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(71) Applicant (for all designated States except US): **PANDUIT CORP.** [US/US]; 17301 S. Ridgeland Avenue, Tinley Park, IL 60477 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **STRAKA, Frank, M.** [US/US]; 3517 North Bosworth Avenue, Chicago, IL 60657 (US). **TELLAS, Ronald, A.** [US/US]; 6926 Hawk Drive, Schererville, IN 46375 (US). **GERMAN, Jason, J.** [US/US]; 21957 Clove Drive, Frankfort, IL 60423 (US). **VAITKUS, Vytas, J.** [US/US]; 8216 Spyglass Circle, Orland Park, IL 60462 (US).

(74) Agents: **MCCANN, Robert A.** et al.; Panduit Corp., 17301 S. Ridgeland Avenue, Tinley Park, IL 60477 (US).

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(54) Title: METHOD AND SYSTEM FOR IMPROVING CROSSTALK ATTENUATION WITHIN A PLUG/JACK CONNECTION AND BETWEEN NEARBY PLUG/JACK COMBINATIONS

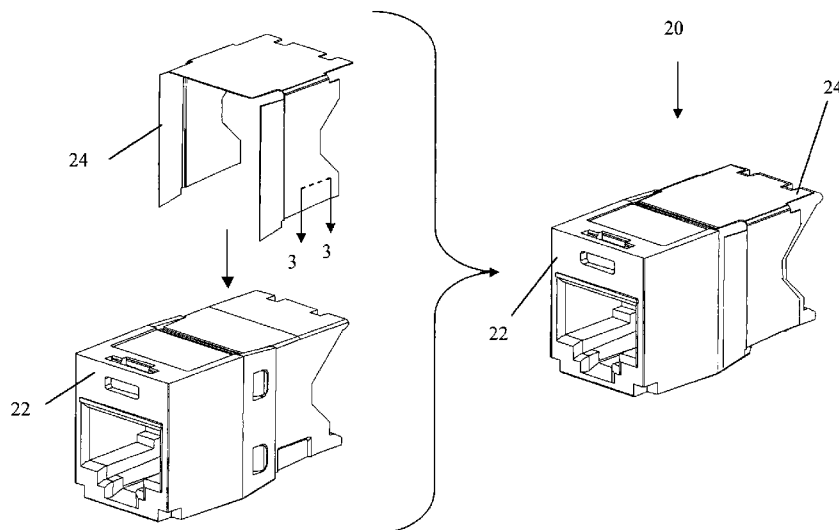


Fig. 1

(57) Abstract: This application describes a jack for improving crosstalk attenuation. The jack has a housing, a foil at least partially surrounding the housing, a printed circuit board, and at least one pair of insulation displacement contacts and vias. Each pair of insulation contacts and vias are associated with a differential signal. A conductive trace stub is routed on the printed circuit board near the edge of the board in order to at least partially balance the coupling from one of the insulation displacement contacts and vias of a pair to the foil with the other insulation displacement contact and via of the pair.

**METHOD AND SYSTEM FOR IMPROVING CROSSTALK
ATTENUATION WITHIN A PLUG/JACK CONNECTION
AND BETWEEN NEARBY PLUG/JACK COMBINATIONS**

BACKGROUND OF THE INVENTION

[0001] There is a continuing need to obtain more margin in communication channels for near-end and far-end crosstalk (NEXT and FEXT), and alien near-end and far-end crosstalk (ANEXT and AFEXT). A major source of NEXT and FEXT occurs within the plug of a plug/jack combination and is typically compensated for within the jack. A major source of alien crosstalk is common mode noise that couples between channels, particularly between adjacent jacks, and becomes converted into differential alien crosstalk (mode conversion).

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] Fig. 1 is a perspective view of an embodiment of a jack with a foil shield according to the present invention;

[0003] Fig. 2 is a perspective view of another embodiment of a jack with a foil shield according to the present invention;

[0004] Fig. 3 is a cross-sectional view taken along section line 3-3 in Fig. 1, illustrating a stack-up for the adhesive foil material according to the present invention;

[0005] Fig. 4 is a schematic view illustrating alien crosstalk occurring due to common mode propagation along jack foil shields in nearby jacks which converts back into differential crosstalk in the jack;

[0006] Fig. 5 is a fragmentary perspective of an embodiment of a communication system according to the present invention;

[0007] Fig. 6 is an exploded perspective view of an embodiment of a modular jack according to the present invention;

[0008] Fig. 7 shows perspective views of some aspects of the jack of Fig. 6;

[0009] Fig. 8 is a perspective view of the plug interface contacts of the jack of Fig. 6;

[00010] Fig. 9 is a see-through perspective view of the multi-layer flex circuit board of the jack of Fig. 6;

[00011] Fig. 10 is a schematic view of the flex circuit board of Fig. 9;

[00012] Fig. 11 is a see-through perspective view of the multi-layer rigid circuit board of the jack of Fig. 6;

[00013] Fig. 12 is a schematic view of the rigid circuit board of Fig. 11;

[00014] Fig. 13 is a schematic view illustrating how alien crosstalk is reduced according to the present invention by blocking common mode propagation along jack foil shields through the use of a split foil;

[00015] Fig. 14 is a perspective exploded view of another embodiment of a jack with a foil shield according to the present invention, where the foil shield is continuous but the metallization layer has a gap;

[00016] Fig. 15 is a perspective exploded view of another embodiment of a jack with a foil shield according to the present invention, where the foil shield is continuous but the metallization layer is present only on a base and one side;

[00017] Fig. 16 is a perspective exploded view of another embodiment of a jack with a foil shield according to the present invention, where the foil shield is continuous but there are selected areas of the foil which have metallization layers; and

[00018] Fig. 17 is a perspective exploded view of another embodiment of a jack with a foil shield according to the present invention, where the foil shield is continuous with continuous metallization but the foil only includes a single side and top portions.

[00019] Corresponding reference characters indicate corresponding parts throughout the several views. The examples set out herein illustrate some preferred embodiments of the invention, and such examples are not to be construed as limiting the scope of the invention in any manner.

DETAILED DESCRIPTION OF THE INVENTION

[00020] Compensation methods and devices are described in a novel design for an improved category 6A (CAT6A) RJ45 jack design, to exceed TIA category 6A standards at 500 MHz, in U.S. Provisional Patent Application Serial No. 61/090,403, entitled "High-Speed Connector with Multi-Stage Compensation," filed August 20, 2008, which is incorporated by reference as if fully set forth herein. This jack addresses the need within the industry to obtain more margin for near end crosstalk (NEXT), far end crosstalk (FEXT), and return loss in order to meet the needs of demanding customers. Additionally, this jack reduces the differential to common and common to differential

mode conversion (herein referred to as “mode conversion”) that occurs within the jack to improve the alien crosstalk performance of the system.

[00021] U.S. Patent Application Publication No. 2006/0134995, also incorporated by reference as if fully set forth herein, discloses communications jacks which are provided with conductive covering layers to reduce the amount of ANEXT between connectors at insulation displacement contacts (IDCs) when the jacks are installed alongside one another. These conductive layers or foils are also part of the above cited U.S. Provisional Patent Application Serial No. 61/090,403.

[00022] In other advances, the present invention addresses some of the current limitations in channel and permanent link performance respective to jack return loss margin at higher frequencies. In one embodiment of the present invention the jack transmission line components can include plug interface contacts (PICs) that mate with a plug and wrap around a sled and interface with a rigid circuit board, a flex circuit board that wraps around the sled with components in contact with the PICs, rigid circuit board circuit elements, and IDCs which also interface with the rigid circuit board and which allow for wires within cabling to connect with the IDCs. The plug/PICs, flex board, PIC region of the rigid board, and a compensation region of the rigid board can be considered a first impedance region; and the IDC vias region of the rigid board and IDCs can be considered a second impedance region following the first impedance region. If a jack connector has a relatively low impedance region (at the first impedance region) followed by a relatively high impedance region (at the second impedance region) there is more return loss margin at lower frequencies, but less return loss margin at higher frequencies. A jack with only the first low impedance region and not a relatively high impedance second region has less margin at lower frequencies, but more relative margin (as compared to a jack having a low impedance region followed by a relatively high impedance region) at higher frequencies. This same relationship applies when the magnitude values are opposite of that described, such as a jack with a high impedance region followed by a low impedance region, where an increase in the impedance of the low impedance region improves return loss.

