United States Patent

Wickersham

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[54] COORDINATE CONVERSION FOR THE TESTING OF PRINTED CIRCUIT BOARDS

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[52] **U.S. Cl.**.....**339/17 M,** 174/68.5, 324/158 F, 339/18 C, 339/151 B, 339/156 R

[51] **Int. Cl.**.....**H05k 1/02**

[58] **Field of Search**.....339/14, 17, 18, 75, 150, 174, 339/176; 174/DIG. 3, 68.5; 29/592, 593; 317/101; 324/158 F

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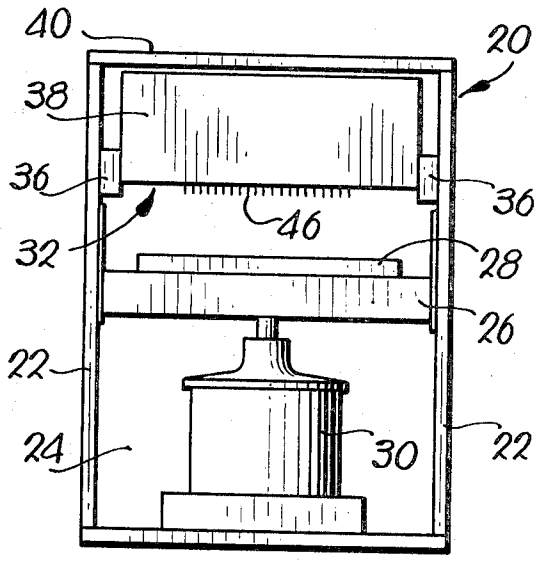
[57] **ABSTRACT**

An array of spring pin contact elements are arranged in a matrix on a uniform rectangular grid and, through a coordinate conversion interface, provide access to the random-arranged contact points of a single or multiple layer printed circuit board for the purpose of conducting electrical tests. The interface is a transition plate constructed in accordance with the artwork of a given board and comprises a baseplate provided with contact pads on one side having the same random arrangement as the contact points of the board, and corresponding contact pads on the opposite side each positioned at an individual contact location having the same planar coordinates as a particular one of the spring pin contact elements. The corresponding pads are electrically interconnected through the baseplate. The board and the interface are supported on a shiftable platen with the random-arranged pads engaging the contact points, the platen being spaced from and aligned with the spring pin elements such that, upon movement of the platen toward the spring pin elements, the pads on the opposite side of the interface are brought into engagement with the elements of like coordinates.

7 Claims, 11 Drawing Figures



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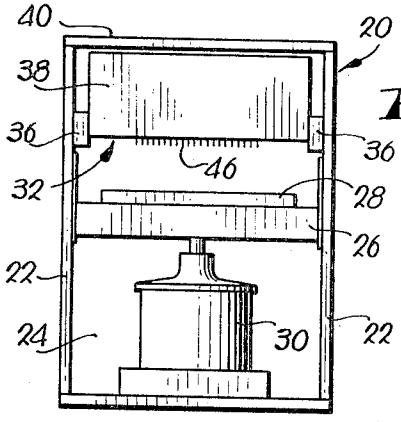

Fig. 1.

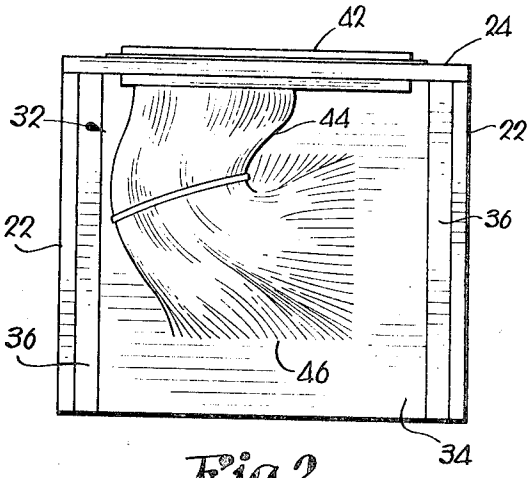

Fig. 2.

