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(54) Lead frame for electrical contact module, electrical connector and contact assembly

(57) The invention concerns an electrical connector a lead-frame and a contact assembly, the electrical connector comprising a housing and a plurality of contact modules in said housing. Each of the contact modules comprises a mating edge and a mounting edge, each mating and mounting edge having a row of contacts. Each mating edge contact is electrically connected to a corresponding mounting edge contact by conductors extending along a predetermined path within the contact module to form a lead frame in each contact module. The conductors of several contact modules are arranged in a matrix of columns and rows when seen in a cross-sectional view through the lead-frame. The connectors in the contact module have different mechanical lengths and individual different widths, the widths of each conductor depending on the conductors mechanical length.

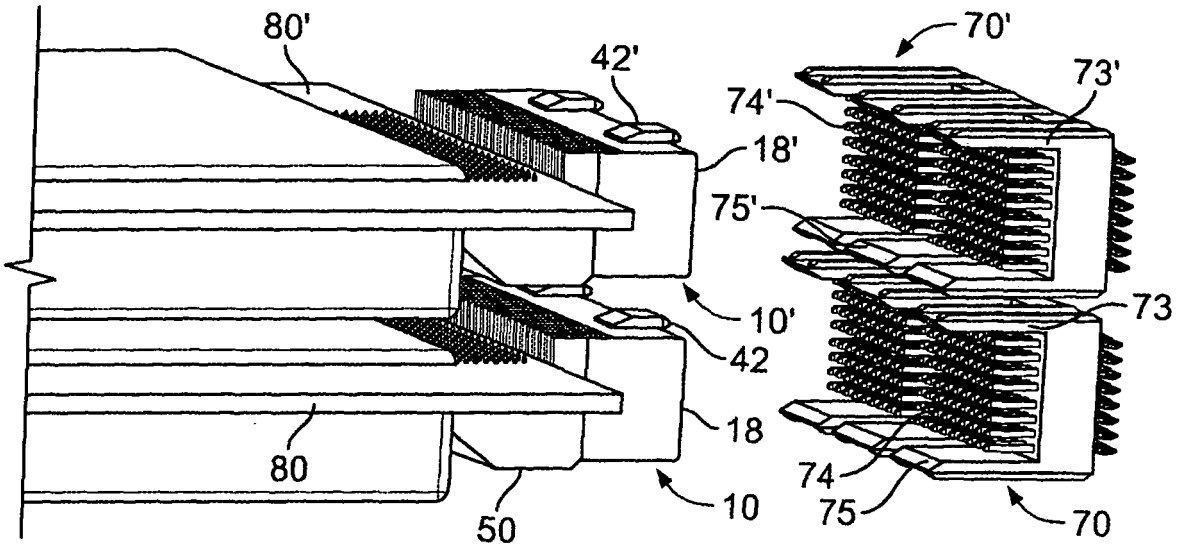

Fig. 8

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Description

[0001] The invention relates generally to electrical connectors and, more particularly, to an electrical connector for transmitting signals at high speeds.

[0002] With the ongoing trend toward smaller, faster, and higher performance electrical components such as processors used in computers, routers, switches, etc., it has become increasingly important for the electrical interfaces along the electrical paths to also operate at higher frequencies and at higher densities with increased throughput.

[0003] In a traditional approach for interconnecting circuit boards, one circuit board serves as a back plane and the other as a daughter board. The back-plane typically has a connector, commonly referred to as a header that includes a plurality of signal pins or contacts which connect to conductive traces on the back plane. The daughter board connector, commonly referred to as a receptacle, also includes a plurality of contacts or pins. Typically, the receptacle is a right angle connector that interconnects the back plane with the daughter board so that signals can be routed between the two. The right angle connector typically includes a mating face that receives the plurality of signal pins from the header on the back plane, and contacts that connect to the daughter board.

[0004] Some older connectors, which are still in use today, operate at speeds of one gigabit per second or less. By contrast, many of today's high performance connectors are capable of operating at speeds of up to ten gigabits or more per second. As would be expected, the higher performance connector also comes with a higher cost.

[0005] US 6,808,420, B1 discloses an electrical connector comprising a connector housing holding signal contacts and ground contacts in an array organized into rows. Each row includes pairs of the signal contacts and some of the ground contacts arranged in a pattern, wherein adjacent first and second rows have respective different first and second patterns.

[0006] US 6,379,188, B1 shows an electrical connector for transferring a plurality of differential signals between electrical components. The connector is made of modules that have a plurality of pairs of signal conductors with a first signal path and a second signal path.