[00023] Pair 4-5 is typically the pair with the worst return loss margin at higher frequencies in present day jack designs. Generally speaking, pair 4-5 has a low impedance region caused by the plug/PICs, flex board, PIC region of the rigid board, and compensation region of the rigid board, followed by a high impedance region caused by the respective IDCs and wire cap. A feature of the present invention is to reduce the impedance of the high impedance region so that the return loss gets relatively worse at lower frequencies, but the margin improves at high frequencies, which results in overall improved return loss margin relative to the CAT6A specification. Since the relationship

between impedance and capacitance generally follows $Z = \sqrt{L/C}$, capacitance is added in the high impedance region to reduce the impedance of the high impedance region.

[00024] In a patch panel or outlet where there are many jacks clustered within an area, high levels of alien crosstalk can occur between these neighboring jacks. Previous understanding of this concept indicated that this coupling was primarily due to inductive differential coupling caused by the proximity of the neighboring wires and blades in adjacent plugs and jacks, and particularly parallel portions which run adjacent to each other. The foil label designs of Figs. 1 and 2 address this problem. In Fig. 1, jack assembly 20 includes jack 22 and an adhesively mounted foil label or shield 24. Jack 22 can be a CAT6A jack design, for example. Alternatively, other jacks such as CAT6, CAT7, or others can be used. Fig. 2 illustrates jack assembly 26 which includes jack 22 and an adhesively mounted foil label 28 with extended sides 29. These foil labels 24, 28 are primarily used to reduce the amount of alien crosstalk occurring between neighboring jacks, as the level of coupling from non-neighboring jacks is already very low due to the fact that they are relatively far apart. Although not shown in Figs. 1-2, jacks 20, 26 typically can include a wirecap as shown in Fig. 6 and other elements of Fig. 6. The foil labels include an adhesive material with a metal liner, then a paint layer and protective coating, which is shown in Fig. 3.

[00025] However, it has been observed, that in a channel environment with a high level of common mode noise, that the foil shields provide an electrical connection (comprising a conductive path around the jack with capacitive coupling to adjacent jacks) for a common mode current to flow to and beyond neighboring jacks as is shown in Fig. 4. This is a significant cause of alien crosstalk between non-neighboring jacks, as well as further increasing the amount of alien crosstalk between neighboring jacks. When several jacks, each of which include the foil shields according to Figs. 1 and 2, are near each other, there exists a very low loss path for a common mode current to travel between jacks due the large amount of capacitive coupling between neighboring foils, and at least one embodiment of the present invention addresses this problem.

[00026] In another aspect according to the present invention, it is desirable to have balanced capacitive and inductive loads between all differential pair combinations within the plug/jack combination in order to minimize mode conversion. It is also desirable to have each differential pair balanced with respect to the foil label design surrounding parts of the jack in order to further reduce mode conversion.

[00027] Herein described is a novel design for a jack with a foil label and an improved rigid circuit board that improves the balance of each differential pair on the jack with respect to the foil label, in

addition to making improvements addressing the problems discussed above. The present invention reduces the mode conversion of the jack and improves alien crosstalk.

[00028] Referring now to the drawings, and more particularly to Fig. 5, there is shown a communication system 30, which can include communication cables, such as patch cables 32 and horizontal cables 33, connected to equipment 34. Equipment 34 is illustrated as a patch panel in Fig. 5, but the equipment can be passive equipment or active equipment. Examples of passive equipment can be, but are not limited to, modular patch panels, punch-down patch panels, coupler patch panels, wall jacks, etc. Examples of active equipment can be, but are not limited to, Ethernet switches, routers, servers, physical layer management systems, and power-over-Ethernet equipment as can be found in data centers/telecommunications rooms; security devices (cameras and other sensors, etc.) and door access equipment; and telephones, computers, fax machines, printers and other peripherals as can be found in workstation areas. Communication system 30 can further include cabinets, racks, cable management and overhead routing systems, and other such equipment.

[00029] Communication cables 32 and 33 are shown in the form of an unshielded twisted pair (UTP) cable, and more particularly a CAT6A cable which can operate at 10 Gb/s. However, the present invention can be applied to and/or implemented in connection with a variety of communications cables. Cables 33 can be terminated directly into equipment 34, or alternatively, can be terminated in a variety of punchdown or jack modules 40 such as RJ45 type, jack module cassettes, and many other connector types, or combinations thereof. Patch cables 32 are typically terminated in plugs 36.

[00030] Fig. 6 shows a more detailed exploded view of jack 40 which generally includes housing 42 that fits an RJ45 plug, a nose 44 that has eight PICs 56 that mate with a plug and wrap around sled 60, and interface with a rigid board 46. Rigid board 46 connects to IDCs 48, and rear sled 50 that holds the IDCs. A wire cap 52 allows for wires within cabling to connect with the IDCs, and this is also part of the jacks of Figs. 1-2, although not shown in the views. Nose 44 includes a flex circuit board 54, plug interface contacts 56, front bottom sled 58 and front top sled 60. Figs. 1 and 2 are different from Fig. 6 in that they respectively show the two foil label designs 24, 28, whereas Fig. 6 illustrates an improved foil label 70 (see also Fig. 7) having a first side 72 and a mirror image second side 74, with a gap 76 therebetween. The design of rigid board 46 described herein works with all three of these foils 24, 28 and 70. Like foil 28, foil label 70 includes extensions 78 that help reduce coupling between plugs and PICs in adjacent jacks.

[00031] Crosstalk compensation components can be included on both PICs 56 and flexible board 54, as shown in Fig. 8 and Figs. 9-10, respectively. Referring particularly to Figs. 11 and 12, rigid board 46 also includes crosstalk compensation components (either the same or opposite of polarity of plug crosstalk components), which are identified particularly in Fig. 12, with the exception of C45. C45 improves return loss margin at higher frequencies in pair 4-5 by reducing the relatively high impedance of the second impedance region, as previously discussed. Although the return loss gets relatively worse at lower frequencies as a result of this modification, the overall margin improves over the frequency band of interest. Rigid board 46 includes lattice type compensation as also discussed in U.S. Provisional Patent Application Serial No. 61/090,403.

[00032] One of the novel aspects of the present invention is that it addresses a naturally unbalanced coupling which exists between all pairs and the foil label on the jack. The primary reason for this unbalance is shown in Fig. 6. The IDCs 48 that are near the edge of the jack (pins 5, 2, 6, 7) capacitively couple more strongly to the foil than the IDCs 48 (pins 4, 1, 3, 8) not near the edge of the jack. This is especially true on pair 4-5 and pair 1-2 where IDCs 5 and 2 are near the foil, and 1 and 4 are far away from it.

[00033] An embodiment of a rigid board solution for balancing the pairs with respect to the foil shield is shown in Fig. 11. In this embodiment rigid board 46 has four layers of conductive traces. The IDC vias receive and retain IDCs. The IDC vias are numbered 5-4-1-2 at the top of the board in Fig. 11, and 7-8-3-6 on the bottom edge of the board, and are also plated through holes which interconnect some of the traces on the various layers. Signals or noise can couple relatively strongly to foil label 70, particularly through the IDC vias and IDCs 5, 2, 6, 7. For pair 4-5, for example, IDC via 5 and IDC 5 are much closer to the foil label 70 than IDC via 4 and IDC 4 are. To balance this pair, conductive trace stub 90 is routed close to the edge of board 46 near the foil 70 and is connected to trace 4 (a conductive trace interconnecting PIC via 4 with IDC via 4). Stub 90 thereby balances conductor 4 with respect to conductor 5 and the foil. Additionally and/or alternatively, trace 4 can be routed relatively close to the edge of rigid board 46 to increase the coupling to foil 70. In the embodiment shown stub 90 is 0.008 inches wide by 0.220 inches long in one half ounce copper (approximately 0.0007 inches thick), although other thicknesses, widths and lengths are possible.