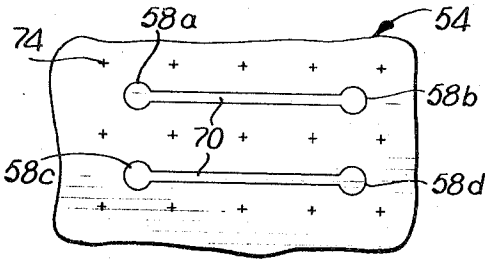

Fig. 8.

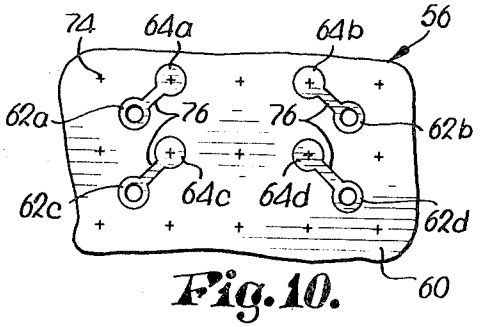

Fig. 10.

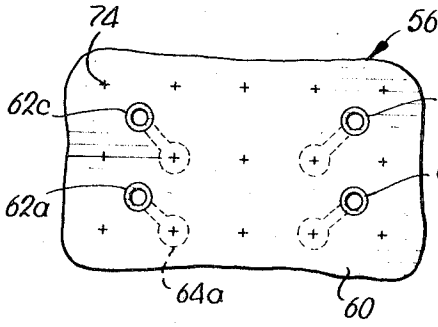

Fig. 9.

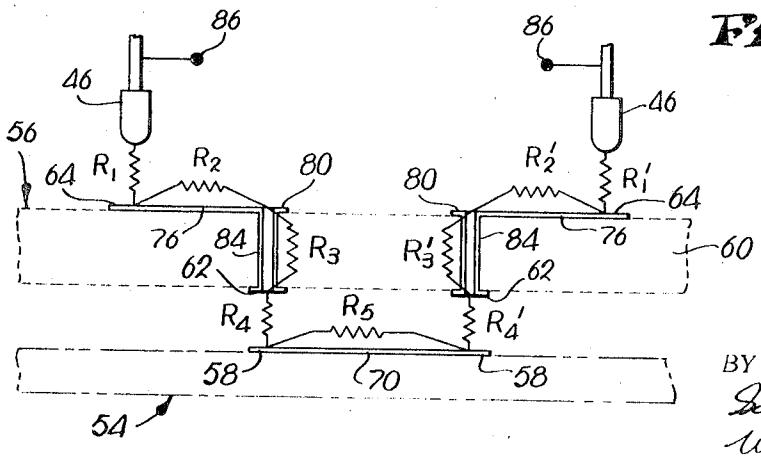

Fig. 11.

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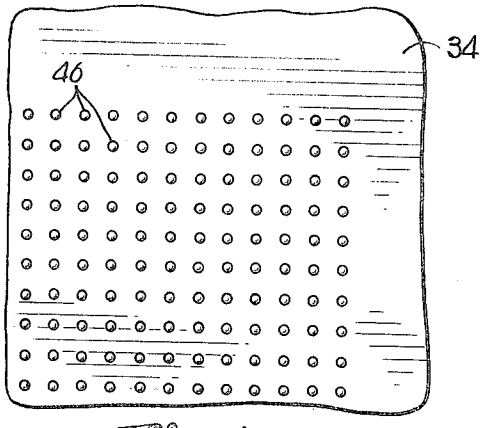

Fig. 4.

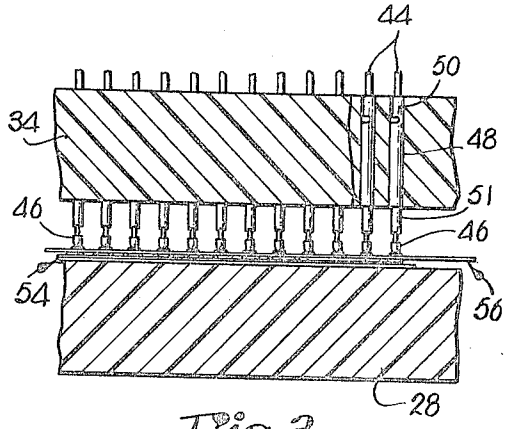

Fig. 3.