[0007] Electrical connectors according to the prior art comprise a plurality of contacts embedded in a plastic housing. Figure 1 shows a plurality of mating contacts 3 in such an electrical connector represented without the plastic housing. Each mating contact 3 is electrically connected to a corresponding mounting contact 6 by a conductor 5. The plurality of conductors 5 connecting mounting contacts 6 with the corresponding mating contacts 3 arranged on one of the columns, constitutes a so-called lead frame, an example of which is represented in figure 2.

[0008] As can be seen in Fig. 2 the lead-frame of a male or female connector has a right-angled contact geometry and therefore a geometry that forces the conductors to have different mechanical lengths. This means that the delay of the electrical signal is different for all the pins, i.e. conductors in the conductor column. This is referred to as "skew".

[0009] In any high-speed applications, skew between pins is an important parameter of overall connector performance. In a column of conductors, there will always be skew because of the length differences of the conductors.

[0010] The object of the present invention is therefore to provide an electrical connector with improved electrical characteristics, such as the same electrical length of all the conductors.

[0011] This object is solved by an electrical connector according to the independent claim 1 and by a lead frame according to independent claim 6. Preferred embodiments are subject matter of the dependent claims.

[0012] According to a first aspect of the present invention an electrical connector comprises a housing and a plurality of contact modules in said housing. Each of the contact modules comprises a mating edge and a mounting edge and each mating and mounting edge have a row of contacts. Each mating edge contact is electrically connected to a corresponding mounting edge contact by conductors extending along a predetermined path within the contact module to form a lead-frame in each contact module. The conductors of several contact modules are arranged in a matrix of columns and rows when seen on a cross-sectional view through the lead-frames. The conductor's in the contact module have different mechanical lengths and individually different widths, the width of each conductor depending on the conductor's mechanical length.

[0013] According to a preferred embodiment of the present invention an electrical connector is provided wherein a conductor with a short mechanical length has a smaller width than a conductor with a long mechanical length.

[0014] According to a further aspect of the invention an electrical connector is provided wherein the width of each conductor in the contact module increases with the increase of the conductors mechanical length.

[0015] In an advantageous embodiment of the invention the conductors are arranged in an essentially square rectangular array.

[0016] In a further advantageous embodiment of the invention, the mating edge and mounting edge in each contact module are substantially perpendicular to each other.

[0017] According to a further embodiment of the invention, a lead-frame is provided for an electrical contact module, the lead-frame comprising a first row of contacts comprising mating contacts and defining a mating edge, and a second row of contacts comprising mounting contacts and defining a mounting edge. Each mating edge contact is electrically connected to a corresponding mounting edge contact by conductors extending along a

predetermined path within the lead-frame, wherein the conductors in the lead-frame have different mechanical lengths. The conductors in the lead-frame have individually different widths, the width of each conductor depending on the conductor's mechanical length.

[0018] According to a further advantageous embodiment of the invention, a contact assembly is provided comprising at least a first and second lead-frame, the second lead-frame being adjacent to the first lead-frame.

[0019] Further features and advantages will become apparent from the following and more particular description of the present invention based on the figures enclosed with the application:

Figure 1 is a perspective view of the plurality of lead frames within one electrical connector according to the prior art;

Figure 2 is a side view of one lead frame according to the prior art;

Figure 3 is a cross-sectional view of the plurality of lead frames shown in figure 1 taken along one of the lines A-A, B-B or C-C shown in Figure 2;

Figure 4 is a cross-section view of the plurality of lead-frames shown in figure 1 taken along one of the lines A-A, B-B or C-C shown in figure 2 according to the present invention;

Figure 5 is a side view of a female electrical connector according to the present invention mated with a male connector;

Figure 6 is a perspective view of a female electrical connector according to the present invention;

Figure 7 is a perspective view of a male electrical connector according to the present invention;

Figure 8 is a perspective view of a multi-board arrangement comprising two female electrical connectors according to the present invention; and

Figure 9 is a perspective view of the plurality of lead frames according to one embodiment of the present invention.

[0020] The following paragraphs will describe the invention including the general characteristics of the chicklet contact arrangement and illustrates further configurations.

[0021] Figure 3 shows a cross-sectional view of the plurality of conductors 5 shown in figure 1, taken along one of the lines A-A, B-B or C-C. In such an electrical connector the plurality of conductors 5 have electrical characteristics, which may vary depending on the length of a particular conductor within the electrical connector. With an identical conductor width a longer conductor has a self-inductance that is higher than a shorter conductor proportional to the length difference of both conductors.

[0022] As illustrated in figure 4, the width of the conductors within the lead-frame is gradually increased so that a longer conductor is wider while a shorter conductor is smaller. Therefore, when two pins are compared in the connector the shorter one is smaller and the longer one is wider.