[00034] Similarly for pair 1-2, for example, IDC via 2 and IDC 2 are much closer to foil 70 than IDC via 1 and IDC 1 are. To balance this pair, conductive trace stub 92 is routed close to the edge of board 46 near the foil 70 and connected to trace 1 (conductive trace interconnecting PIC via 1 with IDC via 1) via plated through hole 94. Stub 92 is similar to stub 90; however, because of space limitations on rigid board 46, stub 92 is only 0.005 inches wide by 0.075 inches long, also in one

ounce copper (approximately 0.0014 inches thick plus additional plating to achieve a thickness between 0.002-0.0035), although other thicknesses, widths and lengths are possible. To compensate for this relatively short length the 12 pair is further balanced by moving trace 1 very close to the board edge (closer to foil 70), and plated through hole 94 provides significant surface area in a third dimension (board thickness) which also capacitively couples to foil 70, giving stronger coupling between conductor 1 and the foil 70, thereby balancing the 12 pair with respect to foil 70. Unplated through holes generally at 96 reduce capacitance between traces 4 and 5 closer to the area of NEXT compensation to lessen the effects of compensation elements on return loss, by better impedance matching.

[00035] The result of the pair balancing with respect to the foil, and the use of a split foil is illustrated in Fig. 13. The present invention achieves less common mode current I' on the foil due to pair balancing relative to the foil, and the split foil eliminates the low-loss path for propagation of the common mode current from adjacent jack to adjacent jack. The overall improvement in alien crosstalk margin has been shown to be at least 4 dB with the improvements of the present invention. Further, the present invention can be used advantageously with each of the symmetric foil designs of Figs. 1, 2, 6 and 14, although the designs of Figs. 1 and 2 would not have the characteristics and advantages of the split shield. Fig. 14 includes a continuous single piece foil with a gap in the metallization.

[00036] In other aspects of the present invention, through hole 100 (shown in Fig. 11) is meant to have the opposite effect as C45, and through hole 98 can be eliminated as unnecessary. The addition of capacitor C24 and elimination of C15 improves NEXT on pair combination 45-12, relative to the invention of U.S. Provisional Patent Application Serial No. 61/090,403. Some other comparisons to U.S. Provisional Patent Application Serial No. 61/090,403 are as follows. Using inductive trace L3, along with the new inductor L3L, connects trace 3 to C38 and uses the lattice compensation and improves 36-78 NEXT. Changing the orientation of L6 to move it further away from the side of the rigid board reduces coupling to the foil. Moving the location of C58 and C16 better accommodates the new artwork of the present invention.

[00037] The asymmetric foil designs of Figs. 15-17 typically require modifications to the balance circuitry shown in Fig. 11, such as smaller balance components on the side of rigid board 46 which have less, or no, conductive shielding. That is, smaller balance components are being provided on a particular portion of the rigid board that does not lie adjacent any conductive foil or shielding. Conceptually, each differential pair needs to achieve balance with each part of the foil so multiple foil parts require each foil part to be balanced with respect to the jack. Fig. 15 illustrates an

embodiment of the foil label where one side does not have any metal (note that the embodiment shown here could be flipped so the opposite side is metalized); Fig. 16 illustrates an embodiment of the foil label with areas selectively chosen for metallization; and Fig. 17 illustrates an embodiment of the foil label which is an L-shaped metalized foil where one side of the jack and the top or base are covered by the foil leaving one side without any covering. Note that the embodiment shown in Fig. 17 can be modified by making the opposite side with a foil and the side shown in Fig. 17 removed.

[00038] Alternative embodiments of the present invention include a jack with the circuit board of Fig. 11, but with a capacitor C15 between IDC vias 1 and 5, or a jack with the circuit board of Fig. 11, but with capacitor C24 completely removed from the board along with any traces connected to it. Another alternative embodiment of the present invention eliminates the flex board.

[00039] While this invention has been described as having a preferred design, the present invention can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles.

CLAIMS:

1. A jack for improving crosstalk attenuation, comprising:
 - a housing;
 - a foil at least partially enclosing the housing;
 - a printed circuit board;
 - first and second insulation displacement contacts, the first insulation displacement contact being located closer to the foil than the second insulation displacement contact, the first and second insulation displacement contacts being associated with a first differential signal; and
 - a first conductive trace stub routed proximate to an edge of the printed circuit board and configured to at least partially balance coupling from the first insulation displacement contact to the foil with coupling from the second insulation displacement contact to the foil for the first differential signal.
2. The jack for improving crosstalk attenuation of claim 1, further comprising a first via associated with the first insulation displacement contact and a second via associated with the second insulation displacement contact, the first conductive stub also configured to at least partially balance coupling from the first via to the foil with coupling from the second via to the foil for the first differential signal.
3. The jack for improving crosstalk attenuation of claim 2, further comprising a sled.
4. The jack for improving crosstalk attenuation of claim 3, further comprising a wire cap.
5. The jack for improving crosstalk attenuation of claim 4, further comprising plug interface contacts.
6. The jack for improving crosstalk attenuation of claim 1, further comprising signal traces on the printed circuit board associated with the first differential signal, a portion of the traces being located close to an edge of the printed circuit board in order to aid in balancing coupling from the first insulation displacement contact to the foil with coupling from the second insulation contact to the foil for the first differential signal.

7. The jack for improving crosstalk attenuation of claim 2, further comprising signal traces on the printed circuit board associated with the first differential signal, a portion of the traces being located close to an edge of the printed circuit board in order to aid in balancing coupling from the first insulation displacement contact and first via to the foil with coupling from the second insulation and second via contact to the foil for the first differential signal.
8. The jack for improving crosstalk attenuation of claim 1, further comprising:
third and fourth insulation displacement contacts, the third and fourth insulation displacement contacts being associated with a second differential signal, the third insulation displacement contact being closer to the foil than the fourth displacement insulation contact; and
a second conductive trace stub, the second conductive stub being routed proximate to an edge of the printed circuit board and configured to at least partially balance the coupling from the third insulation displacement contact to the foil with the coupling from the fourth insulation displacement contact to the foil for the second differential signal.
9. The jack for improving crosstalk attenuation of claim 8, further comprising a third via associated with the third insulation displacement contact and a fourth via associated with the fourth insulation displacement contact, the conductive stub also configured to at least partially balance the coupling from the third via to the foil with the coupling from the fourth via to the foil for the second differential signal.
10. The jack for improving crosstalk attenuation of claim 8, further comprising a sled.
11. The jack for improving crosstalk attenuation of claim 10, further comprising a wire cap.
12. The jack for improving crosstalk attenuation of claim 11, further comprising plug interface contacts.
13. The jack for improving crosstalk attenuation of claim 8, further comprising signal traces on the printed circuit board associated with the second differential signal, a portion of the traces being located close to an edge of the printed circuit board in order to aid in balancing coupling from the third insulation contact to the foil with coupling from the fourth insulation contact and the foil.
14. The jack for improving crosstalk attenuation of claim 9, further comprising signal traces on the printed circuit board associated with the second differential signal pair, a portion of the traces

being located close to an edge of the printed circuit board in order to aid in balancing coupling from the third insulation contact and third via to the foil with coupling from the fourth insulation contact and fourth via to the foil.

