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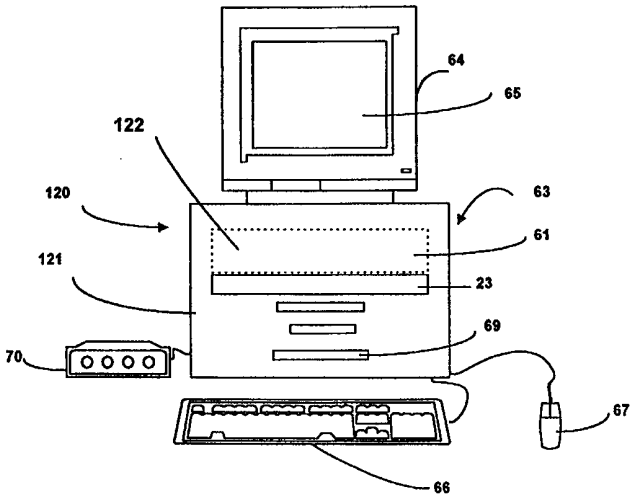
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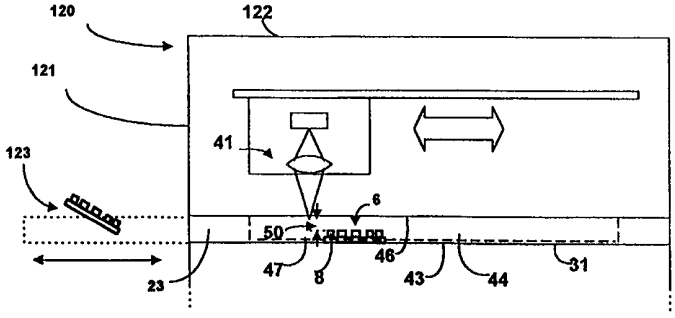
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(54) Title: CIRCUIT BOARD ASSEMBLY INSPECTION

(57) Abstract

Circuit board assemblies (6) consisting of printed circuit boards (7) to which surface mounted components (8) have been mounted are visually inspected by comparison with a reference circuit board assembly. A reference image (81) is visually compared with a test image (80) using the display (64) of a personal computer (63). Image data is acquired in each case by use of an optical scanner (2) in the form of a flatbed scanner. The circuit board assemblies are positioned during scanning so as to locate a major surface of the circuit board and the surface mounted components within an imaging region (44) of the scanner. Alignment of images is automatically effected by the computer so as to display images using a common frame of reference defined relative to fiducial features of the circuit board assemblies. During scanning, the boards may be supported in an upwardly facing or inverted position within a light excluding enclosure. The method has application to small and medium scale production facilities of printed circuit board assemblies.





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CIRCUIT BOARD ASSEMBLY INSPECTION

This invention relates to circuit board assembly inspection and in particular but not exclusively to inspection in production facilities for producing circuit board assemblies comprising printed circuit boards to which surface mounted components are assembled.

It is known to provide testing of circuit board assemblies by visual inspection in which a subject circuit board assembly is compared with a reference circuit board assembly aided by a system which electronically forms an image and displays the image in a suitable form to allow comparison to be made.

Such known systems generally require a first electronic camera to be positioned so as to obtain an image of a reference circuit board assembly and a second camera is then used to image successive subject circuit board assemblies, respective reference and test images then being displayed for comparison. Known comparison techniques include simply displaying the images side by side, alternately displaying the images in registration with one another so as to "flip" from one image to another, or partially superimposing the images to an extent variably determined by a movable scroll line in a "split-scroll" method.

It is also known from EP-A-0247308 to provide inspection of (unpopulated) printed circuit boards by automatic analysis of image data obtained by means of an

optical scanner. This technique is suitable for checking circuit connectivity prior to assembly with surface mounted components.

There remains a need to provide an improved method of inspecting circuit board assemblies consisting of circuit boards to which components have been surface mounted.

According to the present invention there is disclosed a method of inspecting a subject circuit board assembly comprising a circuit board having surface mounted components on a major face thereof, the method comprising the steps of;

optically scanning the subject circuit board assembly to obtain test image data representative of a plan view of the major face of the circuit board including the surface mounted components;

and performing a test procedure on the test image data for detecting defects in the subject circuit board assembly;

wherein the optical scanning step comprises positioning the subject circuit board assembly relative to an optical scanner such that the surface mounted components and the major face of the circuit board are maintained within an imaging region for which the scanner is operable to provide substantially focused imaging and operating the scanner to obtain the test image data.

According to a further aspect of the present

invention there is disclosed a method of inspecting a subject circuit board including the step of optically scanning a reference circuit board assembly using corresponding method steps to those used in optically scanning the subject circuit board to obtain reference image data;

and wherein the test procedure comprises comparing the test and reference image data to detect differences therebetween.

Commercially available scanners such as for example those used for document scanning in conjunction with a personal computer, are found to exhibit an exceptional degree of depth of focus, typically of the order of 10mm, which is exploited in the method and apparatus of the present invention as a means of acquiring image information for circuit board assemblies.

Preferably fiducial features of the circuit board assemblies are identified in the scanned images and used to process image data for successive images using a common frame of reference defined relative to the fiducial features. This alignment facility avoids the need for each assembly to be accurately aligned relative to the scanner during image acquisition. This provides a significant advantage over the prior art arrangements described above which typically require precise alignment of each assembly during imaging. The present invention thereby has the advantage of providing simplified image

acquisition without requiring high tolerance alignment jigs.

Preferred embodiments of the present invention will now be described by way of example only and with reference to the accompanying drawings of which

Figure 1 is a schematic diagram of a scanning system used to form an image of a circuit board assembly;

Figure 2 is a schematic diagram of an alternative scanning system used to form an image of a circuit board assembly;

Figure 3 is a schematic diagram of a further alternative scanning system used to form an image of a circuit board assembly;

Figure 4 is a schematic sectional elevation of a scanning system of the type illustrated in Figure 1;

Figure 5 is a schematic sectional elevation of a scanner for use in a scanning system of the type illustrated in Figure 3;

Figure 6 is a schematic diagram of a testing system for use in testing circuit board assemblies;

Figure 7 is a schematic view of a display of reference image data;

Figure 8 is a schematic view of a display of partially superimposed test image data and reference image data;

Figure 9 is a flowchart illustrating reference image acquisition;

Figure 10 is a flowchart illustrating a test sequence;

Figure 11 is an illustration of a difference image formed from a reference image and a test image;

Figure 12 is a schematic view of an alternative testing system; and

Figure 13 is a sectional elevation of part of the testing system of Figure 12.

Figure 1 illustrates a scanning system 1 comprising a flatbed scanner 2 having a transparent platen 3 which is uppermost relative to the scanner. The flatbed scanner 2 is provided with a lid 4 attached to the scanner by hinges 5 allowing the lid to be closed into the position shown in Figure 1 or opened to allow access to the space above the platen 3, a handle 5 being provided for this purpose.

A circuit board assembly 6 consisting of a printed circuit board 7 and surface mounted components 8 mounted on a major face 9 thereof is positioned face down (i.e. with the major face of the circuit board assembly facing downwards) so as to rest upon the platen 3 with the surface mounted components 8 making contact with an outer surface 43 of the platen.

The lid 4 is configured to be recessed to a sufficient depth to allow adequate clearance of the circuit board assembly 6 when in the closed position as

shown in Figure 1.

Operation of the flatbed scanner 2 produces an electronic output representative of an image of the circuit board assembly 6 in plan view (from below) relative to the major face of the circuit board assembly, revealing detail of the surface mounted components and their relative position on the printed circuit board 7.

An alternative scanning system 20 is shown in Figure 2 and will be described using corresponding reference numerals where appropriate for corresponding elements to those of Figure 1.

The scanning system 20 consists of a flatbed scanner 2 of the same type as described above with reference to Figure 1 and having a platen with an outer surface through which an image is acquired of a circuit board assembly 6.

A cover 21 overlays the scanner 2 and has a side opening 22 allowing a cradle 23 supporting the circuit board assembly 6 to be slidably moved between a withdrawn position as shown in Figure 2 in which the circuit board assembly is accessible and an inserted position (not shown) in which the position of the circuit board assembly corresponds to that shown in Figure 1 relative to the platen 3 with the exception that a clearance is provided between the outer surface of the platen and the components, thereby avoiding damage to both platen and circuit board assembly.

The cradle 23 is provided with a handle 5 and, internally, with an adjustable jig 24 allowing the shape of the cradle 23 to be adapted to the circuit board assembly 6 as required.

When moved to the inserted position, the cradle 23 cooperates with the fixed cover 21 to form a light-tight enclosure of the platen 3 and the scanner 2 is then operable to provide an electronic signal representative of an image of the circuit board assembly 6 in plan view (from below) to show the surface mounted components 8 against the major face of the printed circuit board 7.

A further alternative scanning system 30 is shown in Figure 3 and will be described using corresponding reference numerals to those of preceding figures where appropriate for corresponding elements.

In the scanning system 30, the flatbed scanner 2 is supported in an inverted position above a heavy base 31 and is movable between a lowered position as shown in Figure 3 and a raised position (not shown) in which the scanner is pivoted about hinges 15. In the lowered position, a light-tight enclosure is formed between the base and the scanner 2.

In the inverted position used for forming an image of the circuit board assembly 6, a platen (not shown in Figure 3) of the scanner 2 is maintained in spaced relationship from the circuit board assembly 6, the outer surface of the platen being located slightly above the

maximum height of the surface mounted components 8.