[0023] Changing the width of the conductors changes their self-inductance and therefore starting from the highest self-inductance per unit length for the shortest conductor to the lowest self-inductance per unit length for the longest conductor, the self-inductance per unit length of the conductors is gradually reduced. This difference in inductance per unit length electrically compensates the mechanical length difference of the conductors.

[0024] According to the invention, the longer conductor will be wider, reducing its self-inductance by unit length relative to the short conductor, which has a high self-inductance by unit length.

[0025] This is exemplified in figure 4, where p is the pitch of the conductors and w is their width. As this is a cross-sectional view of the conductor shown in figure 1, along lines A-A, B-B or C-C of Fig. 2 one can see that the shorter conductors at the bottom have a width w1 that is smaller than that of the longer conductors above in this case w2 and w3. This inductance compensation will lead to a reduced electrical skew between the conductors in a connector column. Therefore, higher data rates are made possible.

[0026] Figure 5 illustrates an electrical connector 10 formed in accordance with an exemplary embodiment of the present invention. While the electrical connector 10 will be described with particular reference to a receptacle connector, a right-angle connector interconnecting a back-plane with a daughter board, it is to be understood that the benefits described herein are also applicable to other connectors in alternative embodiments.

[0027] The electrical connector 10 includes a dielectric housing 12. A plurality of contact modules 50 are connected to the housing 12. The contact modules 50 define a mounting face 56, which comprises a plurality of mounting contacts 86. In a preferred embodiment, the mounting face 56 is substantially perpendicular to the mating face 18 of the dielectric housing 12, such that the electrical connector 10 interconnects electrical components that are substantially at a right angle to one another. The mounting contacts 86 are adapted to be mounted on a circuit board 80. The dielectric housing 12 includes a plurality of mating contacts that are accessible to corresponding mating elements through a mating face 18 of the dielectric housing 12. A plurality of ground conductors 104 and signal conductors 106a, 106b connect the mounting contacts 86 and mating contacts.

[0028] A connector 70 comprising mating elements can be mated with the mating contacts of the electrical connector 10. The connector 70 comprises a plastic body 72 in which mating elements 76 are embedded. The plastic body 72 of the connector 70 comprises two side parts 73, 75. The mating elements 76 are embedded in the plastic body 72 in such a way that a longitudinal axis of

the mating elements 76 is parallel to a longitudinal axis of the side parts 73, 75. The plastic body 72 comprises a hollow part arranged between side parts 73, 75, said hollow part having dimensions such that the housing 12 of the electrical connector 10 can be fitted into said hollow part of the connector 70.

[0029] The mating elements 76 of said connector 70 protrude out of the plastic body 72 on the side of the connector 70 oriented towards the hollow part in which the housing 12 of the electrical connector 10 can be fitted. The mating elements 76 protrude towards the hollow part of the connector 70 in mating element ends 74. The mating element ends 74 can be introduced through the mating face 18 of the dielectric housing 12 to mate with the mating contacts of the electrical connector 10.

[0030] Figure 6 shows a female electrical connector 10 according to the present invention. The mounting contacts 86 of the electrical connector 10 are mounted on the electric board 80. The housing 12 of the electrical connector 10 comprises a mating face 18 including a plurality of contact cavities 22 that are configured to receive corresponding mating elements. Further, the housing 12 comprises an alignment rib 42 arranged on an upper face 32 of said housing 12. The alignment rib 42 allows to bring the electrical connector 10 into alignment with the connector 70 during the mating process so that the mating element ends 74 of the mating connector 70 are received in the contact cavities 22 without damage.

[0031] Figure 7 illustrates a male electrical connector according to the present invention. A connector 70' has two hollow parts comprised respectively between a side part 73' and a central side part 75, and between said central side part 75 and a side part 73. Mating element ends 74 and 74' are arranged in the respective hollow parts of the plastic body 72 of the mating connector 70'. The mating element ends 74, 74' arranged in the respective hollow parts are male mating elements, which are adapted to be mated with the mating contacts in the contact cavities 22 of the mating face 18 of a first electrical connector 10 and with the mating contacts in the contact cavities of a mating face of a second electrical connector 10'.

[0032] Figure 8 shows a multi-board arrangement, wherein a first electrical connector 10 is mounted on a first board 80 and a second electrical connector 10' is mounted on a second board 80'. Each electrical connector 10, 10' is adapted to be mated with each connector 70, 70'. In particular, the mating contacts of the respective mating face 18, 18' of each electrical connector 10, 10' are mated with the respective mating element ends 74, 74' of each respective connector 70, 70'.

[0033] Figure 9 shows a perspective view of a plurality of lead frames 100, 200 that are arranged within one electrical connector 10 according to the present invention. The lead frames 100, 200 comprise a plurality of conductors. The conductors extend along a predetermined path to electrically connect each mating edge contact 82 to a corresponding mounting edge contact 86. The mating edge is essentially perpendicular to the mounting edge 56.