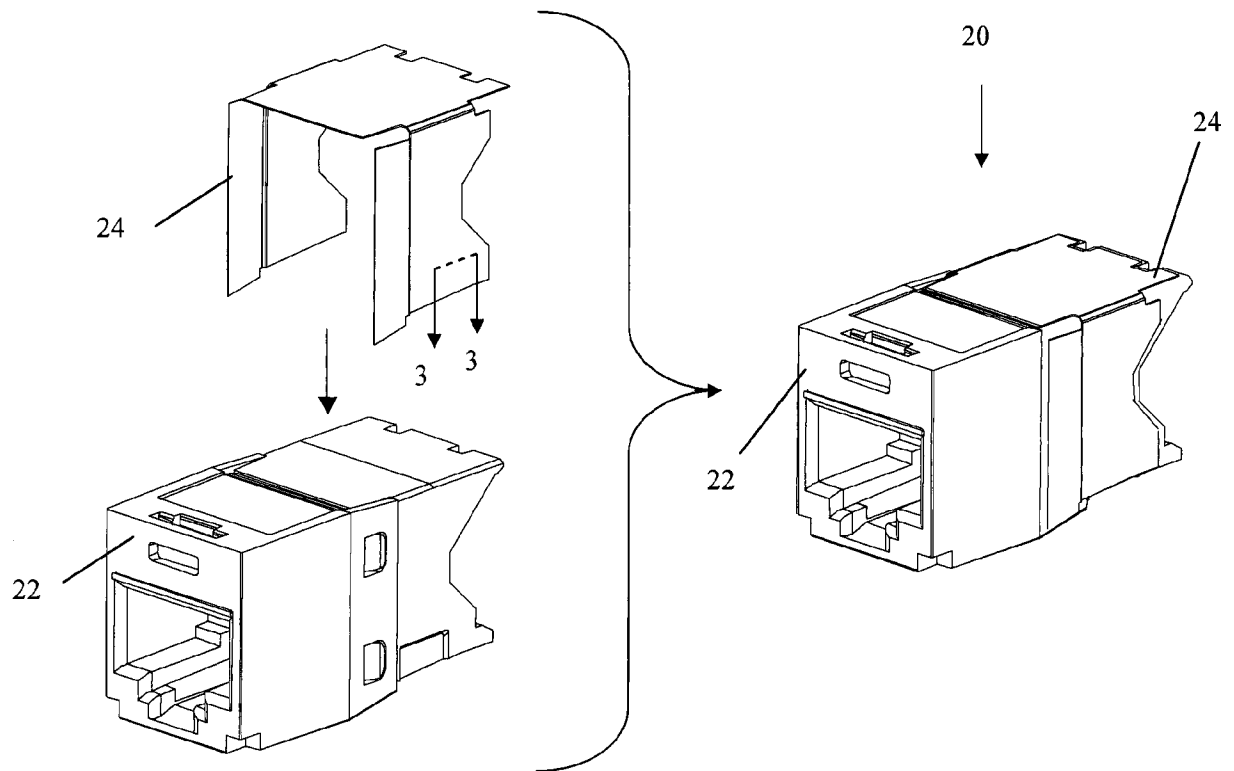


Fig. 1

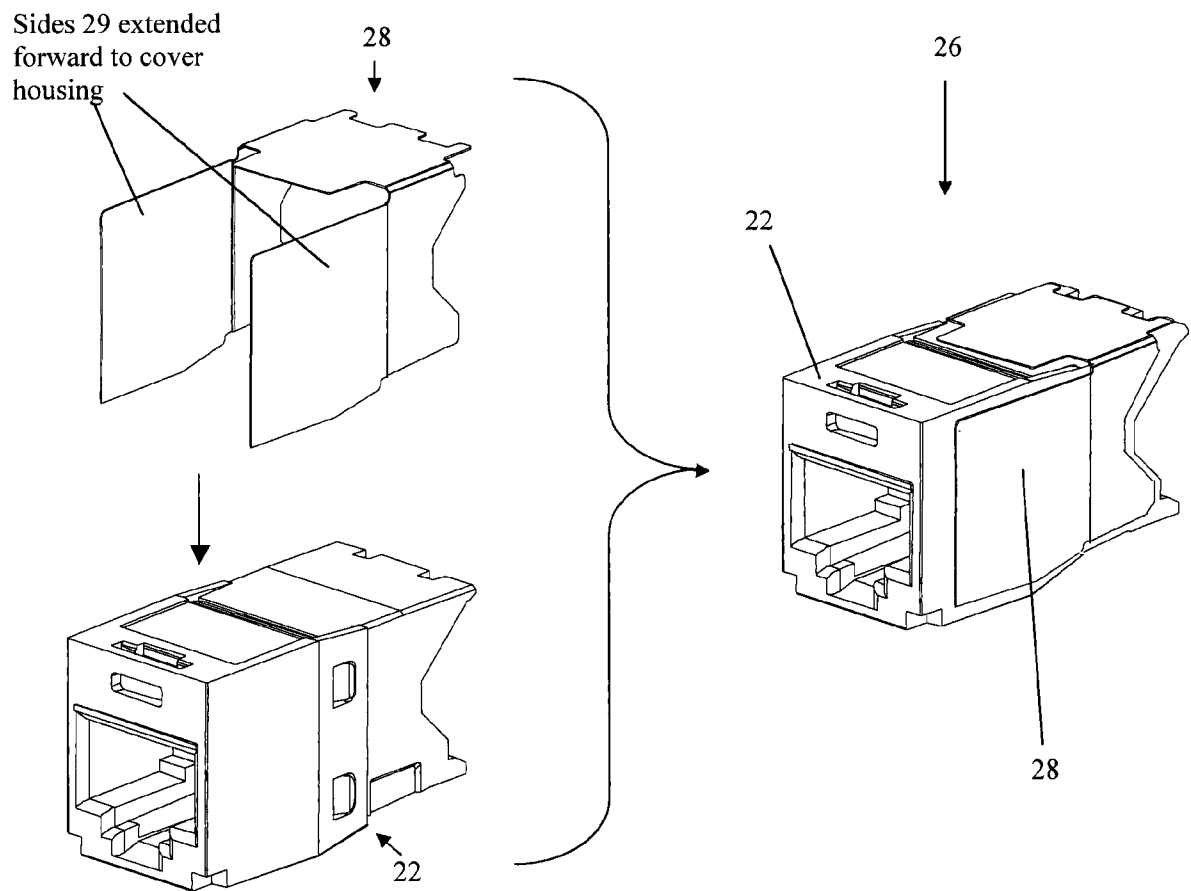


Fig. 2

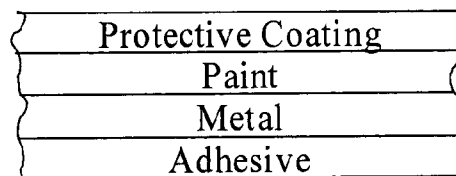
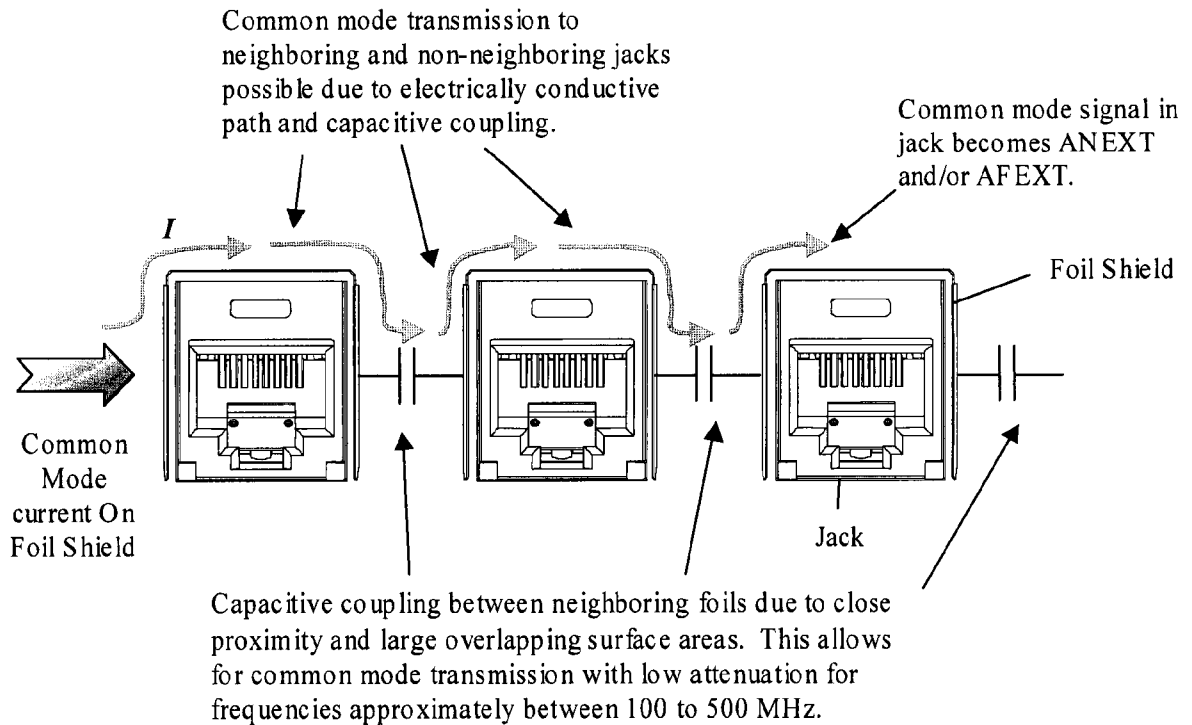


Fig. 3



Note: spacing of jacks is greatly enlarged for clarity, and the foil is shown slightly separated from the housing for illustrative purposes, whereas the foil is actually in contact with the housing. Further, the jack flares slightly from front to back which makes the sides of the foil look slightly thicker than the top in Fig. 5; however, the foil actually has a constant cross-section.

