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# (54) Method for selective metallization of plastic connectors

(57) Method for selective metallization of a plastic connector comprising the steps of:

a. depositing a first, electroless metal layer of a first predetermined thickness on the surface of the connector;
b. ablating predetermined parts of said first metal layer to produce at least two electrically separate metal layer areas;
c. depositing a second, galvanic metal layer of a second predetermined thickness to at least one selected metal layer area;
d. removing any non-selected metal layer area.

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## Description

The present invention relates to a method for selective metallization of plastic connectors.

In the past years connector manufacturers have become increasingly aware of customer demands for higher I/O requirements using SMT while signal clock speed has increased. Simultaneously the drive towards miniaturization in all electronic segments is forcing designs to focus on new techniques to resolve other issues related to signal integrity such as shielding, grounding, mutual coupling cross-talk and signal reflection parameters. Electronic devices are becoming portable and are subsequently exposed to varying environments, and issues of noise suppression due to electromagnetic interferences (EMI) and electrostatic discharged (ESD) are of major concern for designers and users of electronic devices. Connectors play a key role for connection within electronic devices, but also to couple one device to another. In addition to fast-paced advances in electronic technology, transitions are being noticed from analogue signals to faster speed digital technology; simultaneously the operating voltages are being lowered for increased power efficiency - a trend that makes it more difficult to institute measures to suppress interfering noise emissions including EMI and ESD. Digital equipment is intrinsically vulnerable to noise; it also is prone to emit noise.

In order to maintain signal integrity in high-speed applications noise countermeasures have to be taken on different levels. First of all, connections have to be made between on-board grounding and frame-grounding points to provide overall good grounding. Secondly, shielding will have to be provided on cabinets besides establishment of a proper connection between connector casings and cable's woven metal sheaths, in order to reduce interference noise emission. Thirdly, filter elements may be used in series with signal lines, in order to reduce line-carried noise interferences. Fourthly, special wiring techniques may be used in order to reduce cross-talk between adjacent signal lines within cables or within cabinets.

Commonly current connector designs need to be enhanced to fit their application in modern electronic circuitry. Shielding and grounding facilities are required and designs need adaption.

Figure 1a to 1f show different connector configurations, known as such, each having its own range of application.

Figure 1a represents a conventional lower frequency application in which a connector 1 comprises several, e.g. 7, adjacent signal contact members 2. There is mutual coupling between adjacent signal contact members 2 and signal integrity may not be a concern.

As frequency increases, more grounding will be required as shown in figures 1b and 1c. In figure 1b connector 1 comprises six signal contact members 2 and one ground contact member 3 at an arbitrary location. By varying the location of the ground contact member 3 mutual inductance and capacitance to ground may be varied. Locating, for instance, the ground contact member 3 in the middle of the connector 1 would reduce the electrical loop length and would somewhat improve the performance.

In the embodiment of figure 1c connector 1 comprises several signal contact members 2 and several ground contact members 3. The signal contact members 2 and ground contact members 3 alternate. Thus, the loop length is significantly reduced. There is less coupling via mutual impedance, and noise suppression with improved signal transmission is established. Such a configuration is easily achieved with conventional connectors by appropriate rooting and pole assignments. This does, however, imply a reduction of the number of signal contact members 2 in the connector 1, which reduces I/O density.

In figure 1d connector 1 comprises seven adjacent signal contact members 2 and a ground plane 4 at one of its side surfaces. The ground plane 4 may be a metal plate, whereby the loop length can be further reduced. This then, can be a means of achieving further electrical enhancement of the connector 1 for the digital transmission of signals with a larger number of signal pins. In addition, the ground plane 4 is a better barrier to suppress unwanted stray EMI noise emitted from components adjacent to the connector.

Figure 1e shows connector 1 with seven adjacent signal contact members 2 and a further ground plane 5 at a side surface of connector 1 opposite to ground plane 4, thereby further improving the high speed electrical performance.

As shown in figure 1f the connector 1 can be entirely enclosed by a shielding 6 which is similar to a Faraday cage and shields the signal contact members 2 from any outside electromagnetic radiation.

It is noted that in the configurations of figures 1d to 1f one or more of the signal contact members 2 may be substituted by a ground contact member 3 to reduce cross-talk between the signal contact members 2. However, this results in a lower I/O density.