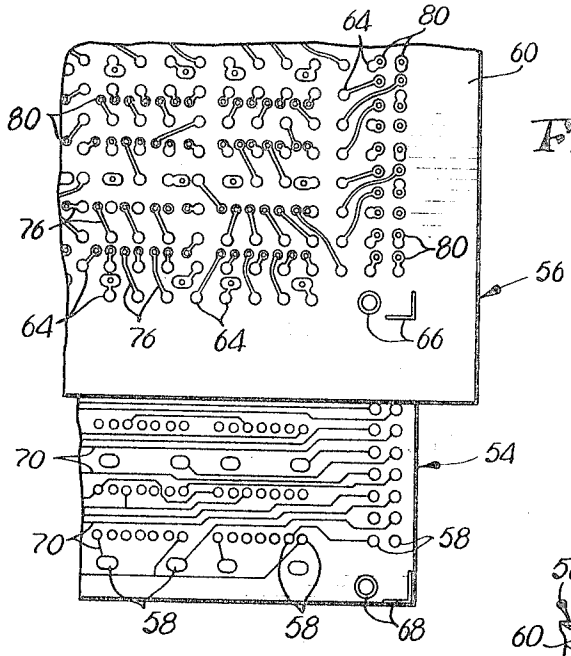

Fig. 5.

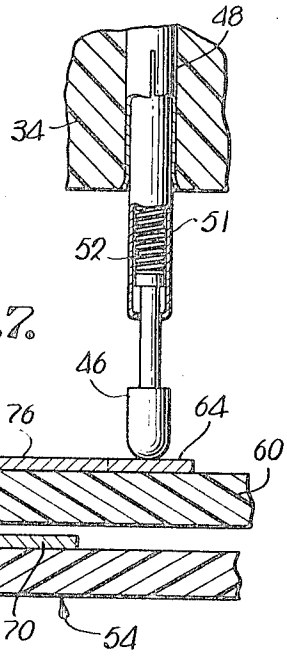

Fig. 7.

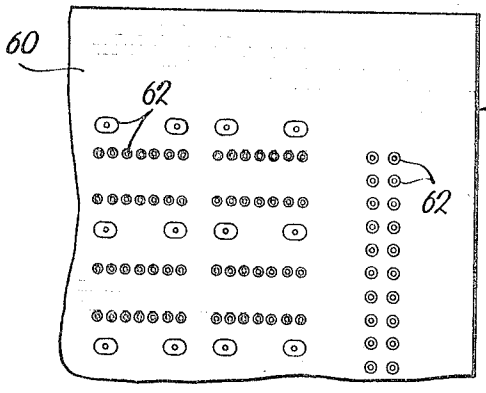

Fig. 6.

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COORDINATE CONVERSION FOR THE TESTING OF PRINTED CIRCUIT BOARDS

This invention relates generally to the testing of printed circuit boards or the like and, in particular, to a method and structure for making electrical connections to the random-arranged contact points of a single or multiple layer board.

With the continuing use of printed circuit techniques in the construction of electrical apparatus, it has become both desirable and advantageous to employ an automatic circuit analyzer to test printed circuit modules prior to assembly of the composite apparatus. This has led to the recent development of a special fixture for providing access to the various nodes of multilayer printed circuit boards utilized to form the modules. The access fixture permits electrical contact to be made to all of the nodes of a board for the purpose of conducting insulation and continuity resistance tests or general electrical tests. The board to be tested is inserted into the fixture beneath an array of spring pin contacts with each spring pin contact being aligned with a corresponding node on the board. The board is supported by a pneumatically actuated platen which is then caused to shift toward the spring pins to bring the latter into pressure engagement with the nodes. The means by which the platen is actuated is incidental, and may be hydraulic or motor-driven through appropriate gearing.

Since the patterns and layouts of the artwork of printed circuit boards present a nearly infinite variety of spacings and land routings, it has been necessary to accommodate this variable by providing a different spring pin array for each artwork to be tested. Such arrays take the form of matrix boxes which are selectively positionable in the access fixture and are provided with a standard connector to form the interface between the matrix box and the circuit analyzer. This arrangement provides considerable flexibility when testing boards having different artwork in that it is only necessary to change matrix boxes to achieve access to the different node patterns.