Fig. 4

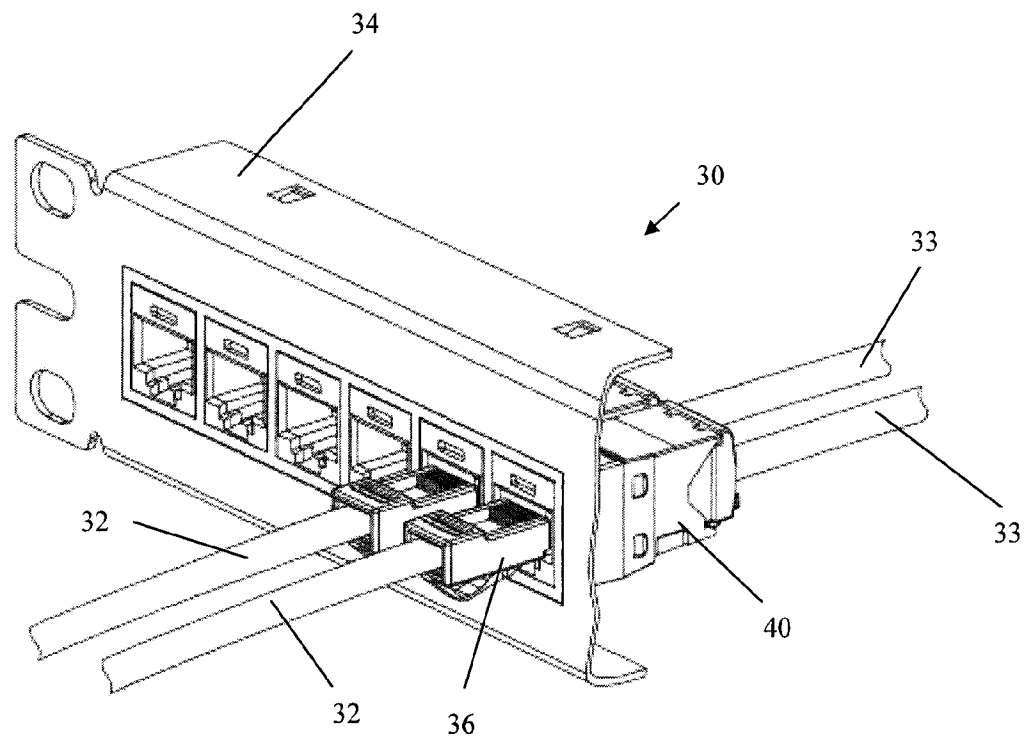


Fig. 5

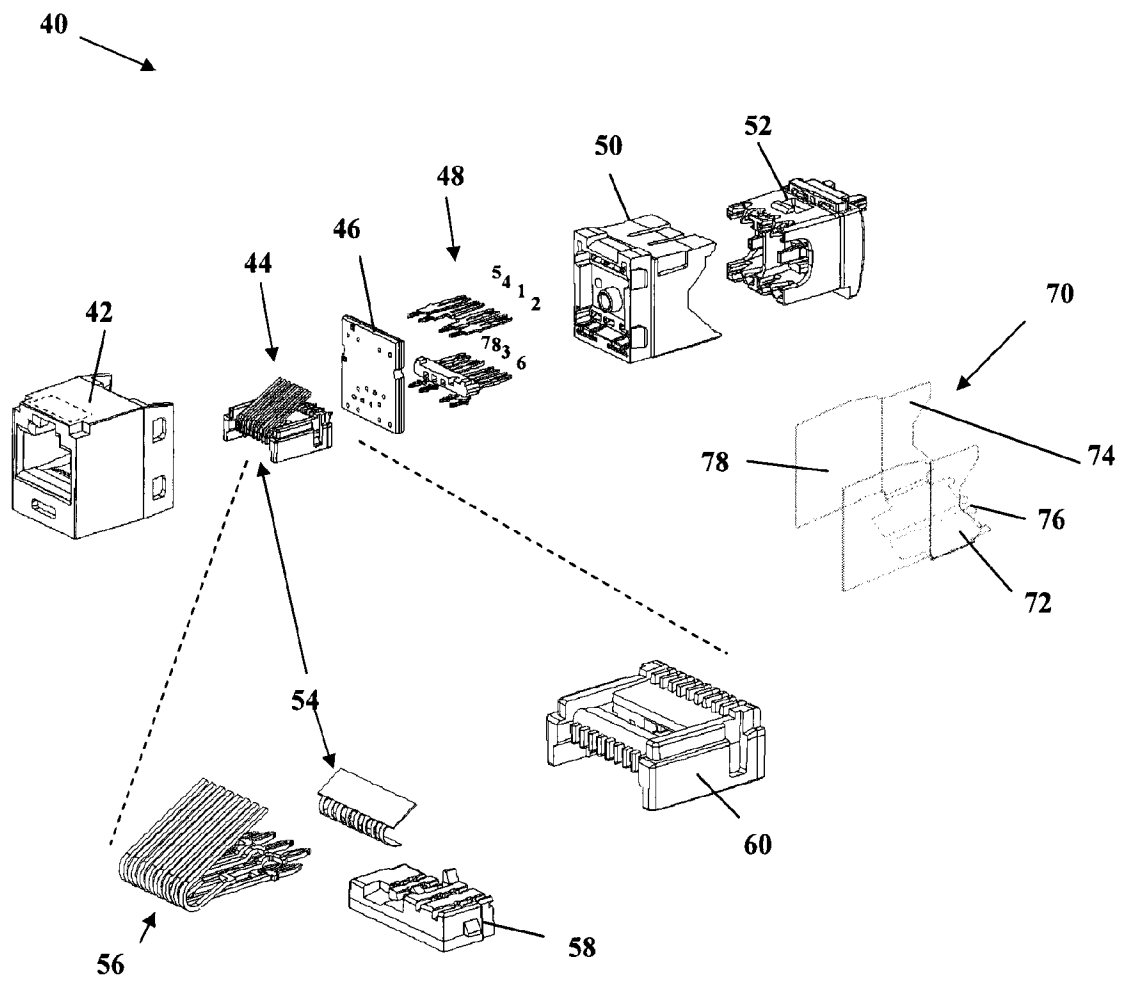


Fig. 6