[0034] Further, although the present application describes in detail the preferred embodiment of a rectangular or square array, a plurality of conductors with a curved cross-section may also be foreseen in an electrical connector, said plurality of conductors being arranged in such a way that they form an essentially curved array. Preferentially, the plurality of conductors is foreseen with a circular cross-section, said plurality of conductors being arranged in such a way that they form an essentially circular array. In the case of a circular array of conductors, the term width defined in the present application shall then mean the diameter of said conductors.

[0035] The electrical connector according to the present invention has improved electrical characteristics, in particular, uniform electrical properties of the conductors within the electrical connector. Moreover, the electrical connector according to the present invention achieves a high speed signal transport through a right angle or vertical interconnection system while having both a high signal density as well as an easy track-routing on the printed circuit board. Various termination techniques for board mounting, such as surface mounting or press-fit, can be applied to mount the electrical connector according to the present invention on a corresponding board.

Claims

1. An electrical connector (10) comprising:

a housing (12);
a plurality of contact modules (50) in said housing (12), each said contact module (50) comprising a mating edge and a mounting edge (56), each said mating and mounting edge (56) having a row of contacts (82, 86);
each mating edge contact (82) being electrically connected to a corresponding mounting edge contact (86) by conductors (106a, 106b, 104) extending along a predetermined path within said contact module (50) to form a lead frame (100) in each contact module (50);
said conductors (106a, 106b, 104) of several contact modules (50) being arranged, when seen in a cross-sectional view through the lead frames (100), in a matrix of columns and rows;

wherein conductors (106a, 106b, 104) in the contact module (50) have different mechanical lengths;
the conductors (106a, 106b, 104) in the contact module (50) having individually different widths (w1, w2, w3, .., wn), the width of each conductor depending on the conductor's mechanical length.

2. The electrical connector (10) according to claim 1,

wherein a conductor with a shorter mechanical length has a smaller width (w1) than a conductor with a longer mechanical length.

3. The electrical connector (10) according to claim 1 or 2, wherein the width of each conductor in the contact module (50) increases with the increase of the conductors' mechanical length.

4. The electrical connector (10) according to any of claims 1 to 3, wherein the conductors (106a, 106b, 104) are arranged in an essentially square or rectangular array.

5. The electrical connector (10) according to any of claims 1 to 4, wherein said mating edge and mounting edge (56) in each contact module (50) are substantially perpendicular to each other.

6. A lead frame (100) for an electrical contact module (50), said lead frame (100) comprising:

a first row of contacts comprising mating contacts (82) and defining a mating edge; and
a second row of contacts comprising mounting contacts (86) and defining a mounting edge;
each mating edge contact (82) being electrically connected to a corresponding mounting edge contact (86) by conductors extending along a predetermined path within the lead frame (100);

wherein conductors (106a, 106b, 104) in the lead frame (100) have different mechanical lengths;
the conductors (106a, 106b, 104) in the lead frame (100) having individually different widths (w1, w2, w3, .., wn), the width of each conductor depending on the conductor's mechanical length.

7. The lead frame (100) according to claim 6, wherein a conductor with a shorter mechanical length has a smaller width (w1) than a conductor with a longer mechanical length.

8. The lead frame (100) according to claim 6 or 7, wherein the width of each conductor in the lead frame (100) increases with the increase of the conductors' mechanical length.

9. The lead frame (100) according to any of claims 6 to 8, wherein said mating edge and mounting edge (56) in each lead frame (100) are substantially perpendicular to each other.

10. A contact assembly comprising at least a first and second lead frame (100) according to one of claims 6 to 9, said second lead frame being adjacent to said first lead frame.