Although the foregoing access approach has proven to be successful from the standpoint of operability, it may be appreciated that considerable tooling is required to produce a matrix box for each artwork configuration. This involves the construction of spring pin arrays having different relative locations of the pins thereof to accommodate the unique node spacing of each individual artwork configuration. Manifestly, tooling costs and hence the overall cost of the testing equipment and procedure could be materially reduced if a single matrix box were utilized to provide access to all artwork configurations regardless of the degree of variance of the patterns and layouts.

It is, therefore, the primary object of the present invention to eliminate the need for providing a specially constructed matrix box to permit access to each artwork configuration in order to thereby facilitate the testing of multiple layer printed circuit boards both before and after assembly thereof and, therefore, facilitate the testing of printed circuit boards in general including single and multiple layer types employing integrated circuits or discrete components, and other similar electrical circuit structures having accessible contact points.

In accordance with the foregoing object, it is another important aim of this invention to provide a method of and structure for, in effect, transferring the random-arranged nodes of printed circuit boards to contact locations having predetermined planar coordinates such that a universal array of contact elements in the nature of spring pins or the like may be employed to provide access to all artwork configurations.

In furtherance of the above aim, it is a particular and important object of the invention to provide a coordinate conversion interface for use in conjunction with a printed circuit board and the aforesaid universal array of contact elements, in order that the latter may accommodate and provide access to any artwork configuration through the use of a conversion interface appropriate to each of the different configurations.

Another important object of the invention is to provide a method and apparatus for making electrical connections to the random-arranged nodes or contact points of a printed circuit board or the like wherein only a single universal array of contact elements as aforesaid is required regardless of the artwork of the board under test.

In the drawings:

FIG. 1 is a diagrammatic, front view of an access fixture for use in making electrical connections to a printed circuit board;

FIG. 2 is an enlarged, top view of the apparatus shown in FIG. 1, the lid of the fixture and the cover of the matrix box being removed to reveal the array of spring pins and leads extending therefrom;

FIG. 3 is a fragmentary, cross-sectional, detailed view showing a group of spring pins in contact with the superimposed transition plate interface and printed circuit board under test;

FIG. 4 is a fragmentary, bottom view of the matrix box enlarged with respect to FIG. 2 and showing the uniform grid of spring pins;

FIG. 5 is a fragmentary, top view of an exemplary printed circuit board and associated transition plate interface on the same scale as FIG. 4, showing the same shifted relative to each other rather than in their superimposed, operative interrelationship in order to provide a visual comparison of the configurations of the board and the interface;

FIG. 6 is a fragmentary, bottom view of the same portion of the transition plate interface illustrated in FIG. 5, and shown on the same scale;

FIG. 7 is a greatly enlarged, cross-sectional, detailed view illustrating coordinate conversion by the interface;

FIG. 8 is a fragmentary, diagrammatic, top view of a printed circuit board;

FIG. 9 is a fragmentary, diagrammatic, bottom view of a transition plate interface for use with the board illustrated in FIG. 8;

FIG. 10 is a fragmentary, diagrammatic, top view of the transition plate of FIG. 9; and

FIG. 11 is a superimposed, diagrammatic mechanical and electrical schematic illustration depicting the circuit resistances in an electrical continuity test utilizing the transition plate interface of the present invention.

Referring initially to FIGS. 1 and 2, an access fixture 20 is illustrated and comprises an upright, rectangular housing having a pair of sidewalls 22 and a rear wall 24. A horizontal, rectangular frame 26 is secured to the sidewalls 22 within the fixture 20 and serves as a support for a horizontal, vertically reciprocable platen 28 shown in its lowermost position resting on the frame 26. A pneumatic piston and cylinder assembly 30 is mounted on the base of the fixture 20 beneath the platen 28 and, when actuated, shifts the platen 28 upwardly toward a matrix box broadly denoted 32.

The matrix box 32 has a substantially square base 34 of plexiglass or similar material which is supported by a pair of opposed side support members 36 secured to respective sidewalls 22 of the fixture 20 above the frame 26. The matrix base 34 is held in a horizontal position in parallelism with the platen 28 and is normally enclosed by a cover 38 and an overlying lid 40 of the fixture 20 seen in FIG. 1. A connector panel 42 is secured to the rear edge portion of the base 34 and may, for example, receive a mating plug-in connector (not shown) for the purpose of making electrical connections to a multitude of leads 44 that extend from an array of contact elements 46 to the connector panel 42.