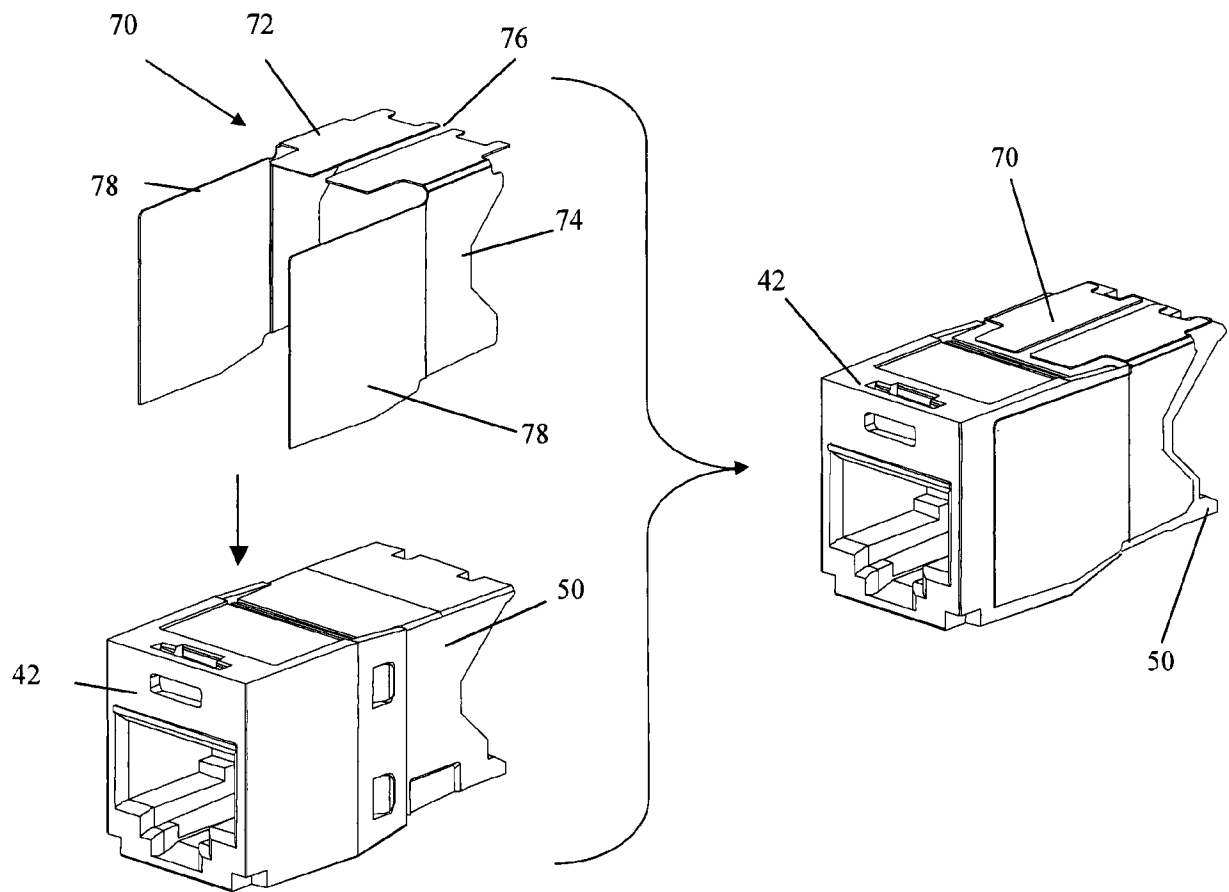


Fig. 7

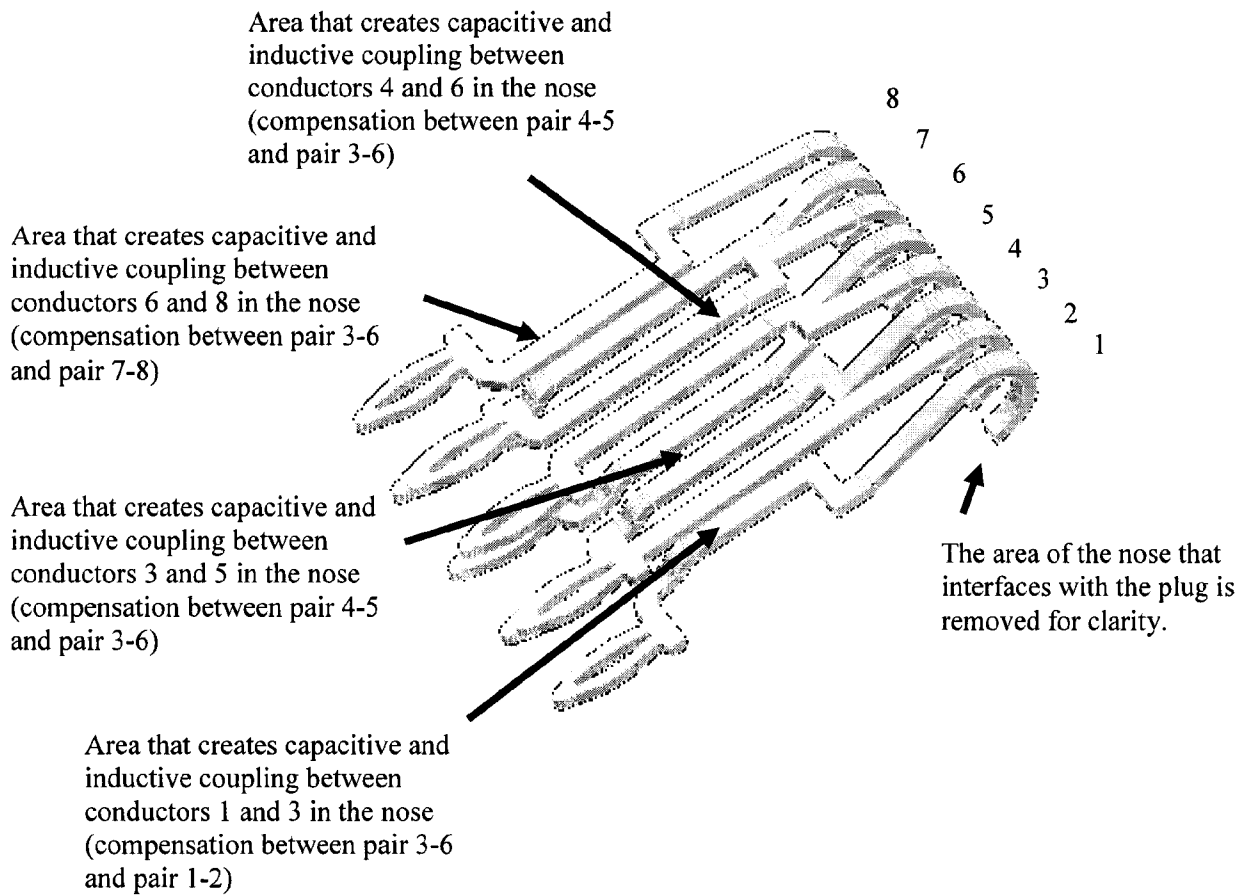
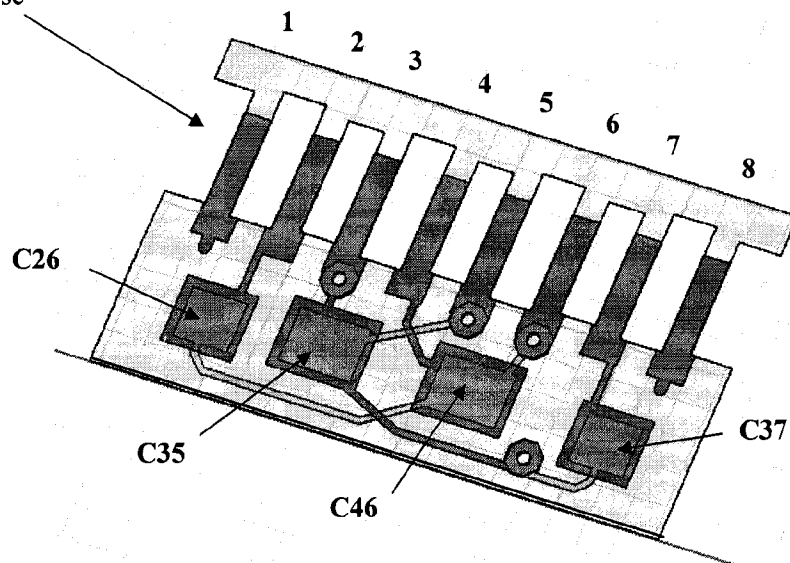