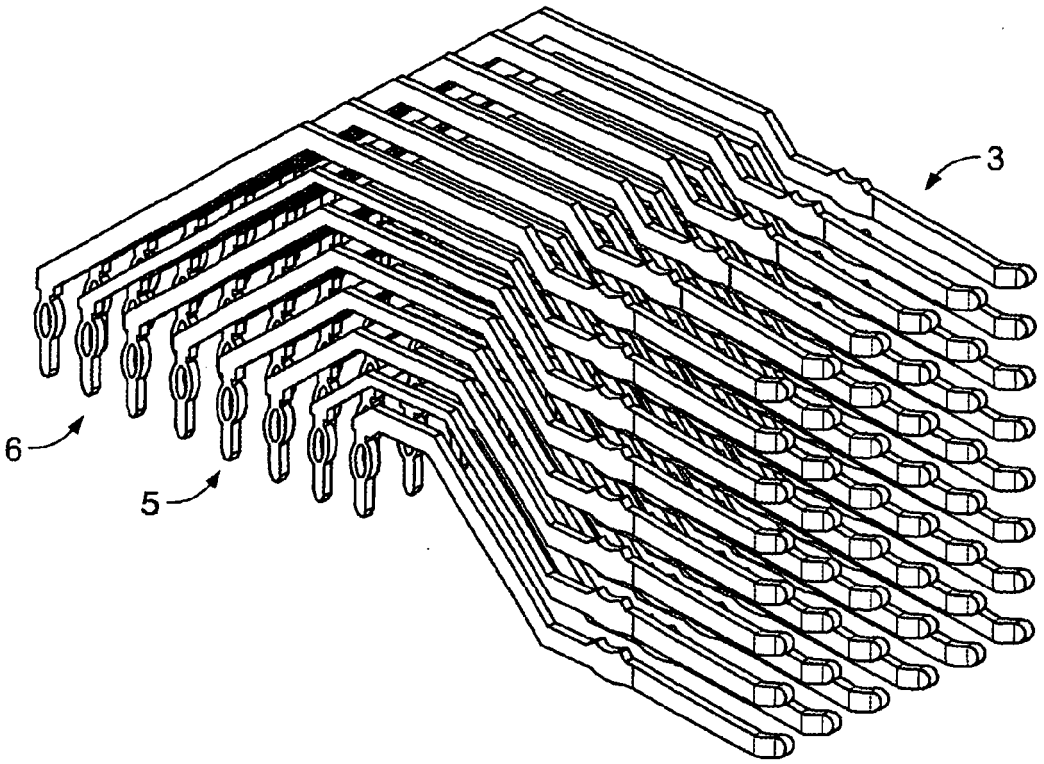

Fig. 1

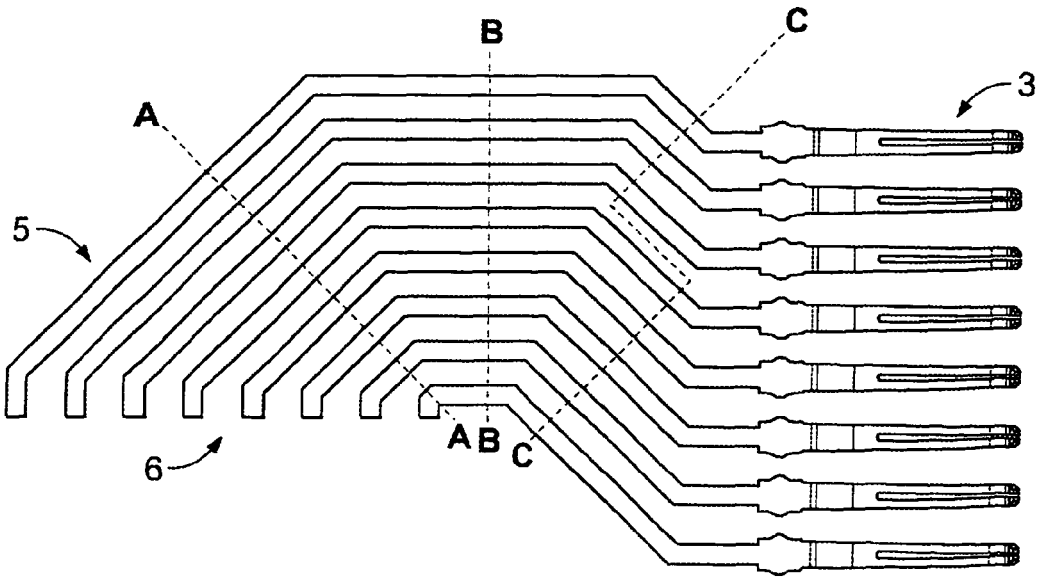

Fig. 2

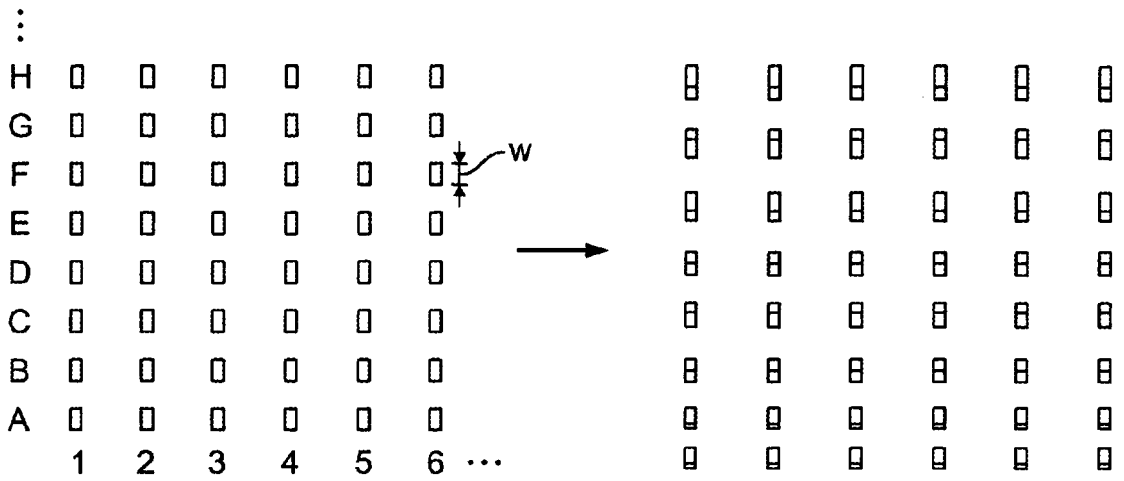

Fig. 3

