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(54) ELECTRICAL INTERCONNECTOR APPARATUS

(71) We, INTERNATIONAL BUSINESS MACHINES CORPORATION, a Corporation organized and existing under the laws of the State of New York in the United States of America, of Armonk, New York 1504, United States of America do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to electrical interconnector apparatus.

In electronic packaging, it is often desirous to interconnect one electrical device, e.g. a circuit module or chip, to another electrical device, e.g. a printed circuit board, by means of an interconnector. By way of example, there is described in the publication entitled "Connector Interposed For Module-To-Board Electrical Interconnection", R. L. Agard et al, IBM Technical Disclosure Bulletin, Vol 15, No. 3, August 1972, page 912, a planar interconnector which uses metallized through-holes for making connection between the pins of a circuit module mounted on top of the interconnector and the connector pins of a printed circuit board located beneath the interconnector. Also, for example, in the publication entitled "Low-Noise Interconnection System For Monolithic Modules", L.T. Olson, IBM Technical Disclosure Bulletin, Vol. 9, No. 4, September 1966, page 360, interconnection of monolithic modules is effected by a planar interconnector.

The invention provides electrical interconnector apparatus, comprising a block, sheet or lamina of electrically insulating material having a first set of terminals connected to a first pattern of printed circuit conductors on one side of the block, sheet or lamina and a second set of terminals connected to a second pattern of printed circuit conductors on the other side of the block, sheet or lamina, and a multiplicity of severable discrete conductor elements forming a third pattern of conductors interconnecting the first and second patterns of conductors so that by severing predetermined selected ones of the elements the first and second terminals are electrically interconnected in a predetermined relationship only through the remaining unsevered conductor elements.

The invention will now be fully described by reference to examples of electrical interconnector apparatus embodying the invention and illustrated in the accompanying drawings, in which:—

Figure 1 is a perspective and partially exploded view illustrating a preferred embodiment of apparatus embodying the invention;

Figure 2 is a perspective and exploded view, partially broken away, of the embodiment of Figure 1;

Figure 3 is a more detailed partial perspective view of the embodiment of Figure 1;

Figure 4 is a side elevation view of one modular section of the embodiment of Figure 1 taken along line 4-4 of Figure 2.

Figure 5 is a partial side elevation of another embodiment of the invention; and

Figure 6 is a perspective schematic view of still another embodiment of the invention.

In the Figures, like elements are designated with similar reference characters.

Referring to Figures 1-4, interconnection between a circuit module device 1 having pin terminals 2 and a circuitized assembly such as a printed circuit board device 3 having printed circuit conductor pattern 4 is provided by electrical interconnector apparatus, that is interconnector 5. Board 3 is preferably a multilayer printed circuit board. As partially shown schematically in Figure 3, board 3 has appropriate contact pads 4a, via holes 4b and terminal contacts 4c. Interconnector 5 is formed of discrete laminate members arranged in plural identical modular sections 5A, 5B, etc.

Each of the sections 5A, 5B, etc., has a lamination 6 which includes a printed circuit substrate 7 with first and second predetermined printed circuit conductor patterns 8, 9 that are disposed on its opposite planar surfaces or sides, cf. for example, section 5B shown in greater detail in Figures 2 and 4. By way of example, the individual conductors of pattern 8 are configured with identical S-like shapes across the side of substrate 7, as shown in Figure 2. Again by way of example, the individual conductors of pattern 9 are configured with identical elongated shapes running from the top to the bottom edges of substrate 7, cf. Figure 4. By way of further example, each of the conductors of pattern 8 is aligned with one of the con-

ductors of pattern 9, hereinafter referred to sometimes as an aligned pair.

Severable conductor means 10, 10', which preferably are also printed circuit conductors formed concurrently with patterns 8 and/or 9 in a wrap-around manner, connect the patterns 8, 9 across at least one laminar edge of lamination 6 at predetermined locations. In the embodiment of Figure 1, for sake of simplicity, the conductors 10, 10' are symmetrically disposed across the top edge of lamination 6. For the particular example of conductor patterns 8, 9, each of the conductors 10, 10' integrally connects, i.e. bridges, the two conductors of one of the aforementioned aligned pairs of conductors of patterns 8, 9. As hereinafter explained, the conductors designated 10' have been severed but are shown in phantom outline in Figure 2, for sake of clarity.