Fig. 8

Part of flex board that makes
contact with the nose



54

Fig. 9

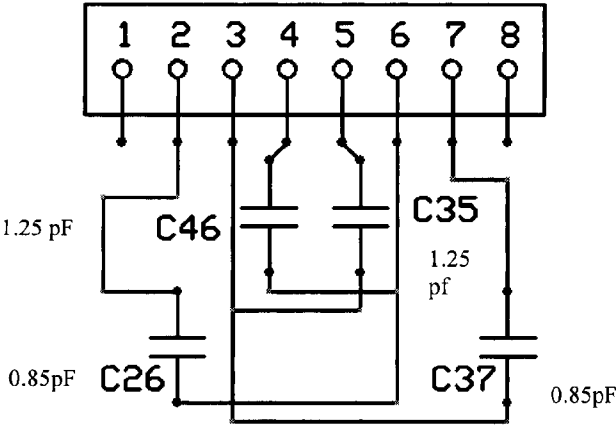


Fig. 10

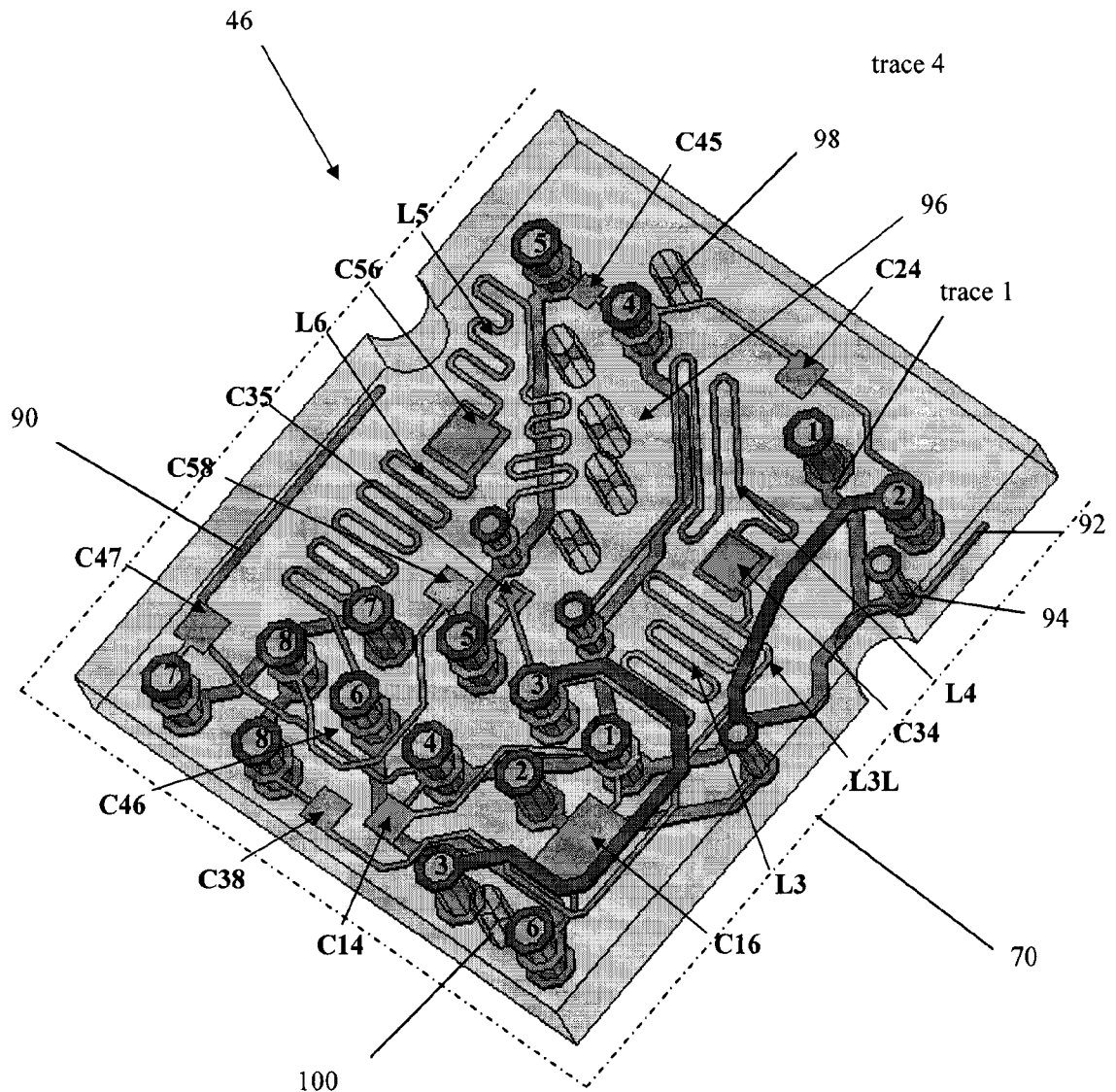


Fig. 11

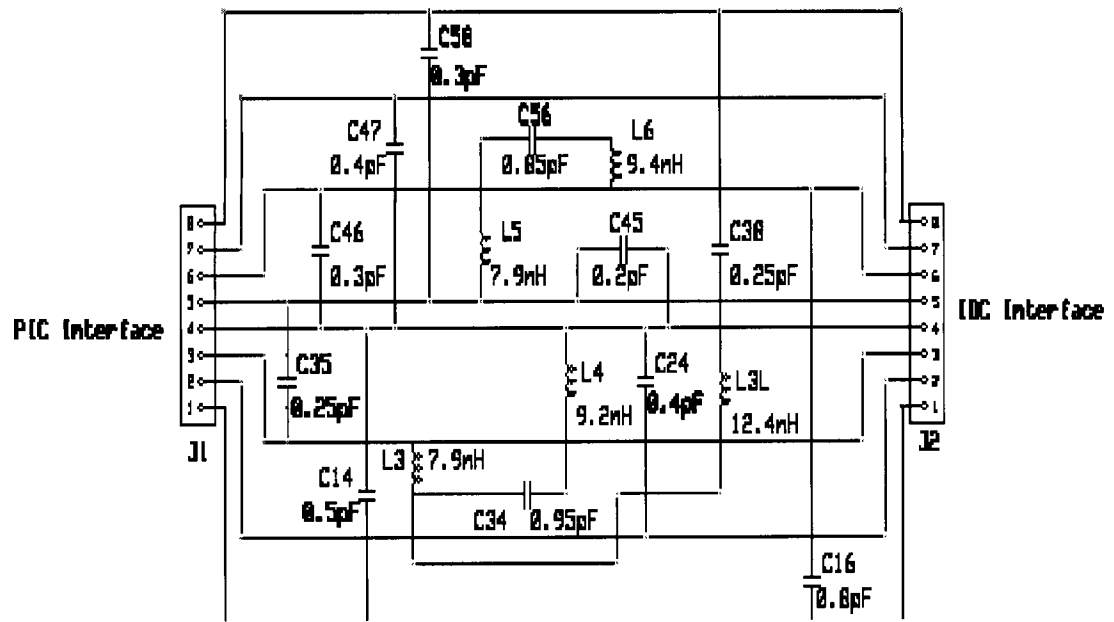
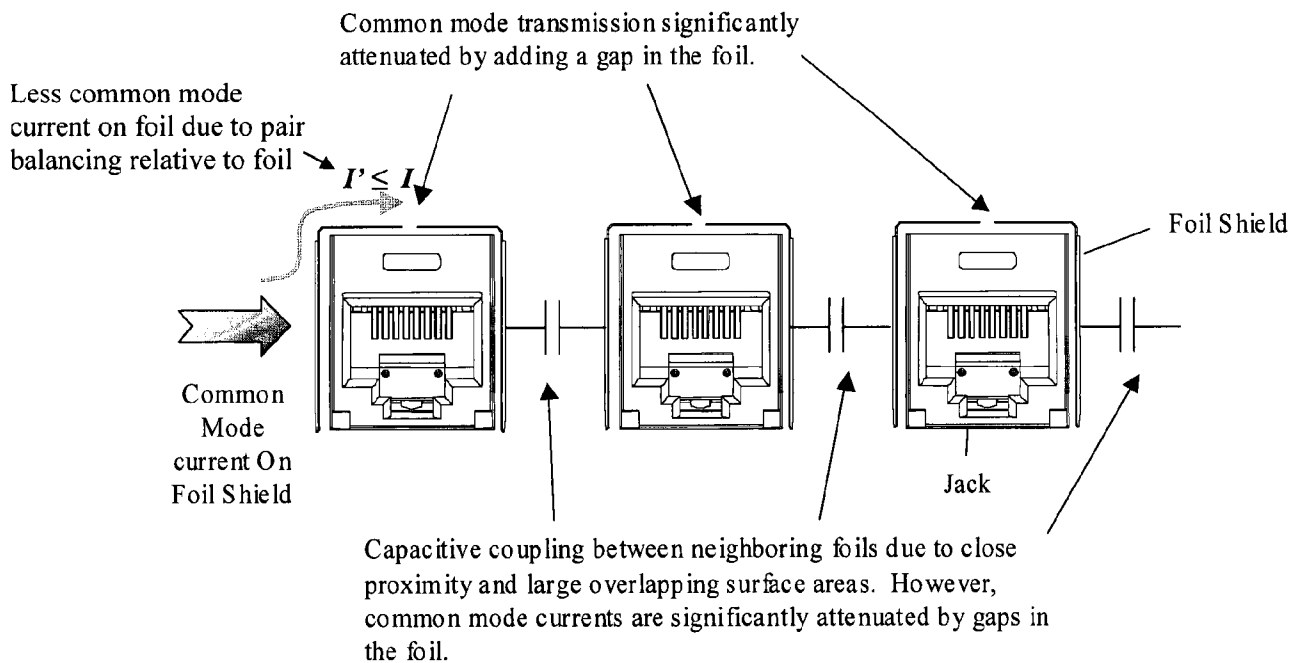