A handle 5 is attached to the scanner 2 allowing the scanner to be raised and lowered, the enclosure being accessible in the raised position of the scanner to allow insertion and removal of each circuit board assembly.

A spacer 32 interposed between the base 31 and the scanner 2 determines the height of the enclosure formed therebetween. Spacers 32 of different height may be used according to the required dimensions of the circuit board assembly 6.

Figure 4 illustrates schematically the manner in which the flatbed scanner 2 operates in the scanning system 1 of Figure 1 to form an image of the circuit board assembly 6. The scanner 2 comprises a housing 40 within which an imaging device 41 is mounted for reciprocating movement on a transport mechanism 42. The imaging device consists of a light source, focusing element and light receptor in the form of a linear imaging element such as a charged coupled device (CCD) configured to image a linear array of pixels at each one of a succession of positions in the direction of transport provided by mechanism 42. A complete image is acquired by translating the imaging device 41 to define an image plane, storing the image information in a buffer and subsequently outputting an image signal in rasterised form.

The imaging device 41 is movable beneath a

transparent platen 3 as described above, the imaging device being arranged to have a focal plane 46 at or immediately above the outer surface 43 of the platen and defined by the locus of points of focus for which imaging occurs during translation of the imaging device. The outer surface of the platen is defined herein as being that surface of the platen which is outermost relative to the internal workings of the scanner such as the imaging device; for an upright scanner the outer surface is uppermost and for an inverted scanner the outer surface is lowermost.

The imaging device 41 has a depth of field of about 10mm extending from the focal plane 46 to an imaginary surface 47 defined by the locus of points of maximum focal depth for which imaging is possible when the imaging device is translated, thereby defining an imaging region 44 immediately above the platen within which substantially focused imaging is available.

The circuit board assembly 6 is supported in contact with the platen 3 such that those features which are to be imaged, i.e. the surface mounted components 8 and the printed circuit board 7, lie within the imaging region 44.

Extraneous light and unwanted images formed by reflection are eliminated by the presence of the lid 4.

The scanner 2 used in the system of Figure 2 differs from the arrangement of Figure 4 in that a small

clearance is maintained between the components of the circuit board assembly 6 and the outer surface 43 of the platen 3 by virtue of the assembly 6 being supported clear of the outer surface by the cradle 23.

Figure 5 illustrates similarly the structure of the flatbed scanner 2 when inverted as for example in the case of the scanning system 30 of Figure 3. An imaging region 44 is similarly defined, this time beneath the outer surface 43 of the platen 3, and the circuit board assembly 6 is supported related to the platen at a location such that both the surface mounted components 8 and the major face 45 of the printed circuit board 7 are within the imaging region 44. A clearance 50 is maintained between the outer surface 43 of the platen 3 and the components 8 of the circuit board assembly 6, the clearance being determined by choice of spacer 32 between the lid 4 and scanner housing 40.

Figure 6 illustrates schematically the overall circuit board assembly testing system 60 which may include any one of the scanning systems 1, 20 or 30 described above, represented in Figure 6 by a scanning system 61.

An image signal 62 from the scanning system 61 is input to a processor 63 typically comprising a PC (personal computer) and having a VDU (Visual Display Unit) 64 with a display screen 65.

The processor 63 is provided with a keyboard 66,

mouse 67 and joystick 68 for the input of operator controls and is further connected to a data storage device 69 for the mass storage of image data, the data storage device typically being in the form of a compact disc writer.

A reader 70 for reading machine readable codes such as bar codes is also provided and connected to the processor 63 for the input of data associated with circuit board assemblies 6.

The circuit board assembly testing system of Figure 6 may alternatively be configured as illustrated in Figure 12 where an alternative testing system 120 is illustrated using corresponding references to previous figures where appropriate for corresponding elements. The system 120 achieves the same functions as the system 60 but is more conveniently constructed in that a housing 121 contains the scanning system 61 in addition to the processor 63 and data storage device 69. The visual display unit 64 rests conveniently upon the housing 121 in use.

The scanning 61 of the testing system 120 includes an inverted flat bed scanner 122 as illustrated in Figure 13 in which the operative components of the scanner correspond generally to those described above with reference to the scanner 2 of Figure 5. The scanner 122 however does not include a platen.

Moreover, the scanner 122 includes a cradle 23

similar to that described above with reference to Figure 2 in that the cradle is horizontally slidable between a withdrawn position (shown in dotted lines in Figure 13) and an inserted position in which the position of the circuit board assembly is correctly aligned for scanning by the inverted flat bed scanner.

In Figure 13, the manner in which the printed circuit board is inserted to the withdrawn cradle is illustrated schematically at position 123 in which the cradle projects horizontally from the housing 121 sufficiently for the circuit board assembly to be positioned in the cradle using a jig 24 of the type illustrated in Figure 2.

The testing system 120 is provided with a motorised actuating system for automatically moving the cradle 23 between its withdrawn and inserted positions for ease of use.

In use, the housing 121 constitutes a light excluding exclosure during scanning. The adjustable jig of the cradle 23 ensures that successive assemblies can be accurately positioned in a repeatable manner when inserted for scanning.

Figure 7 illustrates a typical view of a display available on the display screen 65 of VDU 64, showing a reference image 71 of a circuit board assembly 6.

Fiducial mark images 72 and 73 corresponding to fiducial marks applied to the printed circuit board 7

appear at spaced apart locations of the image 71 and are used as a basis for alignment of subsequently displayed images, an alignment routine implemented in software by the processor being used to align each image such that the fiducial mark images are located at the same display screen coordinates as images 72 and 73.

Also visible in Figure 7 is a machine readable code 74 uniquely identifying the circuit board assembly to which the image 71 relates.

The code 74 may also include human readable indicia which can be read on screen.

Figure 8 provides a view corresponding to that of Figure 7 when a "split-scroll" method of image comparison is used to compare a test image 80 with the reference image 81 upon which it is partially overlaid, the positions of each of the test and reference images being superposed in alignment with fiducial mark images 72 and 73 and a movable scroll line 82 delineating between the extent of the test and reference images.

The position of the scroll line 82 is variable by movement of the joystick 68 and a user is thereby able to scan the scroll line up and down the images to reveal differences in the test and reference images which become most noticeable in the vicinity of the scroll line when the scroll line passes over a point of dissimilarity.

The split-scroll method may alternatively provide relative movement between the scroll line and the images

by retaining the scroll line at a fixed position on the display screen 65 and providing operator controlled movement of both test image 80 and reference image 81 in registration with one another. The operator may select one or other modes of split-scroll operation as required.

Other options for image comparison are selectively available. The "image flipping" method provides comparison by sequentially displaying the reference image and test image in alternating manner. A further option is to simply display the test image continuously. A further option provides recognition software to automatically highlight areas of difference for operator assessment.

The processor 63 may selectively develop a difference image formed by comparing pixel data for the reference image and test image so that a difference image can be displayed in which any differences are highlighted. The above techniques of split-scroll comparison, image flipping or single image display may additionally make use of the difference image so that for example the image flipping method may sequentially display in alternating manner any combination of two images selected from the reference image, test image and difference image. The split-scroll method may similarly be used to split-scroll between the difference image and reference image or the difference image and test image.

In any of the above comparison techniques, variable

magnification of the images may usefully be used in order to provide closer scrutiny of localised image areas.

Figure 11 illustrates the generation of a difference image shown in Figure 11C from a reference image shown in Figure 11A and test image shown in Figure 11B. In Figure 11A, the reference image includes a component 110 which is absent from the subject circuit board and therefore does not show up on the test image of Figure 11B. The difference image generated from a digital comparison of the reference and test images shows only the component 110. The image flipping method rapidly allows the omission of the component 110 from the test image to be located by sequentially displaying the reference image and difference image or the test image and the difference image.

In each of the above image displays, a text display of assembly type and serial number data is provided on the screen 65 to identify the image being viewed.

Figure 9 illustrates the sequence of steps carried out when acquiring an image of a reference circuit board assembly.

At step 90, type data characterising the reference circuit board assembly is input to the PC using the keyboard 66 and the files necessary to store information relevant to the reference circuit board assembly are created. This process is simplified using an appropriate software tool or "wizard" which leads the user through

a series of steps using software to interface with the user via the display screen 65.

At step 91, the reference circuit board assembly is mounted in the scanner and the settings of the scanner are adjusted by the user via the PC which generates control signals 75 as illustrated in Figure 6. Optimum scanner settings including brightness, contrast, resolution, sharpness and colour settings are determined by inspecting the image appearing on the screen 65 and the optimum scannings are stored in the data file created for the reference circuit board assembly. Different settings required for specific options of image comparison may be separately stored for retrieval according to which option is later selected.

At step 92, the fiducial mark images 72 and 73 are identified in the image appearing on the display screen 65 and the co-ordinates of the marks are measured and recorded. A software routine provided for this purpose automatically logs the co-ordinates of the images of the fiducial marks when the mark images are identified by the user aligning a cursor using the mouse 67 and clicking the mouse when alignment is achieved.

At step 94, a template is created for future alignment of test images based on the fiducial mark co-ordinates obtained from the reference image, the template establishing a common frame of reference for image comparison.

At step 95, the reference image is stored in the hard drive of the processor 63 and, if required, may also be stored in a mass storage medium such as a CD ROM by writing using the data storage device 69.