Interconnector 5 has contact means, e.g. the printed circuit conductor lands 11 shown in Figure 4 and/or the bifurcated spring connectors or receptacles 12 of which only one is shown in Figure 2 for sake of clarity. Lands 11 and connectors 12 are disposed along the bottom and top edges, respectively, of laminate 6. The pair of contact plates 12a, 12b of each connector 12 are symmetrically housed in one of the symmetrical recesses 13 formed inwardly from the top edge of laminate 6. The common stem portion 12c is affixed to the bottom land of the adjacent S-shaped conductor of pattern 8, for example, by a solder bond. The bottom edge of laminate 6 is also symmetrically and inwardly recessed to form inner legs 14. Each land 11 is aligned with the bottom edge of one of the conductors of pattern 9 and is preferably integrally formed therewith in a wrap-around manner. Thus, as shown in Figure 4, printed circuit conductors 8, 9, 10, 11 are integral. Receptacles 12 are coactable with the terminal pins 2 of pluggable module 1, and lands 11 are coactable, e.g. by solder bond, with conductor pads, e.g. pad 4a, that are part of the printed circuit conductor pattern 4 of board 3.

Each modular section of the embodiment of Figure 1 also includes a pair of lamination members 15, 16 that act as reference voltage, e.g. ground, planes for the conductor patterns 8, 9, respectively, of the particular member 6 that is interleaved between them. More particularly, each of the members 15, 16 has a dielectric substrate 17 of thickness t that supports an integral conductive layer 18. Members 15, 16 are oriented so that their respective conductive layers 18 face outwardly with respect to the particular member 6 with which they are associated, as shown in Figure 4. As is apparent to those skilled in the art, when the respective bare surfaces of substrates 17 of members 15, 16 of a particular section are placed in contacting relationship with the adjacent surfaces of intermediate member 6, the conductor patterns 8 and 9 thereof are in signal plane relationships with the respective

conductive layers 18 of members 15 and 16, respectively.

On each of the side edges of members 15, 16, as well as member 6, there is formed an integral leg or pedestal, for example, leg 17A of member 16 and leg 14A of member 6, Figure 2, to provide clearance for the printed circuit conductors of pattern 4 of the underlying board 3. The top edges of members 16, 17 are provided with integral extensions 17E. The extensions 17E are aligned in pairs. Each pair has one extension 17E from member 16 and one from member 15, the two members 15, 16 being associated with the same modular section. Each of the pair of extensions 17E in turn is aligned with one of the recesses 13 of member 6 of the particular section, thus enclosing the open sides of the particular recess 13 when the members 6, 15, 16 are assembled in the afore-described containing relationship.

Between adjacent modular sections, i.e. sections 5A and 5B, 5C, etc., an insulated spacer lamination member 19 is provided. Also, if desired, an identical member 19 may also be provided adjacent the respective outer faces of the first and last sections 5A and 5N, as shown in Figure 1. For purposes of explanation, it will be assumed that the pins 2 of device 3 have equal spacings S in the X and Y directions. Accordingly, each of the respective center spacings in the Y direction between adjacent recesses 13 for the same member 6 are substantially equal to S . Likewise, by judiciously selecting the thickness dimensions of members 6, 15, 16 and 19, an equal spacing S in the X direction between the centers of the corresponding aligned recesses 13 of the identical members 6 of adjacent modular sections is provided. Each of the members 19 are provided with integral legs or pedestals 19A, 19B which are in alignment with the corresponding respective legs, e.g. legs 14A, 17A, of members 6, 15, 16, so as to provide clearance for the printed circuit conductors of pattern 4 of board 3.

The interleaved spacer members 19 and adjacent sections, cf. for example, the spacer member 19 between sections 5B and 5C of Figure 3, are configured to form a wire raceway, duct or channel 20 in which insulated wire conductors, e.g. conductors 21, are run, if desired, to interconnect the printed circuit conductors of patterns 8 and 9 of members 6, as shown in Figure 3.

An insulator cover 22 having an array of openings 23 compatibly aligned with the array of openings formed by the tops of the recesses 13 fits snugly over the assembly of modular sections 5A-5N and spacer members 19, thus keeping the assembly in alignment. The assembly may also be secured together by suitable fasteners, not shown, such as screws, bolts, clamps, etc.

To program the connector 5, different predetermined ones of the connectors 10 are severed in accordance with the desired inter-

connection pattern. In Figure 2, by way of example, every other connector, i.e. those designated by the reference character 10' are severed by, for example, an abrading device.