Figure 2 shows a chart developed to compare multi-row connection structures in terms of anticipated high-speed performance, in the context of high I/O and miniaturization needs. The chart is based on conventional knowledge in the field. In the bottom row of the chart according to figure 2 several connector configurations are schematically depicted. In the three rows above the bottom row the performance of each of these connector configurations as regards cross-talk, impedance matching, and signal density mounting is indicated by symbols explained under the chart. Clearly, coaxial connectors out-perform other configurations. However, they are expensive and in general they do not satisfy the drive towards miniaturization and the need for connector modularity and systems approach. Pseudo-coaxial and electrically enhanced ground-planes are effective means in most modern electronic circuitries.

In figure 2 the first connector configuration shown relates to a 1:1 arrangement of alternating signal contact members and ground contact members. Of course, the arrangement may have another ratio, as shown in figure 3. However, by increasing the ratio of signal contact members to ground contact members the transmission performance will be reduced.

As shown by figures 1d to 1f the electrical performance of connectors for higher frequencies is enhanced by shielding at least selected parts of the connectors.

In order to shield (selected parts of) connectors several methods have already been proposed.

US Patent 4,600,480 discloses a method to selectively plate a connector comprising the steps of providing an electroless metal layer over all of first selected surfaces, and electroplating the first selected surfaces twice. Second selected surfaces are not plated by the electroplating step. However, this known method will only work under various specific conditions. As long as the first and second selected surfaces are subjected to the same external conditions the known method is not able to distinguish the first from the second selected surfaces and, therefore, under those conditions no selective metallization will be established. Moreover, no sharp transitions between the first and second selected surfaces can be expected by this known method.

Another method of selectively plating connectors is known from US Patent 5,141,454. In this known method first selected surface areas are chemically roughened, creating micropores which function as anchor sides for plating. Those parts of the surface of the connector not being chemically roughened will not be suitable for plating in the next step in which electroless plating is used to build conductive layers on the chemically roughened surface areas of the connector. Typically copper is applied to render a conductive base surface. Said base surface may be further metallized by electroless, electrolytic or emersion plating techniques. Applicable metals include nickel, tin, silver, palladium and gold. However, since the distinction between those surface areas which are plated and those which are not is made by a chemically roughening process the accuracy of the transition between the plated and unplated surface area on the connector is limited.

Selective metallization of plastic elements is also known from the leaflets: "Mitsui-Pathtek Process Type" (6/90) from Mitsui-Pathtek Corporation and: "Elite; Molded Circuit Interconnects" from Du Pont. However, the processes to separate plated parts from not plated parts as described in these leaflets are based on chemical etching which my not always result in as sharp transitions as required.

Selective plating of connector elements may also be done by sputtering techniques, as e.g. disclosed by US Patent 4,932,888 or by the application of conductive ink, as disclosed in US Patent 4,846,724. However, neither of these latter techniques leads to very accurate transitions between those parts being plated and those parts being not plated.

Since more accuracy between separating plated parts and not plated parts of connectors is an essential element for further miniaturization of connectors, very accurate separating techniques are needed.

A very accurate separation between different metal surface areas on a printed circuit board is disclosed by Japanese patent application 54.67690, which discloses the use of light beams, laser beams or electron beams to separate an integrally made conductive metal layer on a substrate into several conductive metal lines.

G.K.H. Schammler, and others, "Comparison of the metallization of chemically and laser-etched structures in BPDA-PDA polyimide", IEEE Transactions on components, hybrids, and manufacturing technology, Vol. 16, Nr. 7, November 1993, pages 720-723, shows that the use of laser ablation may lead to very steep side walls of vias, which are filled with electroless copper.

Neither Japanese patent application 54.67690 nor G.K.H. Schammler suggest how to use high energy beams or the like to manufacture selectively metallized plastic connectors.

The object of the present invention is to provide a method for selective metallization of connectors by which a very accurate distinction between plated and not plated surface areas can be obtained.

Therefore, the method for selective metallization of a plastic connector according to the invention comprises the steps of:

a. depositing a first, electroless metal layer of a first predetermined thickness on the surface of the connector;

b. ablating predetermined parts of said first metal layer to produce at least two electrically separate metal layer areas;

c. depositing a second, galvanic metal layer of a second predetermined thickness to at least one selected metal layer area;

d. removing any non-selected metal layer area.