Figure 10 illustrates the steps required in acquiring a test image of a test circuit board assembly and comparing the test image with the reference image.

At step 100, type data is input to the PC to identify the generic type of the test circuit board assembly and appropriate file records are created using a software tool or wizard for this purpose. The PC displays a menu of assembly types for which reference data exists, allowing the user to select the appropriate assembly type, and appropriate files are opened for the current test assembly.

At step 101, following a prompt generated by the processor 63, part number data uniquely identifying the test circuit board assembly is input to the PC. In this embodiment, this data is acquired by means of a bar code reader 70 which scans a bar code previously applied to the test circuit board assembly during manufacture. Input manually via the keyboard of part number data is available as an option.

At step 102, the test circuit board assembly is positioned in the scanning system 61 which for example in the case of the system in Figure 2 requires alignment of the assembly using jig 24 and moving the cradle 23

into a position such that the assembly is within a light-tight enclosure and within the imaging region 44 of the scanner 2.

The PC sets the scanner operating parameters according to the stored optimum settings which were acquired in step 91 and the operator then actuates the scanner so that image information is required and received by the processor 63.

At step 103, images of fiducial marks in the scanned test image are identified by displaying the image on the display screen 65 and by alignment of a cursor using the mouse 67. Co-ordinate information for the fiducial marks is then made available to software in the processor 63 which is used at step 104 to align the test image with the template.

At step 105, the reference image corresponding to the type of circuit board assembly being tested is retrieved from temporary or permanent memory and at step 106, the test image is compared with the reference image using any one of the techniques described above.

At step 107, differences identified during the comparison are recorded together with the results of the test in terms of quality control parameters. The test results may simply be a pass or fail indicator or may comprise details of points of difference identified in the comparison step, including for example the co-ordinates of defects or identifiers corresponding to

missing components.

Points of difference identified in the comparison step may be logged by generating tags which appear on the displayed test image at the co-ordinates of the point of difference. These tags may be of different categories allowing differences to be categorised appropriately, such as for example missing component, incorrectly oriented component, wrong component, or defect in component connection.

At step 108, the test image is stored in the hard drive of the processor 63 and, if required, may be stored in mass storage medium by writing using data storage device 69. A hierarchical file storage is used to organise the stored images according to type and serial number.

At step 109, if more boards are to be tested, control is returned to step 101 or otherwise the procedure ends.

Operation of the processor 63 is effected in accordance with program instructions which may be input to the processor from a storage medium such as a CD ROM, optical disc or floppy disc. The program instructions may alternatively be input via a network connection or by downloading a file from the Internet. Any such instructions for executing the above described processes, when stored in a storage medium or transmitted as an encoded signal, constitute an embodiment of the present

invention.

The scanner 2 used in the preferred embodiments is a Hewlett-Packard ScanJet 6100C (trademark) which provides a linear resolution of 600 dots per inch allowing fine detail such a component leads of thickness 0.02 inches to be resolved. The above scanner requires modification according to the selected form of scanning system for printed circuit board assembly, as for example in the embodiments of Figures 1, 2 and 3.

In the above embodiments, the platen is retained in the form typically provided by manufacturers of document scanners where the document to be scanned is placed in contact with the platen during scanning. It is envisaged that in accordance with the present invention such scanners may be modified by removal of the platen, for example in the embodiments of Figures 2, 3 and 5 where no contact is made in use between the circuit board assembly 6 and the scanner. Removal of the platen 3 may for example allow the printed circuit board assembly 6 to be located closer to the focal plane 46 of the imaging device 41, or for the focal plane to be positioned at any desired position relative to the major face 45 of the circuit board 7. Positioning the scanner in an inverted position is advantageous when no platen is present since debris from the circuit board assembly cannot then fall into the scanner.

The above described methods of visual comparison may

be partially or fully automated using recognition software, for example to identify and locate the images of fiducial marks 72,73 during the alignment sequence.

The above described embodiments make use of a joystick 68 during the split-scroll method of comparison. As an optional alternative, the mouse 67 or keyboard 66 may be used instead of providing a joystick for this purpose.

The present invention thereby allows the use of a personal computer 63 with a commercially available flatbed scanner 61 in a low volume printed circuit board assembly inspection system. It is envisaged that such a system could be realisable at substantially lower cost than currently available systems.

In the described embodiments, means for alignment of the subject assembly relative to the scanner are described. Since however the PC is provided with software for alignment of images using fiduciary marks, the exact position of the assembly relative to the scanner is not critical and such jigs or alignment means for achieving accurate alignment may be dispensed with. It may however be preferable to retain a jig or alignment means to provide approximate alignment to the extent required to achieve satisfactory operation of the scanner to enter a complete image of the assembly or, in embodiment of Figure 2, to ensure that the assembly is securely held in an inverted position.

In the described embodiments, a mouse 67 is described for use as a pointing device in relation to scroll line motion control. Alternative pointing devices such as a tracker ball may equivalently be used.

A principal advantage of the present invention is to dispense with the need for conventional camera optics and related mechanics such as stands, accurately adjusted board mountings etc, and instead using cheaply available components such as scanners and PCs.

CLAIMS

1. A method of inspecting a subject circuit board assembly (6) comprising a circuit board (7) having surface mounted components (8) on a major face (9) thereof, the method comprising the steps of;

optically scanning the subject circuit board assembly to obtain test image data representative of a plan view of the major face of the circuit board including the surface mounted components;

and performing a test procedure on the test image data for detecting defects in the subject circuit board assembly;

wherein the optical scanning step comprises positioning the subject circuit board assembly relative to an optical scanner (2) such that the surface mounted components and the major face of the circuit board are maintained within an imaging region (44) for which the scanner is operable to provide substantially focused imaging and operating the scanner to obtain the test image data.

2. A method as claimed in claim 1 including the step of obtaining reference image data by optically scanning a reference circuit board assembly using a reference scanning step corresponding to the scanning step used in optically scanning the subject circuit board;

and wherein the test procedure comprises comparing

the test and reference image data to detect differences therebetween.

3. A method as claimed in claim 2 wherein the comparison step comprises displaying test and reference images corresponding to the test and reference image data respectively and determining differences by visual inspection of the displayed images.

4. A method as claimed in claim 3 wherein the displaying step comprises alternatively displaying the test image (80) and the reference image (81) in spatial registration on a display screen.

5. A method as claimed in claim 3 wherein the displaying step comprises displaying portions of the test and reference images in spatial registration such that a scroll line (82) defines a transition between the images and varying the relative proportion of each image displayed by controlling the relative position of the scroll line to the images by movement of at least one of the scroll line and the images.

6. A method as claimed in claim 5 including the step of controlling the position of the scroll line relative to the images by operation of a joy stick (68).

7. A method as claimed in claim 2 wherein the comparison step comprises inputting the test and reference data to an image processing apparatus (63) and operating the apparatus to detect differences therebetween.

8. A method as claimed in claim 7 including generating and displaying a difference image in which only features corresponding to differences between the test and reference data are displayed.

9. A method as claimed in claim 8 in which the comparison step comprises displaying the difference image and at least one of the reference image and the test image for determining differences therebetween by visual inspection of the displayed images.

10. A method as claimed in any preceding claim including the step of marking the subject board with identifying indicia (74) representative of identifying information and storing the identifying information in association with the image data.

11. A method as claimed in claim 10 including the step of displaying the identification information with the corresponding image data.

12. A method as claimed in any of claims 10 and 11 including the step of applying the identifying indicia in the form of machine readable indicia (74), and

reading the identifying indicia by operation of a reading apparatus (70) to obtain the identifying information.

13. A method as claimed in any of claims 2 to 12 including the step of identifying fiducial features (72,73) of the image data corresponding to fiducial features of the reference circuit board assembly, analysing the test image data to identify corresponding fiducial features therein, and processing the image data using a common frame of reference defined relative to the fiducial features.

14. A method as claimed in any preceding claim wherein the scanning step comprises operating a linear imaging element (41) to obtain an image signal representative of a linear array of pixels of the image data, translating the linear imaging element to traverse an image plane defined thereby, and obtaining successive image signals at successive positions of the element respectively whereby said image signals are representative of successive linear arrays of pixels of the image data.

15. A method as claimed in any preceding claim wherein

the scanner comprises a flat bed scanner (2) having a planar transparent platen (3) having an outer face substantially coincident with a focal plane (46) of said scanner and wherein said imaging region is defined intermediate said outer face and an imaginary surface (47) defined by a maximum depth of focus of said scanner.

16. A method as claimed in claim 15 wherein said scanning steps are performed with said circuit board assemblies maintained in spaced relationship from said outer face.

17. A method as claimed in any of claims 15 and 16 wherein said scanning steps are performed with said scanner in an inverted position in which said outer surface is downwardly facing.

18. A method as claimed in claim 2 wherein the optical scanner is controlled by a control means (63) to which the scanner is connected, the control means outputting signals (75) representative of operating instructions to the scanner in accordance with user commands input to the control means, and wherein the control means comprises memory means storing said test image data and reference image data.

19. A method as claimed in claim 18 including the step

of inputting the results of comparison of displayed images representative of the test data and reference data to the control means together with identifying information associating the test data with the respective subject board and storing said data and identifying information in said memory means.