The contact elements 46 are best seen in FIGS. 3, 4 and 7. As is apparent in FIG. 4, the elements 46 are arranged in a matrix on a uniform rectangular grid, each cluster of four elements 46 defining the corners of a square. The contact elements 46 are in the nature of spring pins projecting vertically downwardly equal distances from the matrix base 34. To provide a means of mounting the spring pin elements 46 on uniform centers, the base 34 is drilled on such centers and elongated, tubular sockets 48 are inserted into the holes and held by a press fit. As is clear in FIG. 3, the upper end of each socket 48 is provided with a terminal 50 to which a respective lead 44 is connected. In FIG. 7, it may be seen that the lower end of each socket 48 receives plunger portion of the spring

pin 46. Thus, the pin 46, barrel 51, and spring 52 form a contact assembly which is conveniently inserted into the respective socket 48 by a press fit. The spring pins 46 are normally held by the springs 52 at fully extended positions, the springs 52 permitting the pins 46 to retract under applied upward pressure to form resilient contacts as will be appreciated hereinafter.

Referring to FIG. 5, one corner portion of a printed circuit board 54 is shown extending from beneath a transition plate 56 which, as will be discussed, forms a coordinate conversion interface that cooperates with both the array of spring pins 46 and the printed circuit board 54. It should be noted that the board 54 has a characteristic pattern of artwork that presents a number of random-arranged nodes or contact points 58. The board 54 illustrated herein is one of the laminae of a multilayer printed circuit board, it being desired to test the lamina 54 prior to assembly of the multilayer board. It should be understood, however, that the lamina 54 is only illustrative of one particular type of printed circuit board that may be accommodated by the present invention, since both single layer boards and multilayer boards after assembly can be accommodated plus single or multilayer boards having electronic components mounted thereon if the application of the transition plate 56 should be to provide access to the nodes of the fully assembled boards for the purpose of performing tests other than simple continuity and insulation resistance tests, e.g., impedance or functional tests.

The transition plate interface 56 comprises a thin baseplate 60 of insulating material, such as a thin fiberglass sheet. In use, the transition plate 56 is horizontally disposed thereby presenting a top side or face seen in FIG. 5 and a bottom side or face seen in FIG. 6. Initially, the baseplate 60 is coated on each side with a layer of copper or similar conductive material, each copper layer then being etched to leave only the contact pads 62 on the bottom side of the baseplate 60, and the contact pads 64 (and other contact structure to be discussed) on the top side of the baseplate 60. For purposes of illustration, it is assumed that the baseplate 60 is translucent; thus the same is advantageously provided with a pair of register marks 66 adjacent two or more corners thereof. Similarly, the board 54 is provided with a pair of register marks 68 adjacent its corresponding corners. It may be seen that the register marks 66 and 68 are in the form of a bull's-eye and a right angle corner indication, these marks being superimposed in exact register in order to properly position the transition plate 56 in overlying, superimposed relationship to the board 54. The contact pads 62 on the bottom side of the baseplate 60 have the same random arrangement as the contact points 58 of the board 54; therefore, with the plate 56 and the board 54 in register, the pads 62 engage corresponding contact points 58 therebeneath.

It may be appreciated from the foregoing that the bottom side of the baseplate 60 is etched in a manner to reveal segments of the copper layer only where the contact points 58 will be presented beneath the copper segments when the transition plate 56 and the board 54 are brought into proper register. Accordingly, the segments forming the pads 62 are preferably of no greater outside diameter than the corresponding contact points 58 in order to preclude the possibility of shorting across other nodes or lands of the board 54. In some instances, it may be desired to actually reduce the outside diameter of the contact pads 62 as compared with the corresponding contact points 58 to increase the allowable tolerances and to minimize the possibility of inadvertent shorting should, for some reason, the transition plate 56 and the board 54 be aligned in use in other than perfect register.

In contrast to the random arrangement of the lower contact pads 62, the upper pads 64 are arranged on the same uniform grid as the spring pin contact elements 46. Viewed in terms of a planar coordinate system, the upper contact pads 64 have predetermined planar coordinates selected arbitrarily with respect to the positions of the lower contact pads 62, the coordinate location of each of the upper pads 64 being identical to a corresponding spring pin contact element 46.