The present invention is based on the insight that the use of means to ablate one or more very small traces of an integrally made metal layer on a connector, by which traces several metal layer areas on the connector surface are established which are no longer electrically interconnected may result in, very accurate transitions between plated and not plated surface areas on the connector.

In order to ablate said traces from said metal layer on the connector a high energy beam may be used which is selected to be one of the following particle beams: an electron beam or ion beam. However, alternatively, also a light beam or a laser beam may be used. As a further alternative, the ablating step may be carried out by grinding, e.g. by any suitable, high precision abrasive stream of particles.

Removal of the non-selected metal layer areas as defined in step d. above may be done by chemical etching or by grinding.

When a light beam or a laser beam is used the diameter of the high energy beam may be about 75 µm.

The first metal layer may comprise electroless copper or nickel. The first thickness may be between 1 to 2 µm.

The second metal layer preferably comprises galvanically deposited copper.

The second thickness preferably is between 5 to 10 µm.

Step a. defined above may be preceded by immersing the connector in an alkaline bath to roughen its surface in contact with said bath.

If desired, step d. defined above, may be followed by e. depositing a top coat finish layer on said second copper layer, selected to be one of the following group of metals: nickel, gold, or tin-lead.

Said finish layer may have a thickness between 2 to 4 µm.

In one embodiment of the method according to the invention

- said connector comprises at least one cavity extending from a first side to a second side;
- step b. comprises the step of ablating predetermined parts of said first metal layer on contours around the cavities on said first side and in further contours around the cavities on said second side in order to produce metal layer areas within each cavity, which are electrically separated from at least one metal layer area outside each cavity;
- step c comprises depositing a second, galvanic metal layer of said second predetermined thickness to the at least one metal layer area outside each cavity, and
- step d. comprises the step of removing the metal layer areas within each cavity.

By this latter method a selectively metallized connector is obtained wherein all signal contact members are shielded against external electromagnetic radiation.

The proposed method offers great flexibility since metallized and not metallized parts of the connector surface may be separated by ablating traces of a first, very thin metal layer on the connector surface and these traces may have any predetermined contour.

The invention will now be explained in greater detail by reference to some drawings, in which the method according to the invention is explained in general and in one specific embodiment. This specific embodiment is just meant to show one way of using the method according to the invention and is not meant to restrict the shapes of metallized and not metallized surface areas on a connector.

Figures 1a to 1f show various connector configurations known from the prior art, in which shielding and/or grounding enhances connector performance.

Figure 2 shows a chart based on knowledge in the field and in which several connector configurations are compared as to several electrical characteristics.

Figure 3 shows some more possible connector configurations besides the ones shown in figure 2.

Figures 4a to 4f show selective plastic metallization process steps according to the invention.

Figures 5a to 5f show application of the process according to the invention to one specific connector.

Figure 4 shows the subsequent steps according to the present invention. In step 1 (figures 4a and 4b) an electroless metal layer 11 of a first predetermined thickness is deposited on the surface of a connector 10. The electroless metal layer 11 is preferably of copper, whereas the thickness of electroless metal layer 11 is preferably between 1 to 2 µm.

In step 2 one or more predetermined traces 12 are ablated from the first metal layer 11 to produce at least two electrically separate metal layer areas 11a, 11b. The ablation of traces 12 from metal layer 11 may be done by an electron beam, an ion beam, a light beam, a laser beam, or any other high energy beam. It is envisaged that also grinding by sand-blasting or ice-blasting, or the like, may be applied to make the traces 12. These traces 12 surround the separate metal layer areas 11a, 11b, in a predetermined way in order to have isolated metal layer areas 11a, 11b.

In the third step (figure 4d) a second metal layer of a second predetermined thickness is galvanically deposited on selected metal layer area 11b and not on metal layer area 11a. This can be easily achieved by emersion of the intermediate product of figure 4c in an electrolyte and applying a negative voltage to selected area 11b and not to area 11a. Then additional copper 13 of, for instance 5 to 10 µm, may be deposited on selected metal layer 11b, whereas not selected metal layer area 11a remains unchanged in thickness to its initial thickness of 1 to 2 µm.

