (315) for providing the test boards to the at least one moving device, and
means (330) for providing the test boards from each input port to the processing module and
from the processing module to each output port.

6. The test system (100) according to claim 5, wherein each test board (200) is
arranged in each moving device (120) with an axis of insertion into each station extending
transversally to a moving direction of the moving device, each input port (310) and/or
each output port (315) including means (320) for inverting an orientation of each test board (200) along the corresponding insertion axis.

7. The test system (100) according to any claim from 1 to 6, wherein each electronic device belongs to one of a plurality of device types and each test board (200) belongs to one of a plurality of board types for a corresponding device type, wherein the test system further includes means (710) for providing a test plan including an indication of a sequence of batches of electronic devices to be tested, the electronic devices of each batch being of a common device type, and wherein the control means (135) includes means (715) for estimating a use of the test boards in the test system according to the test plan and means (730) for controlling an execution of the batches according to the estimated use.

8. The test system (100) according to claim 7, wherein the at least one storage station (115) includes a plurality of storage entries (510) each one for storing a test board (200), the control means (135) further including means (730) for calculating a new number of test boards for loading the electronic devices of a new batch to be executed, means (730) for selecting the new number of empty storage entries, and means (705) for prompting the supplying of an empty test board of the board type corresponding to the new batch to each selected empty storage entry.

9. The test system (100) according to claim 8, wherein the control means (135) further includes means (730) for monitoring a safe condition of the at least one storage station (115) wherein a current number of the empty storage entries (510) is at least equal to a safe threshold, means (730) responsive to an exit from the safe condition for selecting a set of test boards to be removed from the at least one storage station to restore the safe condition according to the estimated use, and means (705) for prompting the collection of each selected test board from the corresponding storage entry.

10. The test system (100) according to any claim from 7 to 9, wherein the control means (135) further includes means (725) for updating an order of execution of the batches in the test plan to optimize the supplying and the collection of the empty test boards (200) in the at least one storage station (115) according to the estimated use.

11. The test system (100) according to any claim from 7 to 10, wherein the control means (135) further includes means (715,730) for estimating a completion time of each batch being in execution, and means (705) for prompting the supplying of the electronic devices of the new batch to the at least one assembly station (105) and of the empty test
boards (200) of the new batch to the at least one storage station (115) with a predetermined advance with respect to a first estimated completion time.

12. A method (800) for testing electronic devices in a test system including at least one assembly station (105) for loading the electronic devices to be tested onto empty test boards (200) and for unloading the electronic devices being tested from the loaded test boards, at least one test station (110) for testing the electronic devices on the loaded test boards, at least one storage station (115) for storing the test boards, and at least one moving device (120) for moving the test boards among the at least one assembly station, the at least one test station and the at least one storage station, each assembly station having an external assembly port (125e) for supplying the electronic devices to be tested to the test system and for collecting the tested electronic devices from the test system, and an internal assembly port (125i) for interfacing the assembly station with the at least one moving device, and each storage station having an external storage port (130e) for supplying the empty test boards to the test system and for collecting the empty test boards from the test system, and an internal storage port (130i) for interfacing the storage station with the at least one moving device, wherein the method includes the steps of:

moving (840,850-862) the loaded test boards with the electronic devices to be tested from the at least one assembly station to the at least one test station when available or to the at least one storage station otherwise,

moving (834-836,868-872) the loaded test boards with the electronic devices to be tested from the at least one storage station to the at least one test station once available,

moving (876-880,808,824-826) the loaded test boards with the tested electronic devices from the at least one test station to the at least one assembly station when available or to the at least one storage station otherwise, and

moving (824-826,808) the loaded test boards with the tested electronic devices from the at least one storage station to the at least one assembly station once available.

13. A computer program (700) including code means for causing a data-processing system (135) to perform the steps of the method (800) according to claim 12 when the computer program is executed on the data-processing system.
### A. CLASSIFICATION OF SUBJECT MATTER

INV. G01R31/28 H01L21/677

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)

G01R H01L

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

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

EPO-Internal, WPI Data

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tr>
<td>X</td>
<td>US 2006/000083 A1 (DANGEL0 DANIEL J [US] ET AL) 5 January 2006 (2006-01-05) paragraphs [0007], [0015] - [0028]; figures 1,2,3B</td>
<td>1-8, 10-13</td>
</tr>
<tr>
<td>X</td>
<td>US 2008/038098 A1 (IT0 AKIHIKO [JP] ET AL) 14 February 2008 (2008-02-14) paragraphs [0014], [0042] - [0058], [0099] - [0108]; figures 1,2,4,10,11</td>
<td>1-8, 10-13</td>
</tr>
<tr>
<td>X</td>
<td>US 5 940 303 A (SAKAI IWA0 [JP] ET AL) 17 August 1999 (1999-08-17) column 4, line 65 - column 8, line 40; figures 1,2</td>
<td>1-8, 10-13</td>
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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 document but published on or after the international filing date.
  
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