The effect of the transition plate 56 is to achieve coordinate conversion as is best depicted in the simplified illustrations of FIGS. 8–10. A portion of the board 54 (FIG. 8) is shown having contact points 58*a*, 58*b*, 58*c* and 58*d*. A pair of lands 70 interconnect points 58*a* and 58*b*, and points 58*c* and 58*d* respectively. Manifestly, if the continuity, for example, of the lands 70 is to be tested, connections must be made to the contact points 58*a*–58*d*.

A corresponding portion of the transition plate 56 (bottom side) is shown in FIG. 9. The contact pads 62*a*, 62*b*, 62*c* and 62*d* are arranged in the same pattern as the contact points 58*a*–58 and, when the transition plate 56 and the board 54 are in proper register, the pads 62*a*–62*d* will directly overlie and engage the corresponding points 58*a*–58*d*. The array of crosses 74 shown on the transition plate 56 in FIG. 9 represent contact locations having the same planar coordinates as certain of the spring pins 46 depending from the matrix box 32. In other words, with the transition plate 56 and the board 54 in register and properly positioned on the platen 28, these contact locations 74 comprise vertical projections of the axes of the overlying spring pins 46.

The top side of the same portion of the transition plate 56 is shown in FIG. 10. It may be seen that the contact pads 62*a*–62 extend completely through the baseplate 60 and are electrically connected with corresponding upper contact pads 64*a*–64. Each of the pads 64*a*–64*d* is centered on a different one of the contact locations 74 and thus serves to effect coordinate conversion by virtue of a transition land 76 interconnecting each of the pairs of pads 62*a*, 64*a*; 62*b*, 64*b*; 62*c*, 64*c*; and 62*d*, 64*d* respectively. It is now possible to gain access to the contact points 58*a*–58*d* of the board 54 at four contact locations 74 having planar coordinates that are the same as those of four of the spring pins 46. In effect, therefore, as illustrated by the pattern of contact locations 74 shown in FIG. 8 on the board 54, the contact points 58*a*–58*d* are transferred from their random positions to four of the predetermined locations 74. By virtue of the nature of their respective functions, the top pads 64 are hereinafter at times referred to as the coordinate conversion pads, while the bottom pads 62 are at times referred to as the intermediate pads.

FIG. 7 is a greatly enlarged, fragmentary view illustrating the coordinate conversion action of the transition plate interface 56. The intermediate pad 62 is shown directly overlying the corresponding contact point 58 from which one of the lands 70 extends along the circuit board 54. In etching the top side of the baseplate 60 of the transition plate interface 56, a copper segment 80 aligned with the pad 62 is left on the top side of the baseplate 60 in order to provide a means of establishing electrical continuity through the thickness of the baseplate 60. This is done by drilling a hole through the baseplate 60 in alignment with the centers of the pad 62 and the segment 80. The opening 82 thus formed is plated with a conductive substance 84 such as copper so that, as illustrated, the pad 62, the segment 80 and the intercommunicating plating 84 in effect become an integral conductive body. If the pad 62 happened to be positioned at or near a coordinate location corresponding to one of the spring pins 46, then the transition land 76 would not be required (this condition is illustrated for a number of segments 80 in FIG. 5). However, where a substantial change in coordinate location must be effected as illustrated in FIG. 7, the coordinate conversion pad 64 is positioned at an adjacent spring pin coordinate location and electrically connected to the segment 80 (and hence the intermediate pad 62) by the transition land 76.

In the practice of the present invention, a transition plate interface is made for every artwork pattern which it is desired to accommodate, but the matrix of spring pins 46 is utilized to provide access to the contact points of all circuit boards. In the case of multilayer boards, a different transition plate interface would be utilized to provide access to the contact points of each of the laminae for testing prior to assembly. Once assembled into a multilayer board, one or more interfaces would then be utilized to test the composite board. Testing after assembly is desired since, during the pressing operation required

in uniting the laminae, a land may break or short to another land or metal chips from drilling may become trapped within the assembly and cause shorting.