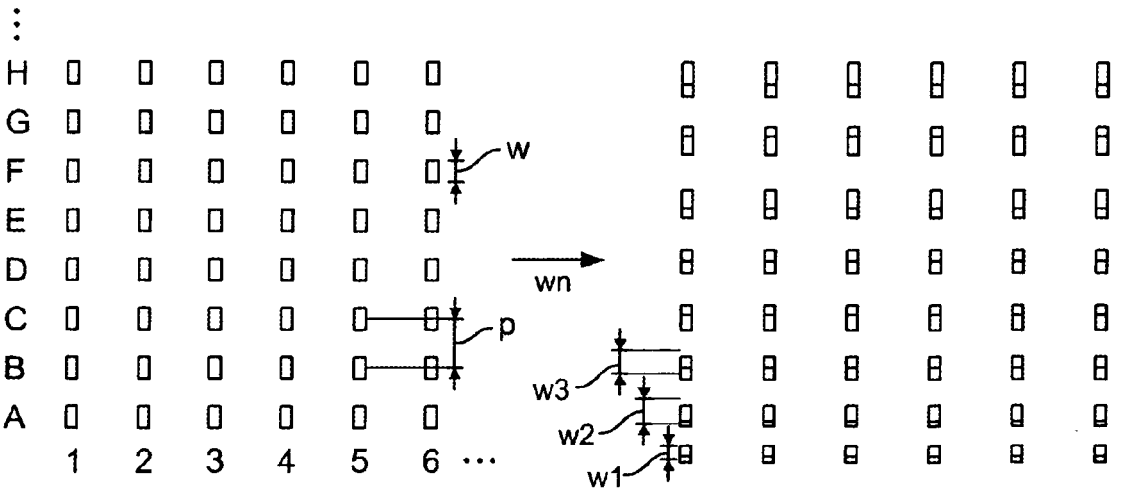

Fig. 4

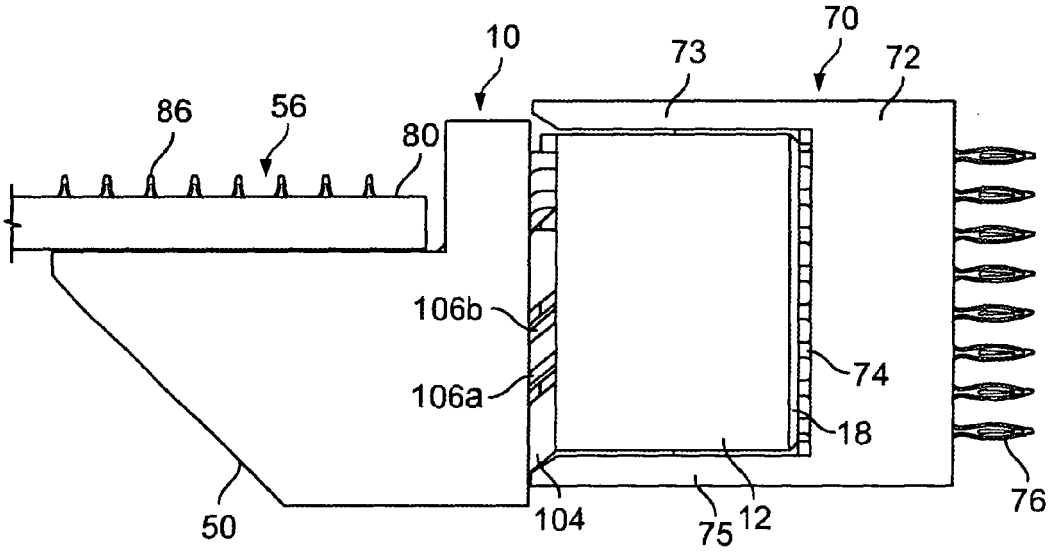

Fig. 5

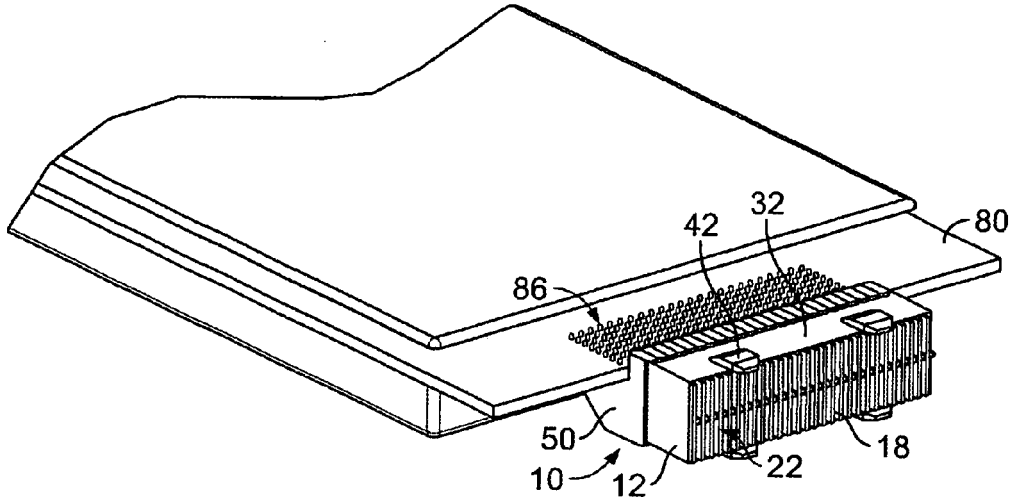

Fig. 6