20. A storage medium storing instructions for operation of a processor (63) of a control means in a method of inspecting circuit board assemblies;

the instructions defining the steps of;

generating the output of control signals from the control means to a scanner to acquire image data;

storing reference image data representative of a reference circuit board;

storing test image data representative of test circuit boards;

storing identifying information in association with the stored test image data;

facilitating comparison of the respective text image data and the reference image data to effect inspection of said circuit board assemblies,

and storing test results representative of the results of said comparison in association with said identifying information.

21. A storage medium as claimed in claim 20, wherein the

step of facilitating comparison comprises outputting display signals to a display means for visual comparison of displayed images representative of the test and reference image data, and receiving user data input representative of the result of said comparison.

22. A storage medium as claimed in claim 20 wherein the step of facilitating comparison comprises said processor operating an image data comparison procedure to identify differences between the test image data and the reference image data.

23. A storage medium as claimed in claim 20 wherein the step of generating control signals to a scanner comprises outputting signals representative of scanner operating settings and further signals initiating scanning operation to acquire image data by translation of a linear imaging element.

24. Apparatus for inspecting a subject circuit board assembly (6) comprising a circuit board (7) having surface mounted components (8) on a major face (9) thereof, the apparatus comprising;

an optical scanner (2) operable to scan the subject circuit board assembly to obtain test image data representative of a plan view of the major face of the circuit board including the surface mounted components;

and

positioning means (3,4;23,24) operable to maintain the position of the subject circuit board assembly relative to the optical scanner such that the surface mounted components and the major face of the circuit board are maintained within an imaging region (44) for which the scanner is operable to provide substantially focused imaging.

25. Apparatus as claimed in claim 24 wherein the scanner comprises a linear imaging element (41) operable to obtain an image signal representative of a linear array of pixels of the image data, and translating means (42) operable to translate the linear imaging element so as to traverse an image plane defined thereby, whereby said imaging element is operable to obtain successive image signals at successive positions of the element respectively and whereby said image signals are representative of successive linear arrays of pixels of the image data.

26. Apparatus as claimed in claim 24 wherein the scanner comprises a flat bed scanner (2) having a planar transparent platen (3) having an outer face substantially coincident with a focal plane (46) of the scanner and wherein the imaging region is defined intermediate the outer face and an imaginary surface defined by a maximum

depth of focus of the scanner.

27. Apparatus as claimed in claim 24 wherein the positioning means is operable to maintain the circuit board assembly in spaced relationship from the outer face.

28. Apparatus as claimed in any of claims 26 and 27 wherein the positioning means is operable to maintain the scanner in an inverted position in which the outer surface is downwardly facing.

29. Apparatus as claimed in any of claims 24 to 28 wherein the positioning means co-operates with the scanner to constitute a light excluding enclosure operable to exclude extraneous light from the imaging region.

30. Apparatus as claimed in any of claims 24 to 29 wherein the positioning means comprises an adjustable jig (24) operable to determine the position of successive assemblies relative to the scanner in a repeatable manner.

31. Apparatus as claimed in any of claims 24 to 30 wherein the positioning means comprises a support (23) for receiving the assembly and a light excluding cover

(4) co-operating with the scanner to exclude light from the imaging region, wherein the support is slidable relative to the cover between a withdrawn position in which the support is accessible for locating the assembly therein and for subsequently removing the assembly therefrom and an inserted position in which the support is operable to position the assembly in the imaging region.

32. Apparatus as claimed in claim 24 wherein the scanner is a flatbed document scanner (2) and the positioning means comprises a transparent platen (3) of the scanner upon which the assembly rests in use and an opaque lid (4) overlaying an imaging system of the scanner, wherein the lid defines a recess for accommodating the assembly in use.

33. Apparatus as claimed in any of claims 24 to 32 comprising a processor (63) connected to the scanner and operable to receive image data therefrom and a display means (64) connected to the processor and operable to display an image (80,81) representative of the image data.

34. Apparatus as claimed in claim 33 comprising reading means (70) connected to the processor and operable to read machine readable indicia (74) applied to the

assembly for the input of identifying information to the processor.

35. Apparatus as claimed in claim 33 wherein the processor and the scanner are integrally housed in a housing (121).

36. Apparatus as claimed in claim 35 wherein the scanner is housed in an inverted position, the apparatus further comprising a support (23) for the circuit board assembly and means for translating the support between a withdrawn position in which the support is accessible for locating the assembly therein and an inserted position in which the support is operable to position the assembly in the imaging region.

37. An encoded signal carrying instructions for operation of a processor of a control means;

the instructions defining the steps of;

generating the output of control signals from the control means to a scanner to acquire image data;

storing reference image data representative of a reference circuit board;

storing test image data representative of test circuit boards;

storing identifying information in association with the store test image data;

facilitating comparison of the respective text image data and the reference image data to effect inspection of said circuit board assemblies,

and storing text results representative of the results of said comparison in association with said identifying information.