5 Further programming may be provided by inter and/or intra-connecting via the aforementioned insulated wires, e.g. wire 21, predetermined ones of the upper lands of the conductors of pattern 8 and of those, not shown, of the conductors of pattern 9 on the reverse side, both of which are accessible via the recesses formed between extensions 17E. Moreover, further programming may be effected by removing predetermined one of the lands 11, e.g. by an abrading device. Thus, when the module 1 is plugged into interconnector 5 and the interconnector 5 has been affixed via its lands 11 to the pads 4A of board 3, the interconnector 5 provides interconnection between the devices 1 and 3 in the desired interconnected pattern.

10 It should be understood that the printed circuit members 6 preferably are each single layer members and all have identical patterns 8 and identical patterns 9. For sake of clarity and by way of example, in any given member 6 the constituent printed circuit members of pattern 8 are not integrally connected to any other of the constituent members of the pattern 8. The same is true for the constituent members of the pattern 9. However, as is apparent to those skilled in the art, the printed circuit members 6 may be multilayer members, and/or have one or more integrally connected constituent printed circuit conductors for at least one of the patterns 8, 9, and/or use via or plated through holes for interconnecting predetermined printed circuit conductors of one of the patterns 8, 9 on the member 6 with predetermined printed circuit conductors of the other pattern of the member, and/or use non-identical but predetermined different printed circuit pattern configurations for the member 6. By judiciously selecting the printed circuit design or configuration patterns 8, 9 and/or with the use of multilayer construction and/or of via holes for the member 6, cross over of its printed circuit conductors is facilitated. In addition, it should be noted that the interconnector 5 will thus enhance the crossover capability of the board 3.

15 In the embodiment of Figure 5, the partially shown electrical interconnector apparatus 5 thereof has adjacent modular sections 5A', 5B', etc. Each section has a discrete printed circuit conductor member 6' having printed circuit patterns, not shown, along its planar sides 8', 9'. For sake of explanation, member 6' is identically configured as member 6 of Figure 1. Each section also has a discrete ground plane member designated 16' with a conductive outer layer 18'. Again for sake of explanation, member 16' is identically configured as member 16 of Figure 1. The conductor pattern of side 9' of member 6' is in signal plane relationship with the ground plane

layer 18' of member 16' of the same section.

Between adjacent sections, there is provided a spacer member 19'. It has a dielectric constant and thickness, the product of which is substantially equivalent to the product of the corresponding parameters of the substrate of a member 16'. By way of example, the thicknesses t of the substrate member 16' and member 19' are illustrated as being substantially equal for the embodiment of Figure 5. As a result, member 19' in coaction with the layer 18' of a member 16' of one section, e.g. section 5C' interacts with the conductive pattern on side 8' of the member 16' of the preceding adjacent section, e.g. section 5B'. Thus, each section in embodiment 5' is also provided with two ground plane laminations, by the interaction of the particular members 16' and 19', adjacent to the sides 8', 9' of the interleaved member 6'. In other words, each ground plane lamination is common to two sections, viz. the section of which it is a part and the adjacent section.

20 In the embodiment of Figure 1, the interconnector 5 is shown as interconnecting only two devices 1, 3. As is apparent to those skilled in the art, the interconnector can be expanded in its X and/or Y directions to accommodate more devices, i.e. device 1. In addition, the vertical laminar edges of the interconnector 5 can be expanded and provided with severable connector means and recesses for accommodating receptacles in a similar manner as the recesses 13 and receptacles 12 are provided at the top laminar edge, thus allowing more pluggable devices 1 to pluggably mounted to the interconnector along its laminated expanded vertical sides. By way of example, there is shown in Figure 6, an embodiment of an interconnector 50 having 3x3 arrays of pluggable modules 100 mounted through a cover 220 to the top and side laminar edge faces 51, 52, 53 of the interconnector 50. Insulator cover 220 is provided with an array of openings, not shown, compatible to the pin array of the modules 100. The bottom face of the interconnector 50 is interconnected to a multilayer printed circuit board 300 in a manner similar to the interconnection of the connector 5 to board 3 of Figure 1.

25 The interconnectors described herein may be modified to include several interconnection patterns in a single unit. Thus, each device of combination of devices to be interconnected has several optional predetermined mounting positions on the interconnector, at any one of which the particular device is connected to a different interconnection pattern. By way of example, there is shown in phantom outline in Figure 6 one of the devices 100 designated by the reference number 100' that is mounted in an optional position by which it is interconnected to another interconnection pattern of the interconnector 50.

As shown, connectors 12 are discrete components solder bonded to the conductors 8. In

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lieu thereof, printed circuit spring connectors may be integrally formed with the conductor patterns 8, 9, the contact faces being parallel to the planar sides of the substrate 7.