In the next step (figure 4e) the product obtained is subjected to selective removal of the unchanged metal layer areas 11a. This may be done by emersion of the product obtained after the preceding step in figure 4d in an etch bath, long enough to etch at least 2 µm of copper. After that step, in which also some of the galvanically deposited copper layer 13 on the selected metal layer area 11b will be etched, still enough of the galvanically deposited copper layer 13 remains.

If required, as shown in figure 4f, a finishing layer 14 to protect the galvanically deposited copper layer 13, may be applied to layer 13. Finishing layers of other suitable metals, like gold or tin-lead, may be applied alternatively. Preferably, the finishing layer 14 has a thickness of 2 to 4 µm.

The removal of the metal layer area 11a (figure 4e) may be done by any suitable method: instead of a chemical etching process indicated above also grinding may be used.

When a laser beam or a light beam as a high energy beam is used, the diameter of the cross-section of the traces 12 may be as small as 75 µm.

It is not necessary to start with electroless copper as a first layer; instead, electroless nickel may be used as well. The galvanically deposited metal layer 13 may be made of any suitable metal.

The step of depositing electroless copper layer 11 (figure 4b) may be preceded by immersing the connector 10 in an alkaline bath to roughen the connector's surface in contact with said bath. Thus, micropores may be obtained which enhance the contact strength between the electroless copper layer 11 and the connector 10.

Figures 5a to 5f show the application of the method according to figures 4a to 4f to a connector body in order to yield a shielded connector body. Figure 5a shows the surface of connector 10 which may be chemically roughened in a first step. However, this step may be omitted.

In the second step (figure 5b) the electroless copper layer 11 is deposited on the surface of connector 10.

In the second step traces 12 are ablated from the electroless copper layer 11 to obtain first metal layer area 11a and second metal layer area 11b. The first metal layer area 11a covers the inside surfaces of all cavities 15 of connector 10, which cavities 15 are intended to accommodate suitable contact members (not shown) afterwards. The second metal layer area 11b covers roughly the outside surface of connector 10. First metal layer are 11a and second metal layer area 11b are electrically separated by traces 12.

In the next step (figure 5d) a galvanically deposited copper layer 13 is applied to the second metal layer area 11b according to the process step described above in accordance with figure 4d. The first metal layer are 11a remains unchanged. In the process step according to figure 5e the first metal layer area 11a covering the inside surfaces of the cavities 15 is removed, e.g. by chemically etching. By that etching step the thickness of the galvanically deposited copper layer 13 is also somewhat reduced.

In the process step according to figure 5f a finishing layer 14, preferably made of nickel, is applied to the galvanically deposited copper layer 13. However, as indicated above, any other suitable metal layer may be used instead. The end product shown in figure 5f is a connector 10 having a body which is entirely shielded at its outside surface. Of course, the connector shown in figures 5a to 5f only relate to one example. By varying the traces 12 selectively metallized areas of any shape may be obtained.

The method according to the invention was tested for a connector made of a polymer resin for high temperatures, known as Vectra A130. The tests have shown that this material is appropriate to be selectively metallised by the proposed method. Moreover, the tests have shown that the electrical performance of a connector selectively shielded by the proposed method is similar to the electrical performance of a connector having separate metal shieldings. Although the use of Vectra A130 has shown good results, the method according to the invention is not restricted to the application of this polymer resin only. The use of any other suitable polymer resin falls within the scope of the present invention.

## Claims

**1.** Method for selective metallization of a plastic connector comprising the steps of:

a. depositing a first, electroless metal layer of a first predetermined thickness on the surface of the connector;
b. ablating predetermined parts of said first metal layer to produce at least two electrically separate metal layer areas;
c. depositing a second, galvanic metal layer of a second predetermined thickness to at least one selected metal layer area;
d. removing any non-selected metal layer area.

**2.** Method according to claim 1 wherein in step b. a high energy beam is used and is selected to be one of the following particle beams: an electron beam or ion beam.

**3.** Method according to claim 1 wherein in step b. a high energy beam is used and is selected to be one of the following radiation beams: a light beam or a laser beam.

**4.** Method according to claim 1 wherein in step b. said ablation is carried out by grinding.

**5.** Method according to claim 1 wherein step d. is selected to be one of the following removing steps: removing by chemical etching or removing by grinding.