Access to the boards is rapidly achieved through the use of the fixture 20. The board under test and its associated interface are positioned in mutual register on the platen 28, the latter being provided with suitable register marks, guides or the like (not shown) for assuring registration of the coordinate conversion pads of the interface with the planar coordinate system of the spring pin matrix. The pneumatic piston and cylinder assembly 30 is then actuated to shift the platen 28 vertically until the coordinate conversion pads are brought to bear against the spring pins 46 and the latter partially compress the springs 52. The platen 28 is then left in a stationary, elevated position during the testing program. The elevated position of the platen 28 is best illustrated in FIG. 3 where a portion of a row of spring pins 46 are shown in engagement with corresponding pads 64 of the transition plate interface 56. An automatic circuit analyzer for conducting insulation and continuity resistance tests, for example, is connected to the spring pins 46 via the connector panel 42 at the rear of the matrix box 32.

FIG. 11 is an equivalent schematic of the circuit involved in resistance measurement, superimposed upon a diagrammatic representation of the structural elements of the circuit. The conditions depicted in FIG. 11 are representative of those between any pair of spring pins 46. The resistance of the land 70 on the board 54 is to be checked, its resistance being represented by R_5. R_1 and R_1' are the pin-to-pad contact resistances of the two spring pins 46 and respective underlying pads 64. R_2 and R_2' are the resistances of the two transition lands 76. R_3 and R_3' are the resistances of the plating 84 through the holes in the baseplate 60. R_4 and R_4' are the butt contact resistances of the intermediate pads 62 and respective contact points 58.

In actuality, as may be seen in FIG. 5, the transition lands 76 are significantly shorter and wider than the lands 70 of the board 54. Thus, it may be assumed that R_2 and R_2' are negligible. Furthermore, since the distance between each segment 80 and its associated intermediate pad 62 is only the thickness of the baseplate 60, the resistances R_3 and R_3' may also be considered to be negligible. This leaves R_1, R_4, R_4', and R_1' as the major series resistances in the circuit between the two spring pins 46, other than the unknown resistance R_5 of the land 70 to be checked. Since these remaining resistances are all attributed to the resistance between the various contact structures of the series circuit, their significance may be significantly reduced by plating the copper pads of the transition plate interface 56 with a suitable contact material such as gold, and assuring that the relative positions of the platen 28 (when elevated) and the matrix box 32 are such as to cause uniform deflection of the pins 46 against their springs 52 to an extent to establish solid electrical contact. The terminals 86 in FIG. 11 electrically connected to the spring pins 46 represent connections to suitable testing instrumentation such as an automatic circuit analyzer.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. Apparatus for making temporary electrical connections to a multiplicity of electrical contact points on a printed circuit board or the like having said contact points arranged in an irregular planar pattern peculiar to a particular type of such boards or the like, said apparatus comprising:

a set of contact elements including a number thereof at least as great as said multiplicity but arranged in a fixed, regular, planar, matrix pattern different from said pattern of said contact points and having predetermined coordinates in the plane of said set;

a coordinate conversion interface comprising a baseplate of insulating material having a pair of opposed sides, a first array of contact pads on one of said sides including a contact pad for each of said contact points respectively and arranged in said irregular pattern peculiar to said type, and a second array of contact pads on the other of said sides including a contact pad for each of the contact pads of said first array but arranged in said regular pattern, each of said contact pads of said first array being electrically coupled with a corresponding contact pad of said second array, each of the contact pads of first array being positioned for conductively engaging a corresponding contact point of said board or the like, each of the contact pads of said second array being positioned for conductively engaging a corresponding contact element;

support means spaced from said contact elements and relatively shiftable with respect to the latter for receiving said circuit board or the like and said interface in superimposed relationship to each other with the contact pads of said first array in conductive engagement with corresponding contact points of said circuit board or the like and the contacts of said second array facing said contact elements; and

means for relatively shifting said contact elements and said support means to move the contact pads of said second array into conductive engagement with the contact elements of like coordinates, whereby to establish electrical continuity between each of said contact points and an individual contact element.

2. Apparatus as claimed in claim 1, said interface having means extending through said baseplate thereof electrically interconnecting corresponding contact pads of said first and second arrays.