5 Preferably, each of the conductive layers 18, 18' is a continuous and integral member which covers the particular surface of its associated substrate 17. However, it should be understood that one or more of the conductive layers may be severed so as to form two or more electrically isolated sections on the substrate 17 so that different reference voltage levels may be applied to the different severed sections.

10 In certain applications such as where impedance matching and *rf* shielding are not critical, the reference voltage plane members may be obviated, if desired.

15 Moreover, the spacer members 19 may be configured to house discrete electrical components which are part of the associated circuitry and which are, for example, termination resistors, decoupling capacitors, diodes, transistors and the like. By way of example, the member 19 may be moulded into a planar configuration which encompasses or includes the electrical components in a manner apparent to those skilled in the art.

20 The interconnector described herein with reference to Figures 1 to 4 provides increased versatility, programmability, and/or microstrip and *rf* shielding constructability. Moreover, engineering changes can be readily made by severing the accessible bridge connectors, e.g. connector 10, and/or making connections with the insulated wire conductors, e.g. conductor 21, and/or positioning the pluggable devices to the various optional mounting positions. These engineering changes, moreover, can be accomplished in the field.

25 WHAT WE CLAIM IS:—

30 1. Electrical interconnector apparatus, comprising a block, sheet or lamina of electrically insulating material having a first set of terminals connected to a first pattern of printed circuit conductors on one side of the block, sheet or lamina and a second set of terminals connected to a second pattern of printed circuit conductors on the other side of the block, sheet or lamina, and a multiplicity of severable discrete conductor elements forming a third pattern of conductors interconnecting the first and second patterns of conductors so that by severing predetermined selected ones of the elements, the first and second terminals are electrically interconnected in a predetermined relationship only through the remaining unsevered conductor elements.

35 2. Apparatus as claimed in Claim 1, in which the third pattern of conductors comprise printed circuit conductors on and edge of the block, sheet or lamina.

40 3. Apparatus as claimed in Claim 1 or 2, in which the first set of terminals comprise an array of sockets to receive pins on an electrical device to be energised through the intercon-

ductor apparatus.

4. Apparatus as claimed in Claim 1, 2 or 3, in which the second set of terminals comprise an array of pads to register with a like array of pads on an electrical supply board.

5. Apparatus as claimed in Claim 1, 2, 3 or 4, further comprising two sheets of dielectric material between which the aforesaid slab, sheet or lamina is sandwiched and the outer faces of which are respectively clad with conducting layers to form signal ground planes.

6. Apparatus as claimed in Claim 5, comprising a multiplicity of modular sections each comprising a slab, sheet or lamina sandwiched between two sheets of dielectric material, as aforesaid, the sections being disposed in side-by-side relationship and being separated from one another by insulating members.

7. Electrical interconnector apparatus for interconnecting the terminals of two electrical devices, said apparatus comprising at least one block, sheet or lamina having first and second predetermined printed circuit conductor patterns on opposing first and second planar sides of said block, sheet or lamina, severable printed circuit conductor means connecting said first and second predetermined patterns at predetermined locations across at least one edge of said block, sheet or lamina and contact means adapted to be connectable to the terminals of said electrical devices, said contact means comprising contacts coupled to predetermined ones of the printed circuit conductors of at least one of said first and second patterns.

8. Electrical interconnector apparatus as claimed in Claim 7, further comprising first and second reference voltage plane laminations disposed adjacent said first and second conductor patterns being in signal imaging relationships with said first and second reference voltage plane laminations, respectively.

9. Electrical interconnector apparatus as claimed in Claim 8, in which each of said reference voltage plane laminations comprises a planar dielectric substrate with one side having a conductive layer disposed therein.

10. Electrical interconnector apparatus as claimed in Claim 7, 8 or 9, in which said first device is a pluggable circuit module having pins as said terminals thereof and said second device is a printed circuit board having a predetermined circuit conductor third pattern including printed circuit contact pads as said terminals thereof, some of said contact means comprising terminal sockets disposed along a first edge of said block, sheet or lamina and arranged to receive said pins, and others of said contact means further comprising printed circuit lands disposed along a second edge of said block, sheet or lamina, said lands being arranged to register with said contact pads of said printed circuit board.

11. Electrical interconnector apparatus substantially as hereinbefore described with reference to and illustrated in Figures 1, 2, 3 and 4,

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of the accompanying drawings.