Fig 1

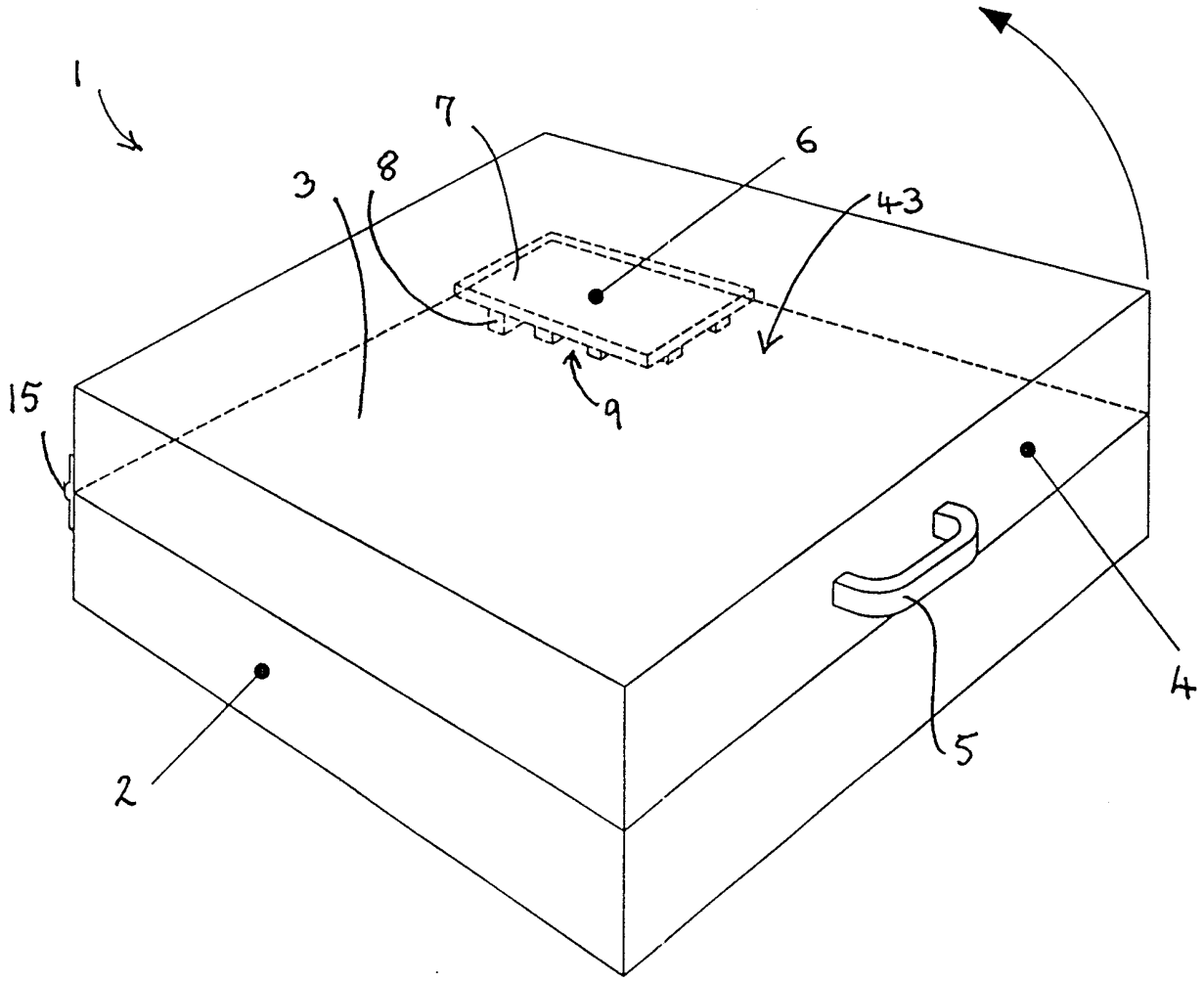


Fig 2

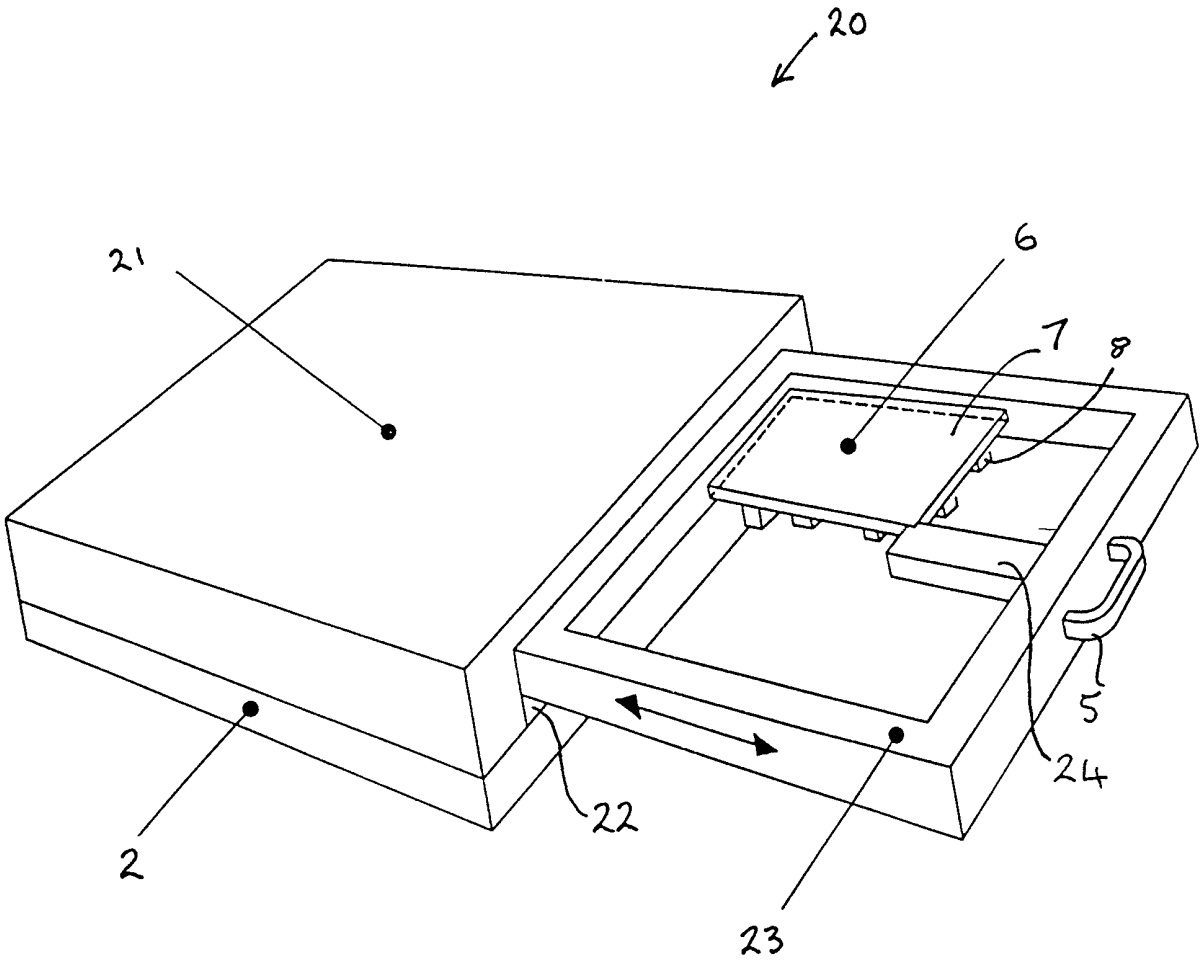


Fig 3

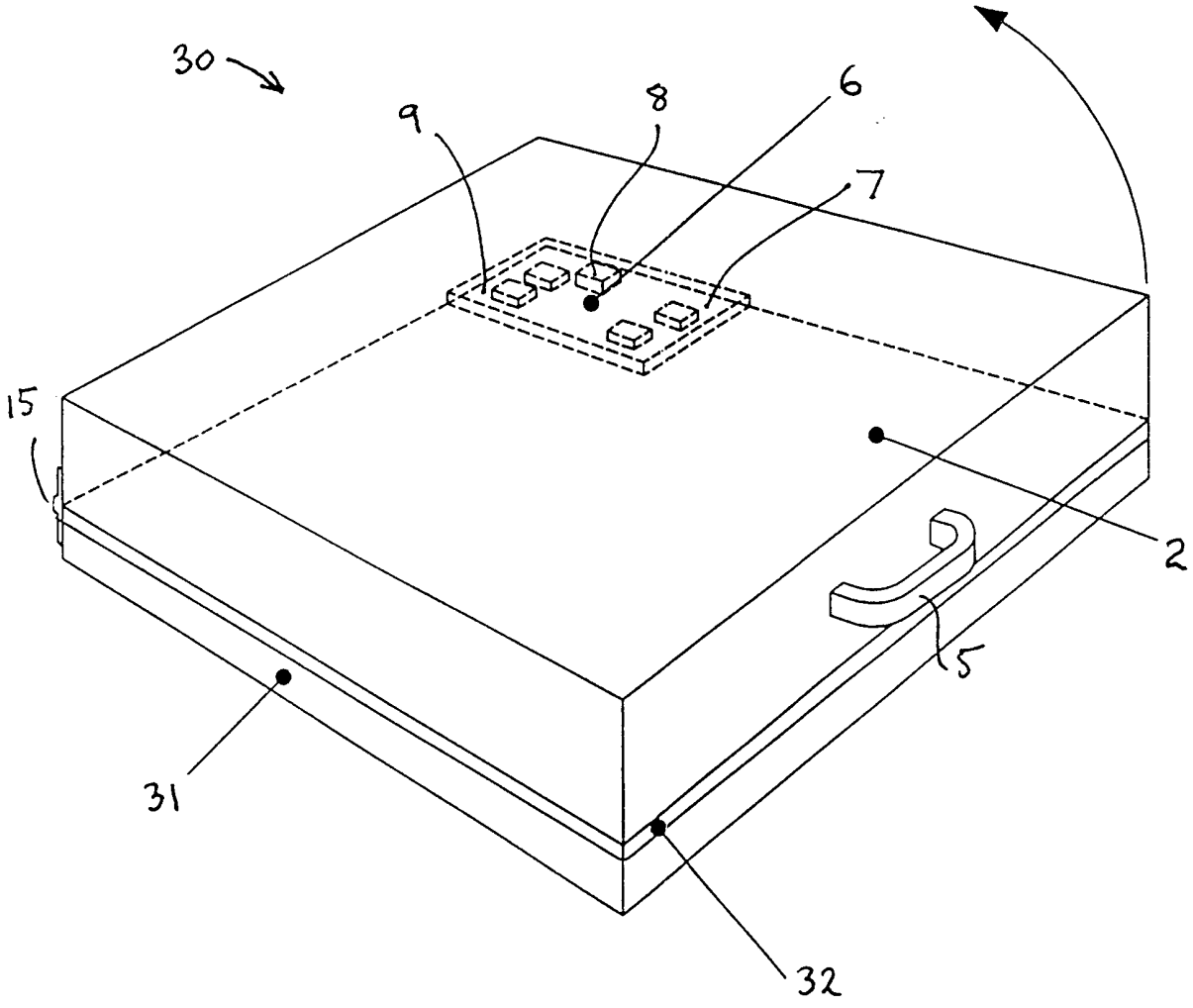


Fig 4

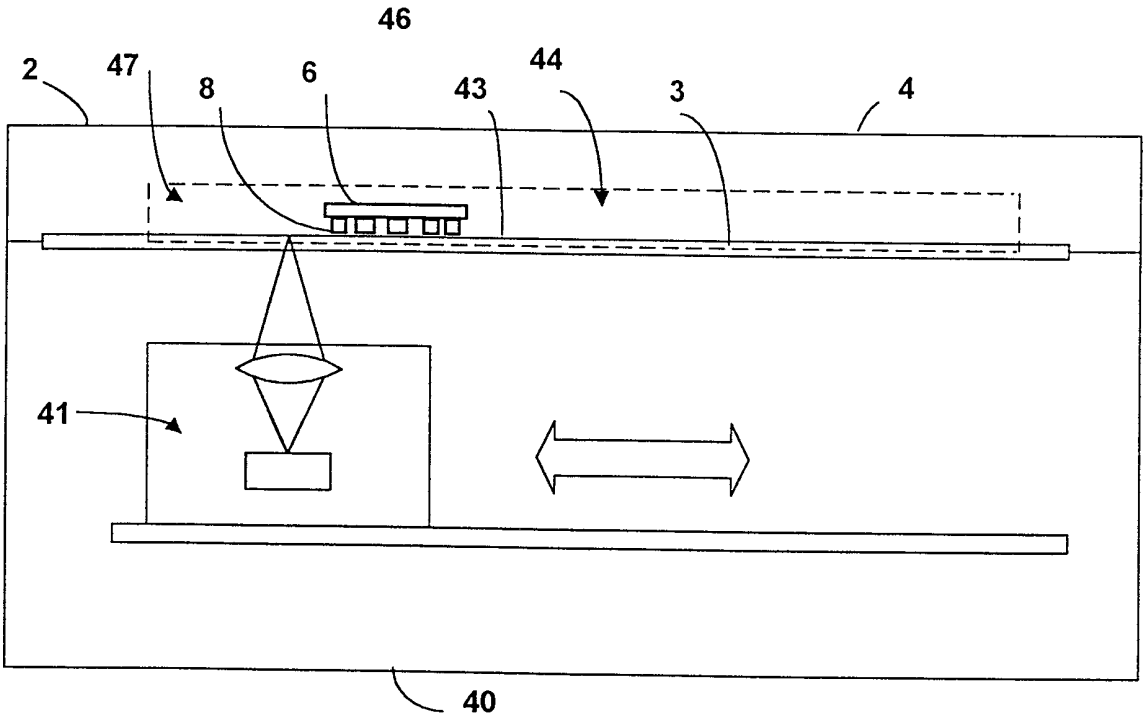


Fig 5

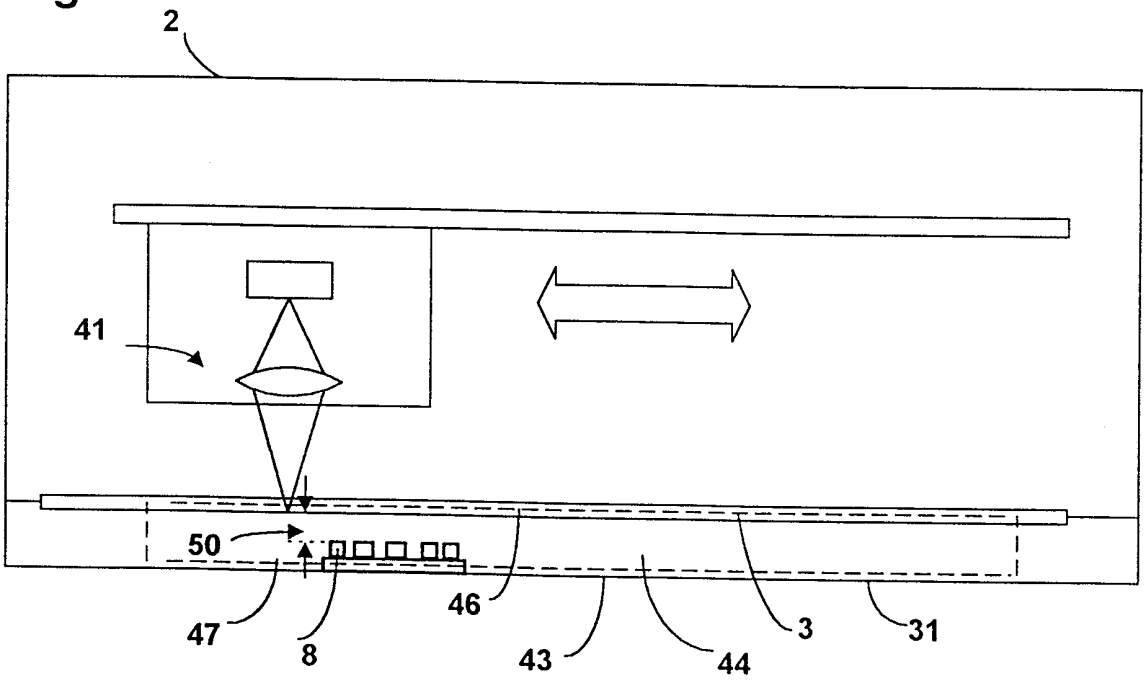


Fig 6

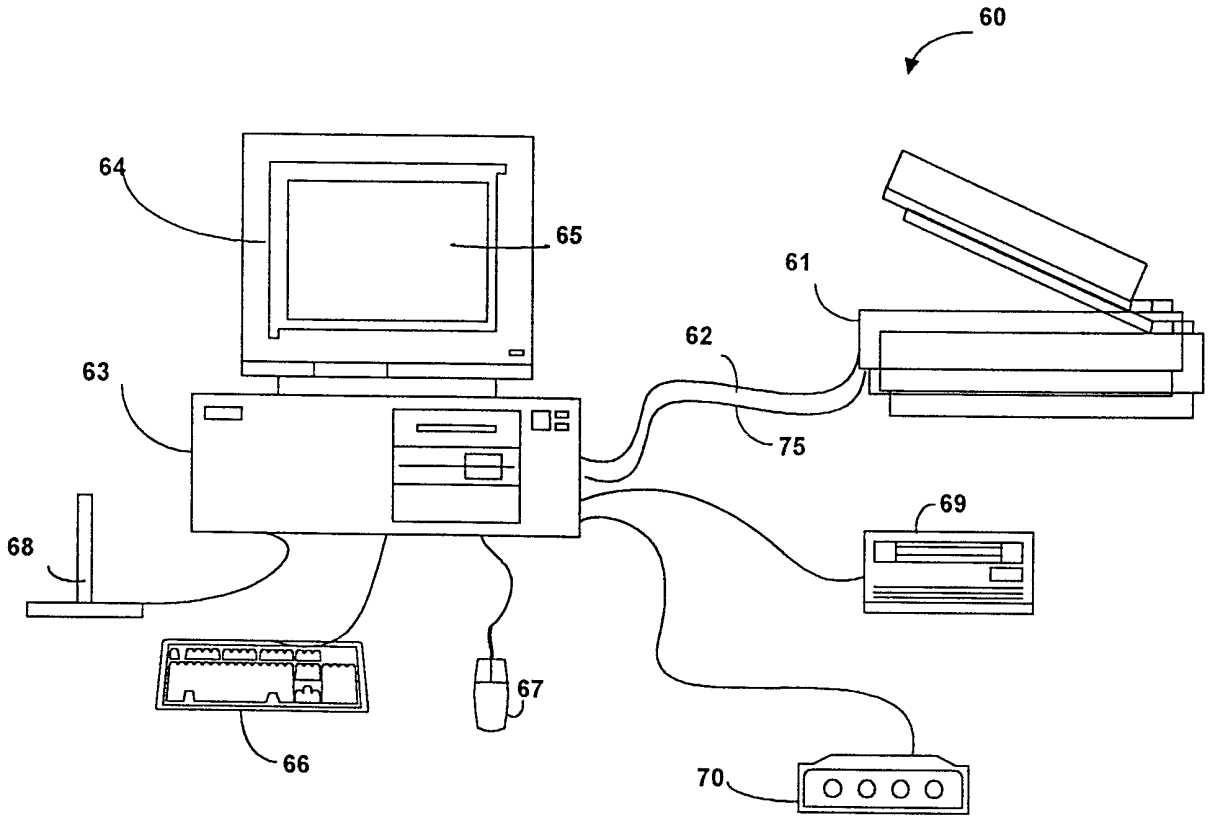


Fig 7

