United States Patent

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[54] **INTERDIGITAL STRIPLINE FILTER MEANS WITH THIN SHORTING SHIM**
10 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** ..... **333/73,** 333/84, 317/101, 339/19(Request), 29/600(Request), 29/629(Request)
[51] **Int. Cl.** **H01p 3/08,** H01p 11/00, H03h 13/00
[50] **Field of Search** ..... 333/73 (S), 84 (M); 317/101 (CC), 101 (CP); 333/73, 84, 3,000 (Inquired); 339/19 (Cursory)

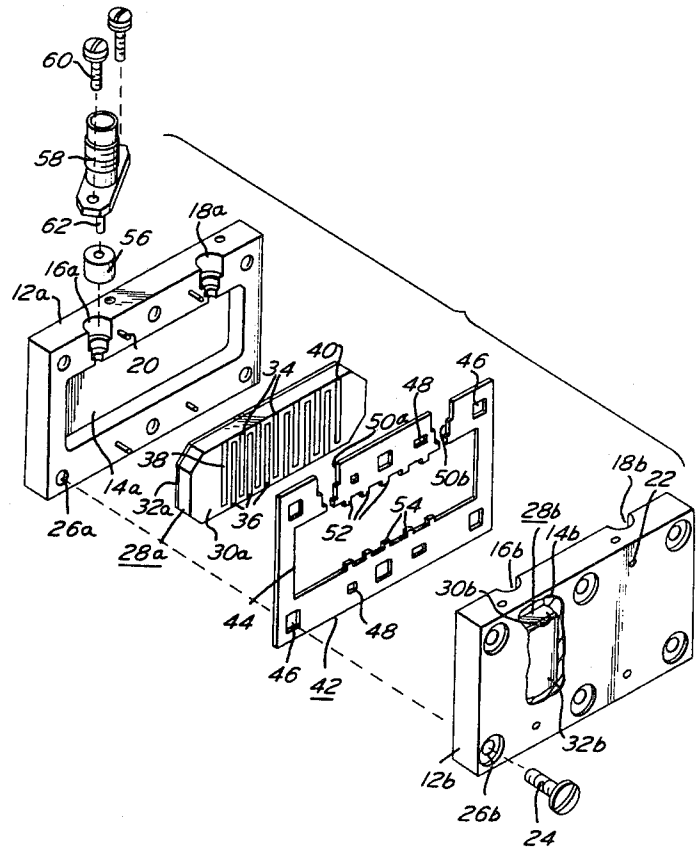
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ABSTRACT: A stripline interdigital filter means in which the stripline ground planes are metal layers on the outer surfaces of a pair of mating sheets of an insulating material, the resonator strips and coupling strips of the filter are a printed circuit on the mating surfaces of one of the insulating sheets, and the shorting member of the filter is a thin metal shim having shorting tabs extending between the mating surfaces of the insulating sheets and clamped against the resonator strips.