**6.** Method according to claim 3 wherein the diameter of the high energy beam is about 75 μm.

**7.** Method according to claim 1 wherein the first metal layer is selected to be one of the elements of: electroless copper or nickel.

**8.** Method according to claim 1 wherein the first thickness is between 1 to 2 μm.

**9.** Method according to claim 1 wherein the second metal layer comprises galvanically deposited copper.

**10.** Method according to claim 1 wherein the second thickness is between 5 to 10 μm.

**11.** Method according to claim 1 wherein step a. is preceded by immersing the connector in an alkaline bath to roughen its surface in contact with said bath.

**12.** Method according to claim 9 wherein step d. is followed by

e. depositing a top coat finish layer on said second copper layer, selected to be one of the following group of metals: nickel, gold, or tin-lead.

**13.** Method according to claim 12 wherein said finish layer has a thickness between 2 to 4 $\mu$m.

**14.** Method according to claim 1 wherein

- said connector comprises at least one cavity (15) extending from a first side to a second side;
- step b. comprises the step of ablating predetermined parts (12) of said first metal layer on contours around the cavities on said first side and in further contours around the cavities on said second side in order to produce metal layer areas (11a) within each cavity, which are electrically separated from at least one metal layer area (11b) outside each cavity;
- step c. comprises depositing a second, galvanic metal layer of said second predetermined thickness to the at least one metal layer area (11b) outside each cavity;
- step d. comprises the step of removing the metal layer areas (11a) within each cavity.