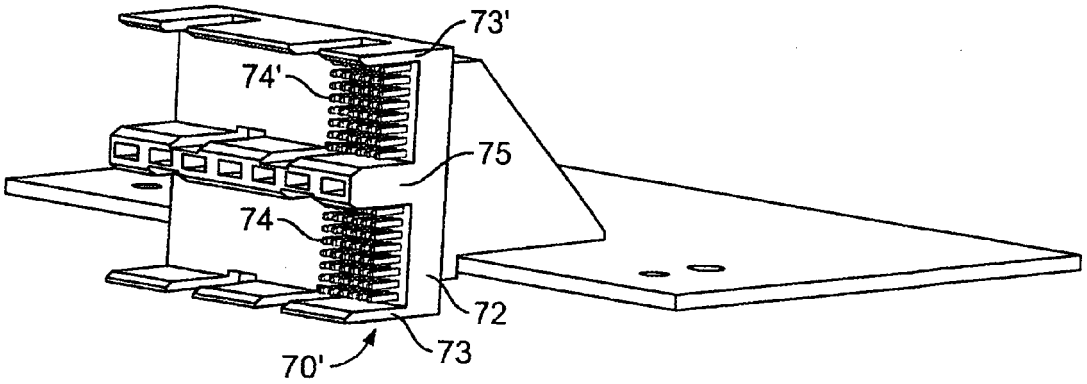

Fig. 7

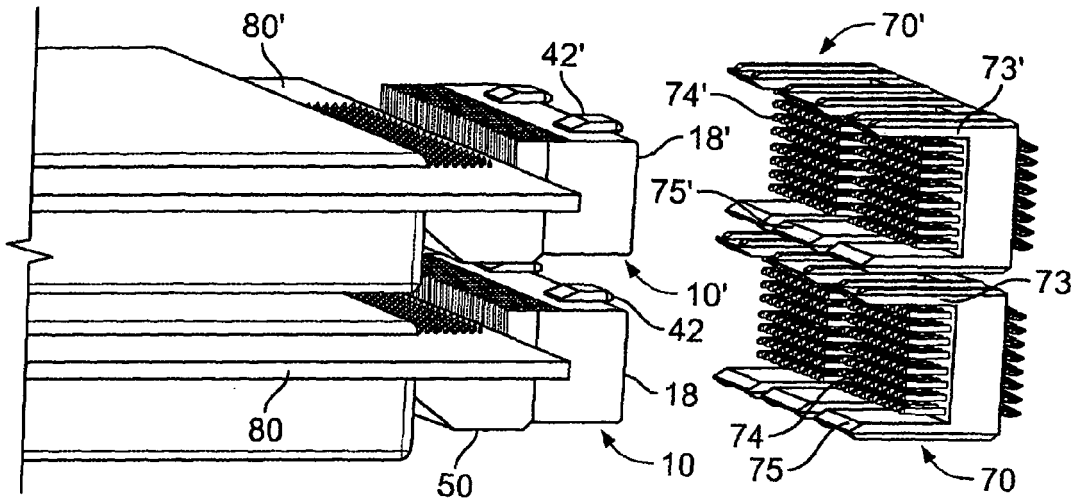
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Fig. 8