12. Electrical interconnector apparatus as claimed in Claim 11, in combination with two electrical devices each substantially as hereinbefore described with referent to and illustrated in Figures 1 to 4 of the accompanying drawings.

stantially as hereinbefore described with reference to and illustrated in Figure 5 or Figure 6 of the accompanying drawings. 10

13. Electrical interconnectors apparatus sub-

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COMPLETE SPECIFICATION

3 SHEETS

This drawing is a reproduction of
the Original on a reduced scale
Sheet 1

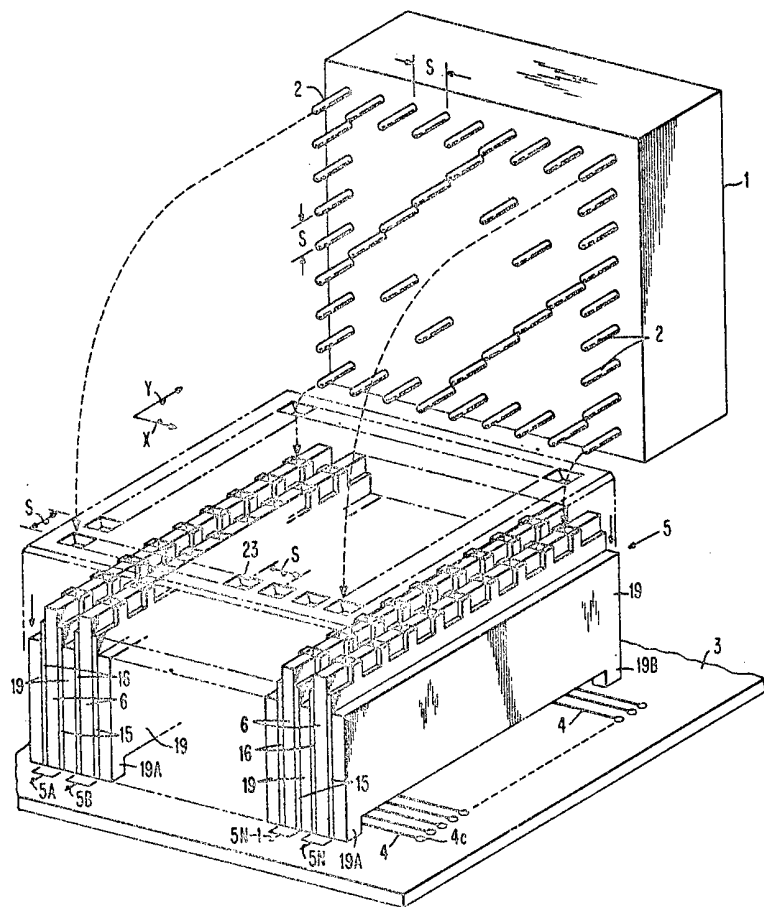


FIG. 1

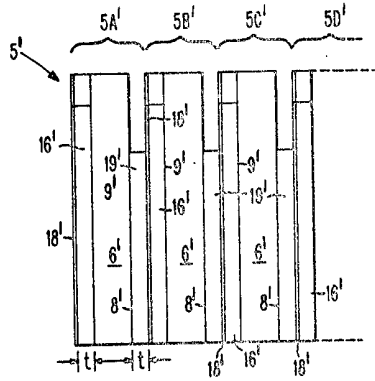


FIG. 5

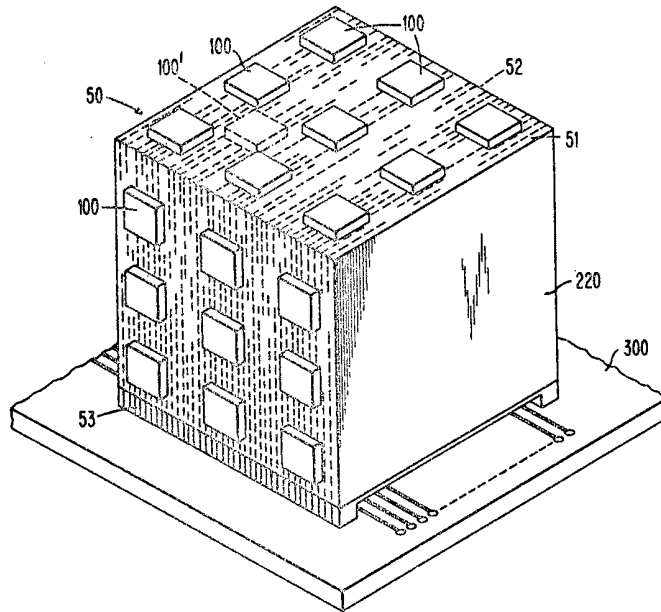


FIG. 6