fig-1a

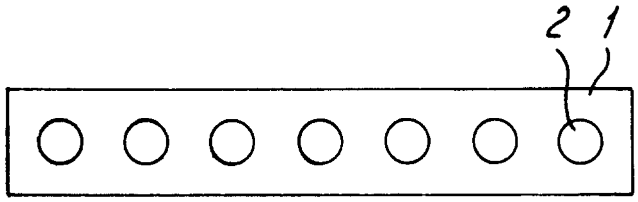



fig-1b

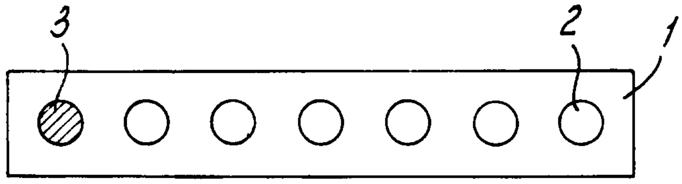



fig-1c

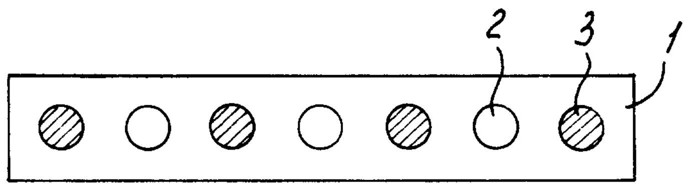



fig-1d

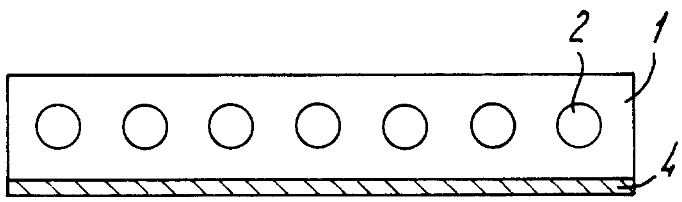



fig-1e

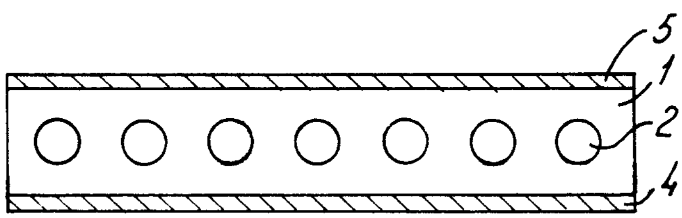



fig-1f

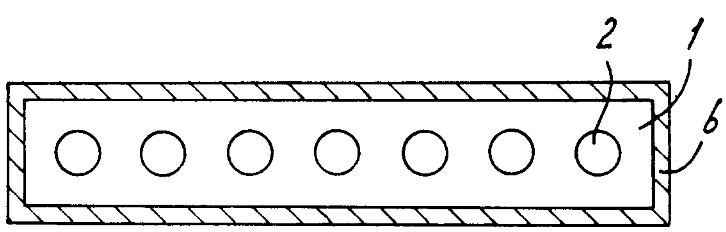


fig-2

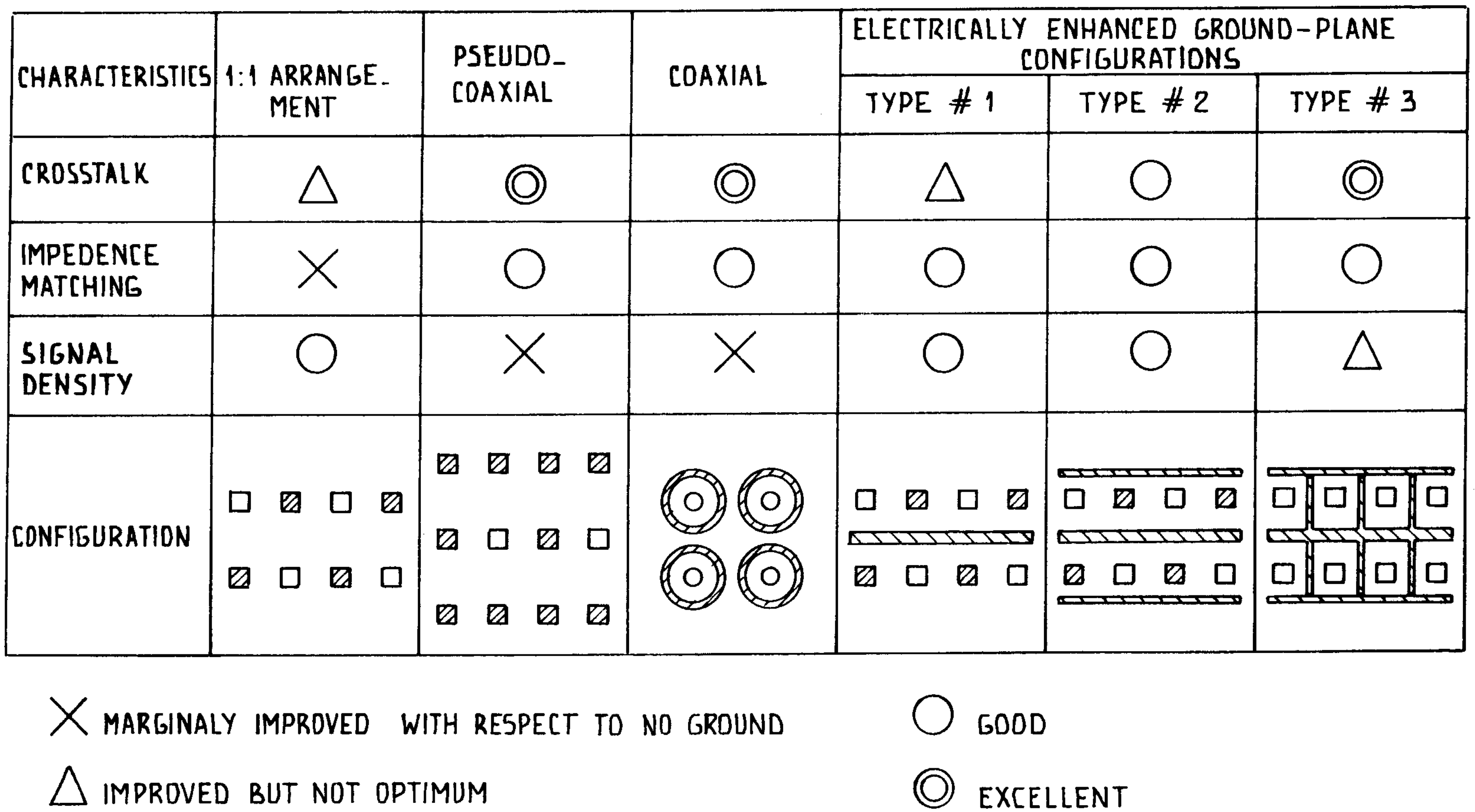

CHARACTERISTICS
1:1 ARRANGE-MENT
PSEUDO-COAXIAL
COAXIAL
ELECTRICALLY ENHANCED GROUND-PLANE CONFIGURATIONS
TYPE # 1
TYPE # 2
TYPE # 3
CROSSTALK
IMPEDENCE MATCHING
SIGNAL DENSITY
CONFIGURATION
MARGINALY IMPROVED WITH RESPECT TO NO GROUND
IMPROVED BUT NOT OPTIMUM
GOOD
EXCELLENT