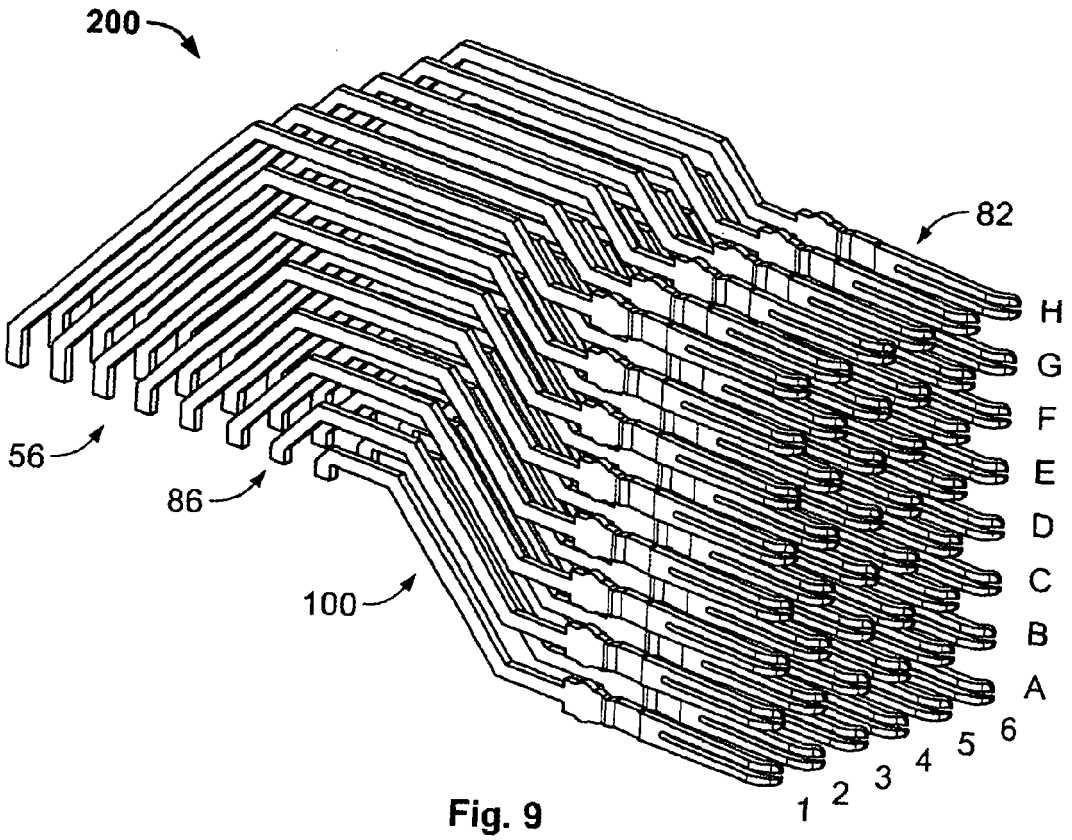
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Fig. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 06 02 5471

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 01/39332 A (TERADYNE INC [US]) 31 May 2001 (2001-05-31) * page 16, line 7 - page 17, line 29; figure 10 * -----	1-10	INV. H01R13/646
A	WO 99/17404 A (RAMBUS INC [US]) 8 April 1999 (1999-04-08) * page 13, line 22 - page 14, line 31 * * page 19, line 13 - page 20, line 26 * * figures 14A,14B * -----	1-10	
A	EP 0 905 826 A (BERG ELECTRONICS MFG [NL]) 31 March 1999 (1999-03-31) * paragraphs [0056], [0061], [0061]; figures 5D,7B,8B * -----	1-10	

TECHNICAL FIELDS SEARCHED (IPC)

H01R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	25 April 2007	Ledoux, Serge

CATEGORY OF CITED DOCUMENTS

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25-04-2007

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 0139332 A	31-05-2001	AU 1921000 A	04-06-2001
		CA 2392322 A1	31-05-2001
		CN 1378713 A	06-11-2002
		CN 1534833 A	06-10-2004
		EP 1232540 A1	21-08-2002
		JP 2003515896 T	07-05-2003
		MX PA02005163 A	28-01-2003
WO 9917404 A	08-04-1999	EP 1064699 A1	03-01-2001
		US 6266730 B1	24-07-2001
		US 6067594 A	23-05-2000
EP 0905826 A	31-03-1999	CN 1213874 A	14-04-1999
		JP 11162580 A	18-06-1999
		TW 416584 Y	21-12-2000
		US 6494734 B1	17-12-2002

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Patent documents cited in the description

- US 6808420 B **[0005]**
- US 6379188 B **[0006]**