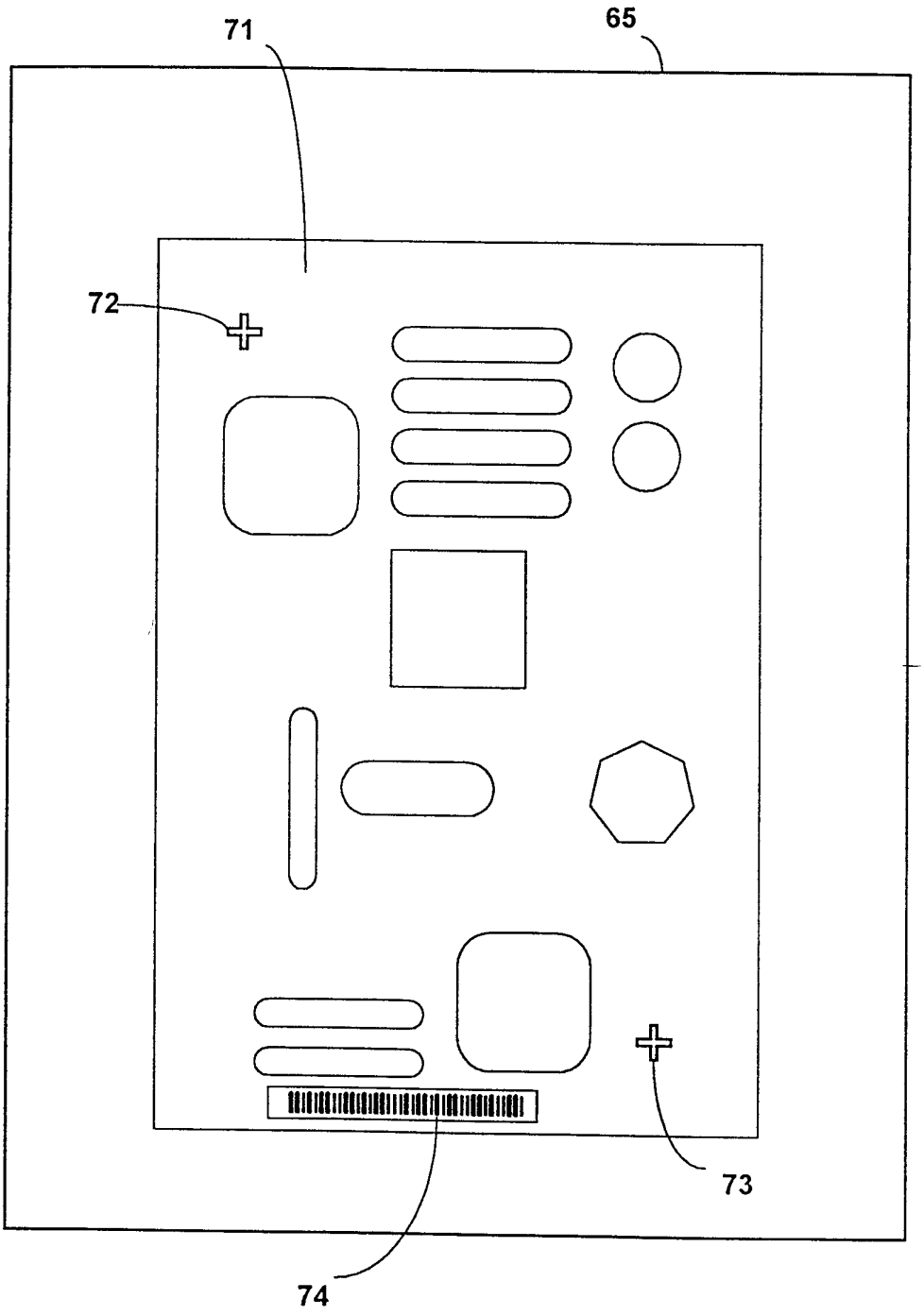


Fig 8

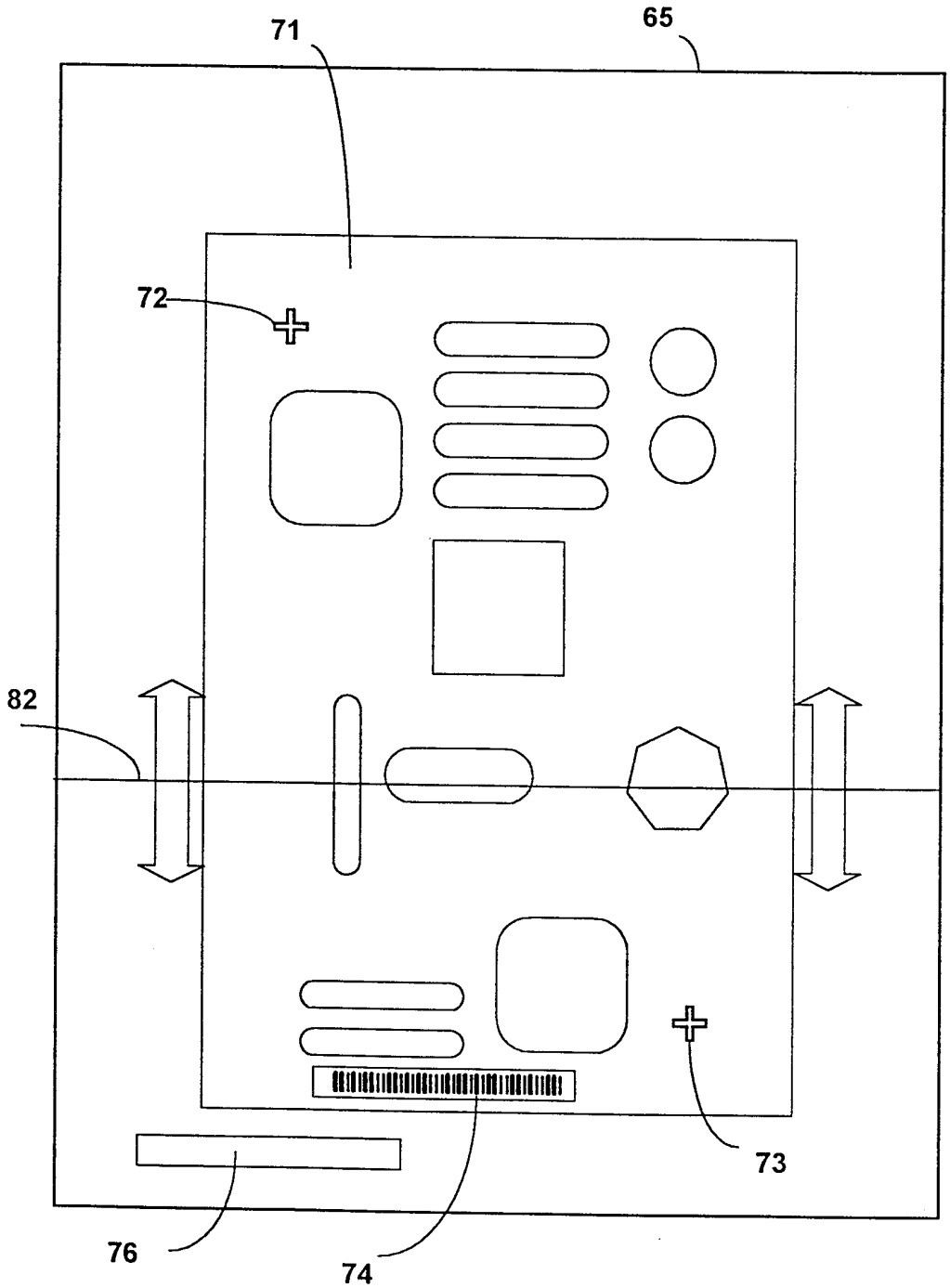


Fig 9

REFERENCE IMAGE AQUISITION

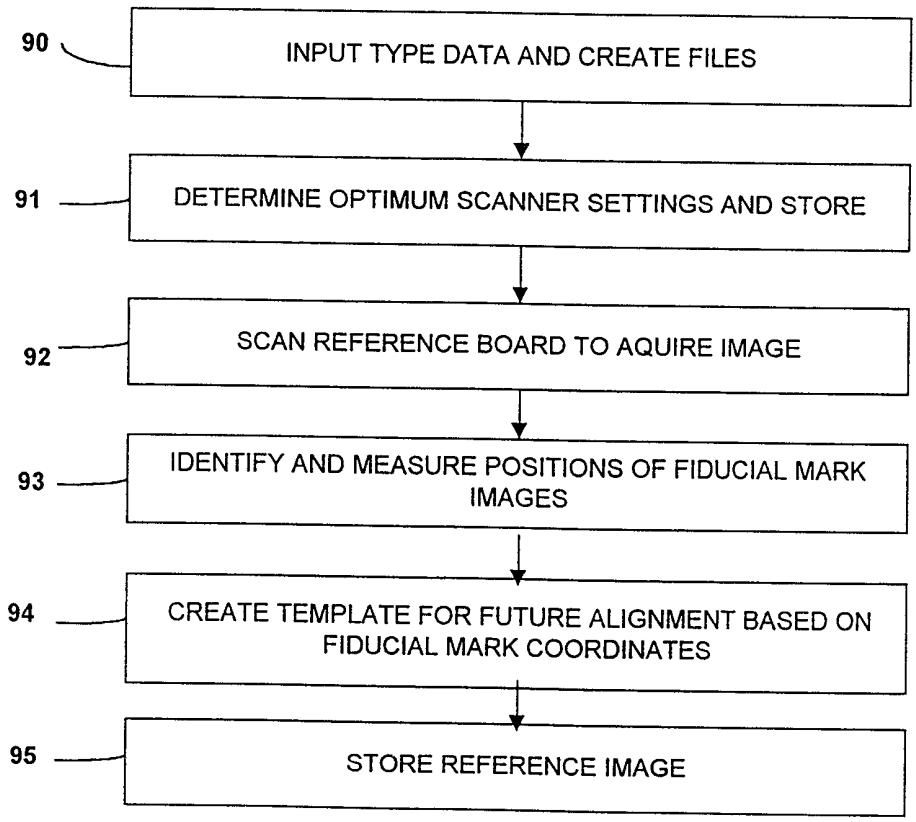


Fig 10

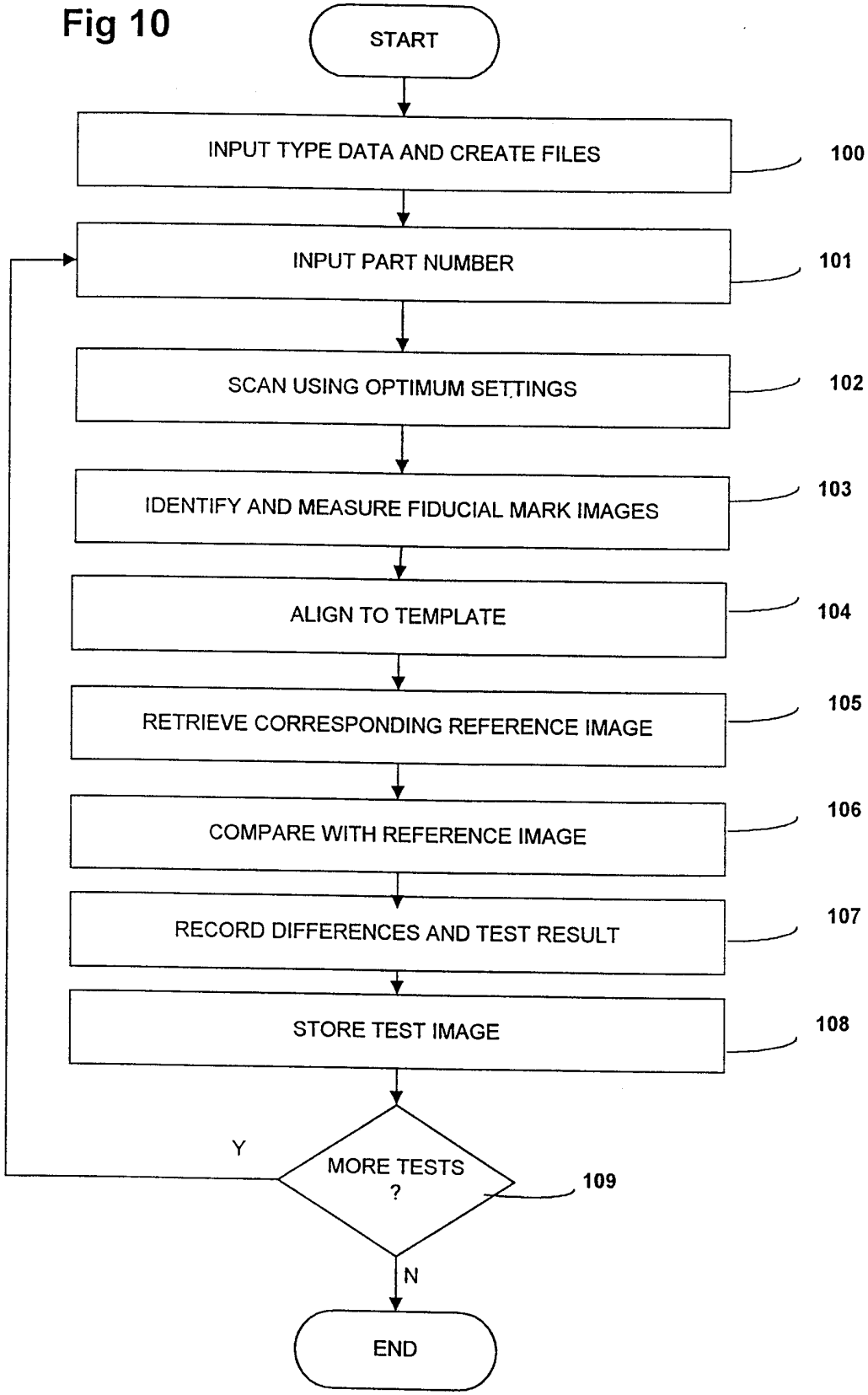

START
INPUT TYPE DATA AND CREATE FILES
100
INPUT PART NUMBER
101
SCAN USING OPTIMUM SETTINGS
102