3. Apparatus as claimed in claim 2, said interconnecting means including a transition land on said other side extending between each interconnected pair of contact pads which are substantially out of alignment.

4. Apparatus as claimed in claim 1, said matrix pattern arrangement disposing said contact elements on the intersections of a uniform rectangular grid.

5. A method of making temporary electrical connections to a multiplicity of electrical contact points on a printed circuit board or the like having said contact points arranged in an irregular planar pattern peculiar to a particular type of such boards or the like, said method comprising the steps of:

a. providing a set of connection locations including a number thereof at least as great as said multiplicity but arranged in a fixed, regular, planar, matrix pattern different from said pattern of said contact points and having predetermined coordinates in the plane of said set;

b. disposing said board or the like in spaced relationship to said set of connection locations with the plane of said contact points parallel to the plane of said connection locations;

c. interposing between said board or the like and said connection locations a pair of spaced, parallel, relatively fixed, planar arrays of contact pads with the planes of said arrays substantially parallel to the planes of said contact points and said connection locations, the first of said arrays including a contact pad for each of said contact points respectively and arranged in said irregular pattern peculiar to said type, the second of said arrays of contact pads including a contact pad for each of the contact pads of said first array but arranged in said regular matrix pattern, each of said contact pads of said first array being electrically coupled with a corresponding contact pad of said second array;

d. moving said arrays jointly to align the contact pads of said first array with said contact points and to align the contact pads of said second set with said connection locations; and

e. relatively moving said board or the like, said arrays of contact pads and said connection locations in the direction perpendicular to their planes to bring the same together with each contact pad of said first array thereof electrically contacting a corresponding contact point of said board or the like and each contact pad of said second array thereof electrically contacting a corresponding connection location,

6. A coordinate conversion interface for use in making temporary electrical connections to a multiplicity of electrical contact points on a printed circuit board or the like having said contact points arranged in an irregular pattern peculiar to a particular type of such board or the like from a set of contact elements arranged in a fixed, regular, planar pattern different from said pattern of said contact points and having predetermined coordinates in the plane of said set, said interface comprising:

a baseplate of insulating material having a pair of opposed, substantially parallel sides and adapted to be interposed between said board or the like and said set of contact elements, said baseplate having openings therein communicating said sides of the baseplate and extending through the contact pads of said first array;

a first array of electrically conductive contact pads on one of said sides of said baseplate including a contact pad for each of said contact points respectively and arranged in said irregular pattern peculiar to said type;

a second array of electrically conductive contact pads on the other side of said baseplate including a contact pad for each of the contact pads of said first array but arranged in said regular pattern, each of said contact pads of said first array being electrically coupled with a corresponding contact pad of said second array,

the contact pads of said first array each being adapted to conductively engage a corresponding one of said contact points while each of the contact pads of said second array is conductively engaging a corresponding contact element; and

means extending through said baseplate electrically interconnecting corresponding contact pads of said first and second arrays, said interconnecting means including an electrically conductive plating on the baseplate within said openings and electrically connected to respective contact pads of said first array.

7. A coordinate conversion interface for use in making temporary electrical connections to a multiplicity of electrical contact points on a printed circuit board or the like having said contact points arranged in an irregular pattern peculiar to a particular type of such board or the like from a set of contact elements arranged in a fixed, regular, planar pattern different from said pattern of said contact points and having predetermined coordinates in the plane of said set, said interface comprising:

a baseplate of insulating material having a pair of opposed, substantially parallel sides and adapted to be interposed between said board or the like and said set of contact elements;

a first array of electrically conductive contact pads on one of said sides of said baseplate including a contact pad for each of said contact points respectively and arranged in said irregular pattern peculiar to said type; and

a second array of electrically conductive contact pads on the other side of said baseplate including a contact pad for each of the contact pads of said first array but arranged in said regular pattern, each of said contact pads of said first array being electrically coupled with a corresponding contact pad of said second array,

said contact elements and conductive pads of said second array both being arranged in the same matrix pattern disposing said elements at the intersections of a uniform rectangular grid and the contact pads of said second array at the intersections of a similar uniform rectangular grid,

the contact pads of said first array each being adapted to conductively engage a corresponding one of said contact points while each of the contact pads of said second array is conductively engaging a corresponding contact element.

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