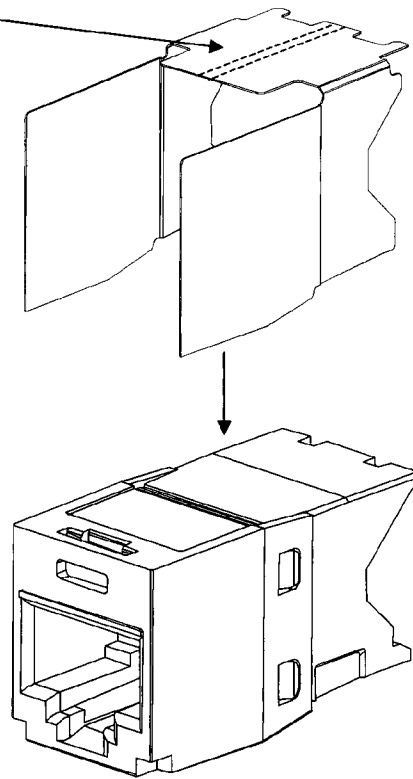
Fig. 12



Note: spacing of jacks is greatly enlarged for clarity, and the foil is shown slightly separated from the housing for illustrative purposes, whereas the foil is actually in contact with the housing. Further, the jack flares slightly from front to back which makes the sides of the foil look slightly thicker than the top in Fig. 5; however, the foil actually has a constant cross-section.

Fig. 13

Gap in metallization
connecting both halves
of the design has been
removed, but the overall
piece still appears as one
label



Almost identical
embodiment as described
in Figs. 6 and 7 but the foil
appears as a single
piece with a gap in the
metallization connecting
the 2 sides

Fig. 14

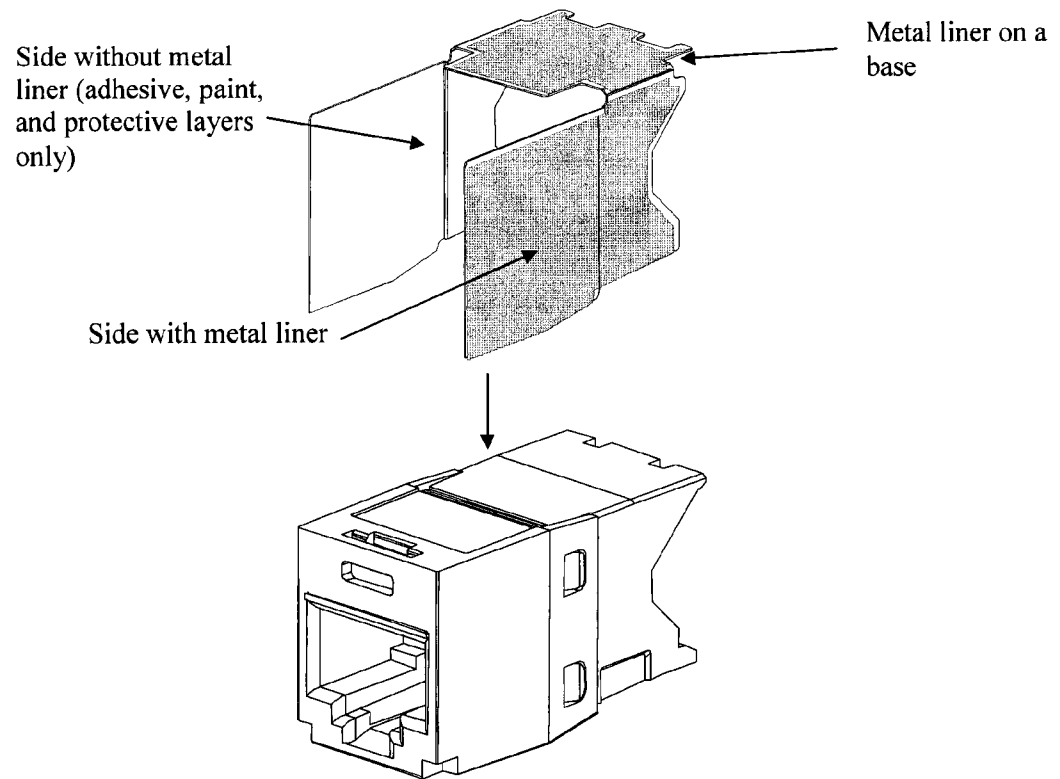


Fig. 15

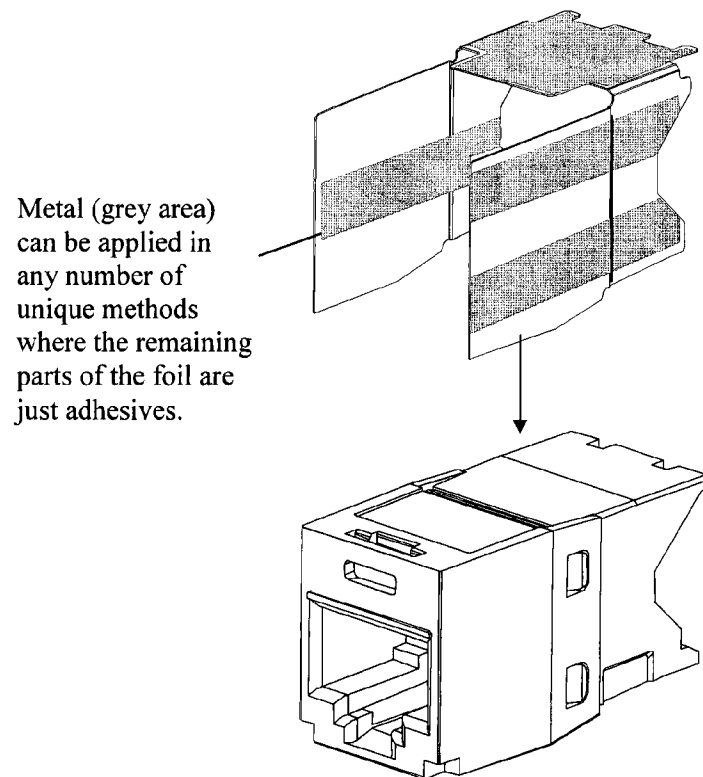


Fig. 16

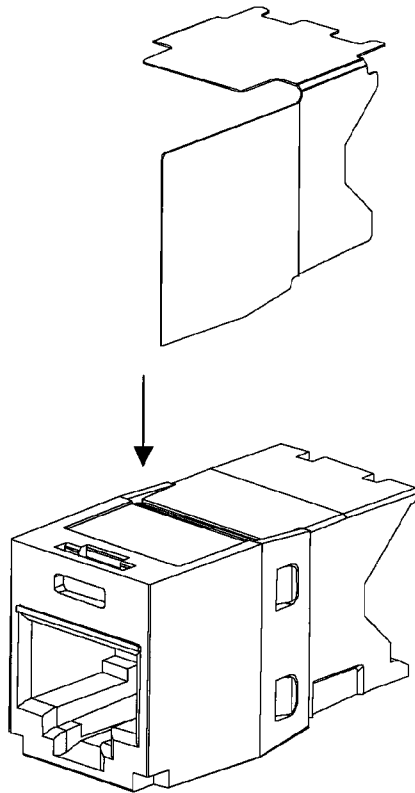


Fig. 17

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2009/066336

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01R24/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2006/134995 A1 (BOLOURI-SARANSAR MASUD [US] ET AL) 22 June 2006 (2006-06-22) cited in the application paragraph [0019] - paragraph [0025] -----	1-14
Y	EP 1 592 097 A2 (COMMScope SOLUTIONS PROPERTIES [US]) 2 November 2005 (2005-11-02) paragraph [0011] - paragraph [0030] -----	1-2, 6-9, 13-14
Y	EP 1 041 683 A1 (INFRA SA [FR]) 4 October 2000 (2000-10-04) paragraph [0021] - paragraph [0031] -----	3-5, 10-12



Further documents are listed in the continuation of Box C.



See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search

10 February 2010

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19/02/2010

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040,
 Fax: (+31-70) 340-3016

Authorized officer

Bertin, Michel

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Information on patent family members

International application No

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