IDENTIFY AND MEASURE FIDUCIAL MARK IMAGES
103
ALIGN TO TEMPLATE
104
RETRIEVE CORRESPONDING REFERENCE IMAGE
105
COMPARE WITH REFERENCE IMAGE
106
RECORD DIFFERENCES AND TEST RESULT
107
STORE TEST IMAGE
108
MORE TESTS ?
109
Y
N
END

Fig 11A

REFERENCE IMAGE

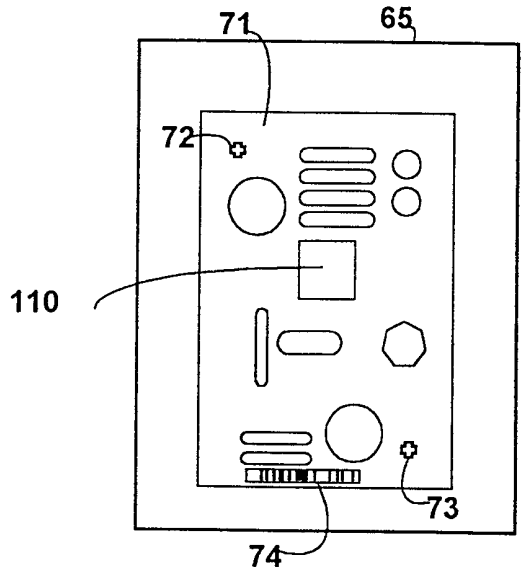


Fig 11B

TEST IMAGE