fig-3

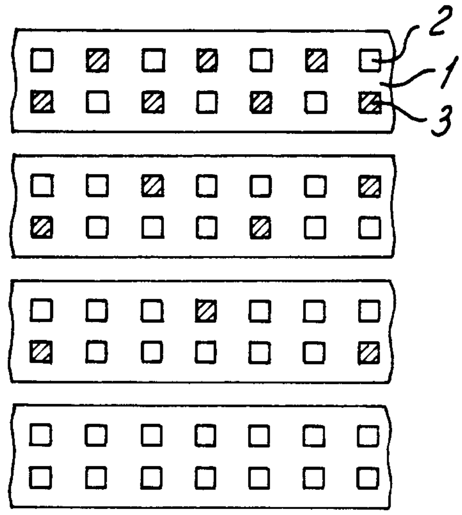



fig-4a

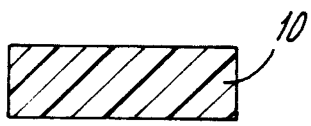



fig-4b

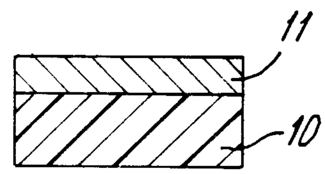



fig-4c

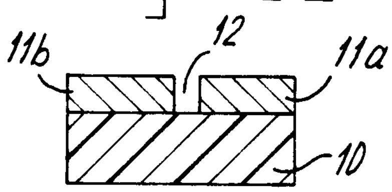



fig-4d

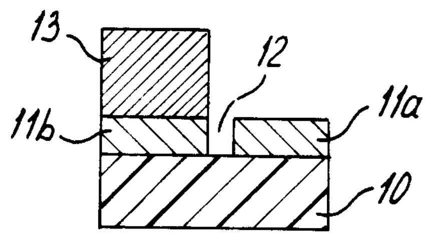



fig-4e

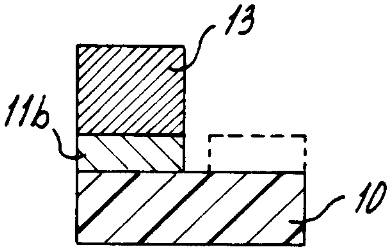



fig-4f

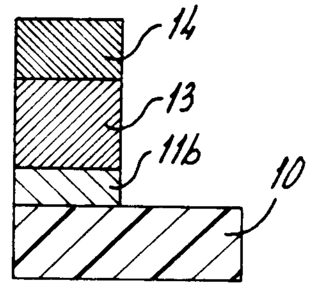


Fig-5a

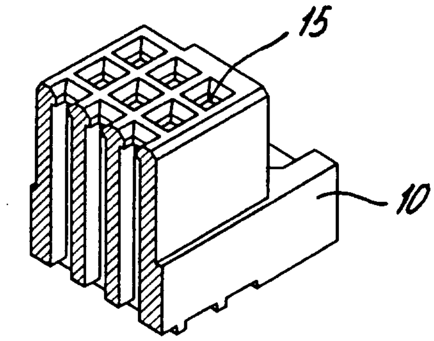



Fig-5b

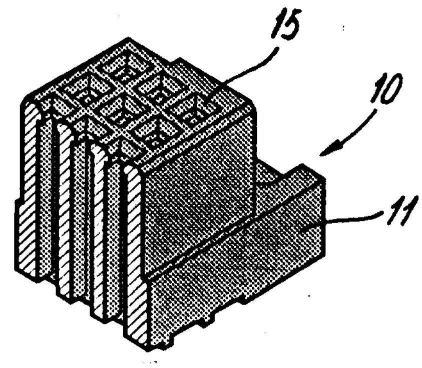



Fig-5c

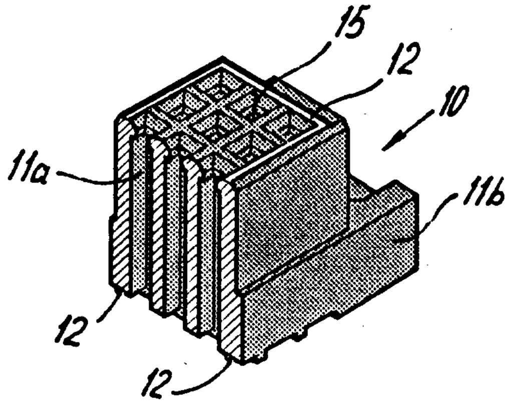



Fig-5d

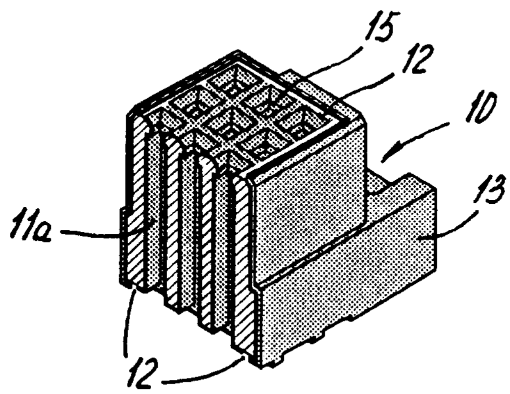



Fig-5e

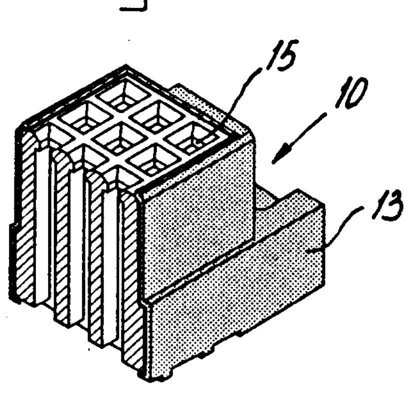
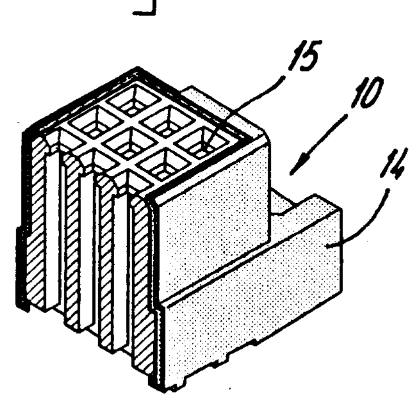



Fig-5f



European Patent Office

# EUROPEAN SEARCH REPORT

Application Number
EP 94 20 2140

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.6) |
|---|---|---|---|
| A | US-A-4 822 633 (INOUE)<br>* column 4, line 60 - column 7, line 9; figures 7A-D *<br>--- | 1-4,9,12 | H01R13/03<br>C23C18/16 |
| A | US-A-4 882 200 (LIU ET AL.)<br>* column 1, line 12 - line 26; figure 3 *<br>--- | 1 | |