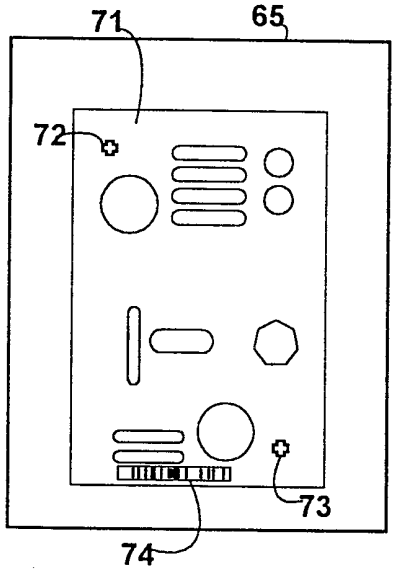


Fig 11C

DIFFERENCE IMAGE

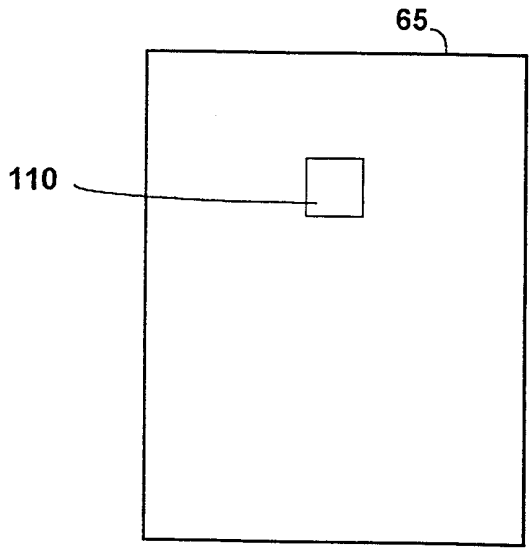


Fig 12

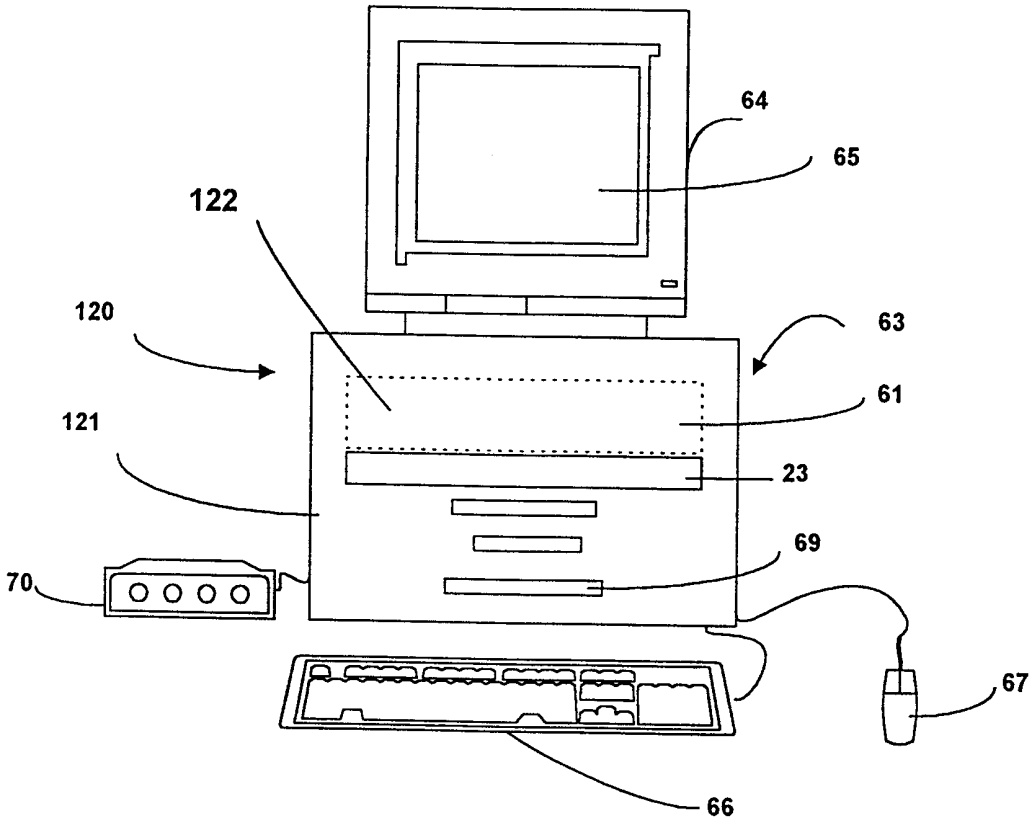
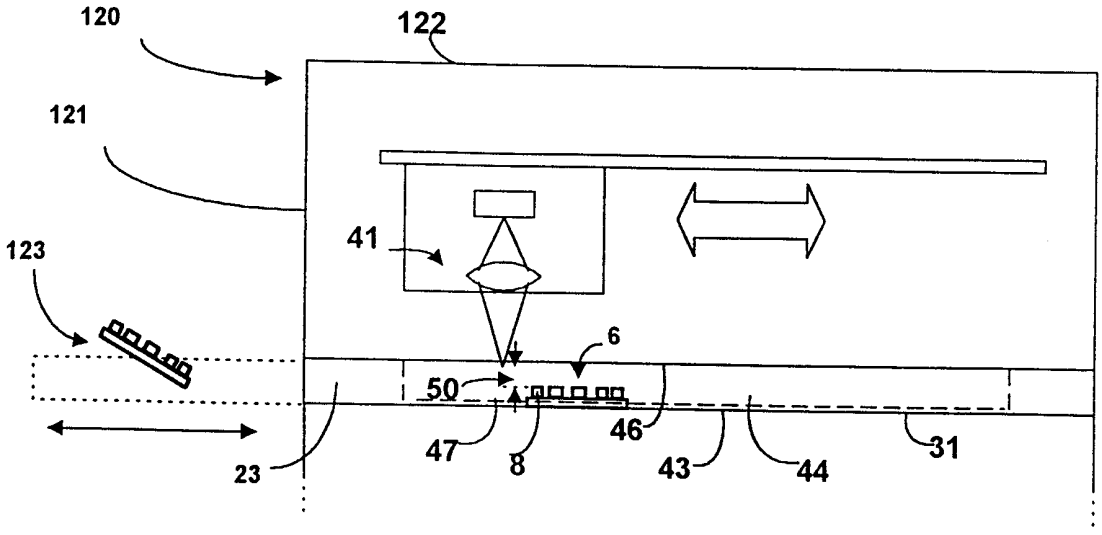

64
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Fig 13


120
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