| A | RESEARCH DISCLOSURE,<br>vol.316, no.105, 10 August 1990, HAVANT GB<br>ANONYMOUS 'Automated system for thin film circuit repair-relies on formation of micro plasma to remove organic debris and subsequent metal deposition'<br>* the whole document *<br>--- | 1 | |
| A | EP-A-0 506 260 (HUGHES AIRCRAFT CO.)<br>* abstract; figure 5 *<br>--- | 1,14 | |
| A | RESEARCH DISCLOSURE,<br>vol.326, no.046, 10 June 1991, HAVANT GB<br>ANONYMOUS 'Mfr. of PCB - is by selective laser ablation of plastic covered substrate'<br>* the whole document *<br>--- | 1 | **TECHNICAL FIELDS SEARCHED (Int.Cl.6)**<br>H01R<br>C23C |
| A | PATENT ABSTRACTS OF JAPAN<br>vol. 11, no. 262 (C-442) 25 August 1987<br>& JP-A-62 063 683 (UBE IND LTD) 20 March 1987<br>* abstract *<br>--- | 1,4 | |
| A | US-A-3 885 076 (HEIDENREICH ET AL.)<br>* column 1, line 58 - line 67 *<br>* column 4, line 44 - line 65; figures 1,4 *<br>----- | 1 | |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 22 November 1994 | Horak, A |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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