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SHEET 1 OF 2

FIG.1

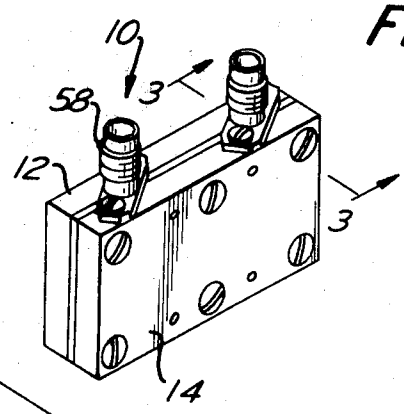


FIG.2

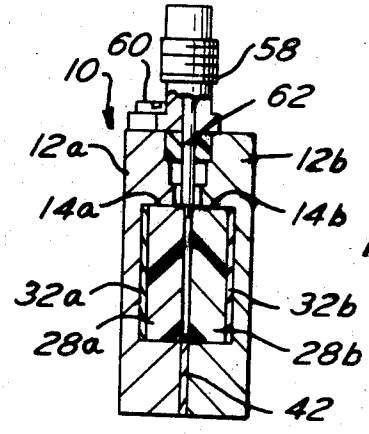


FIG.3

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FIG.5

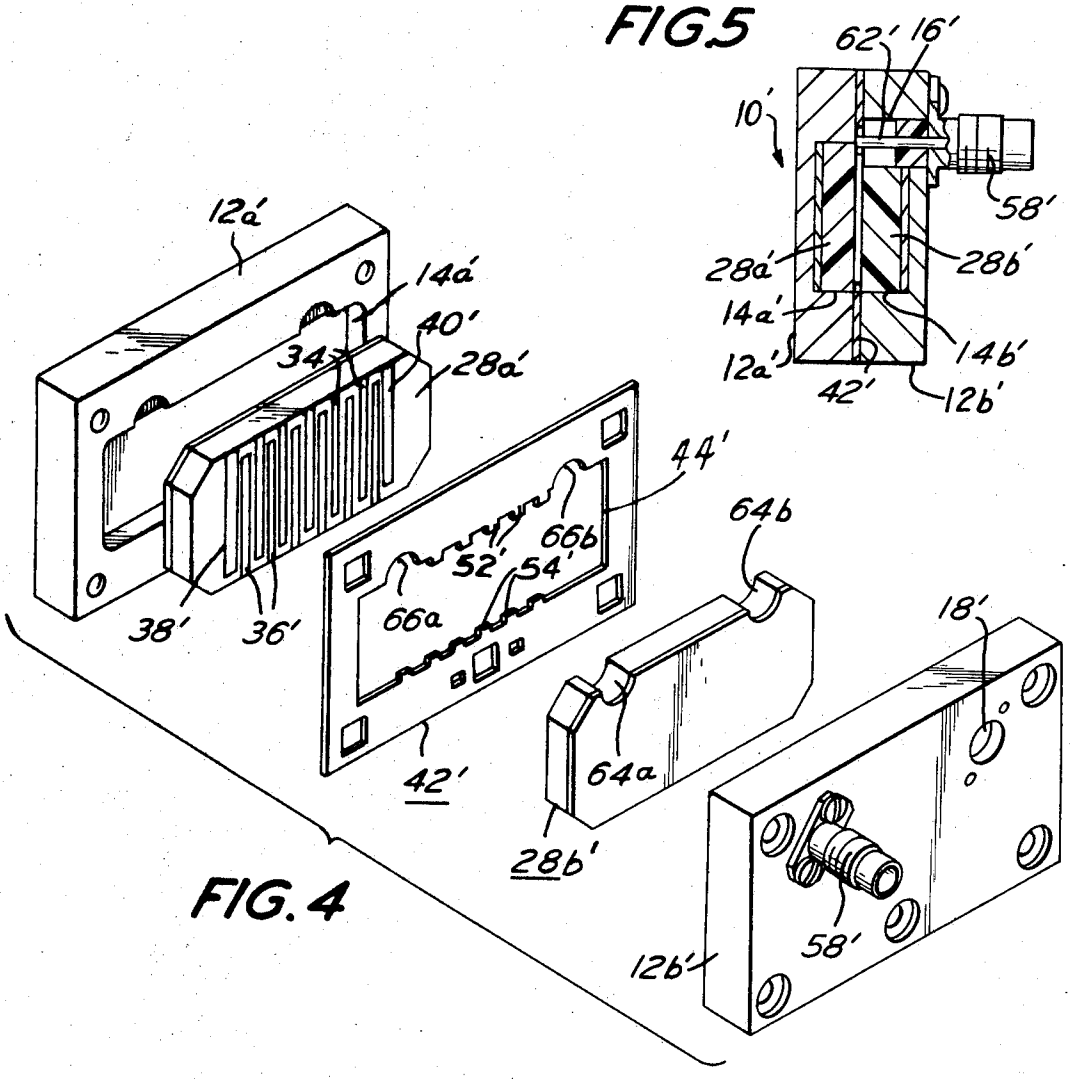


FIG. 4

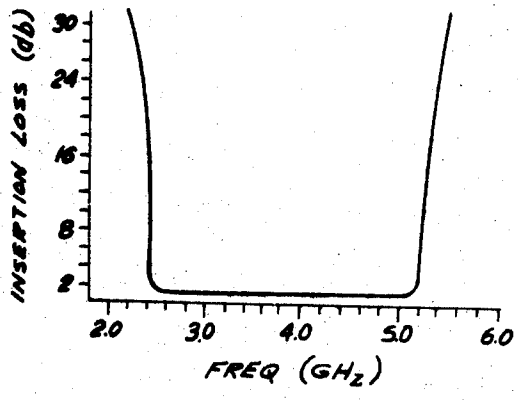
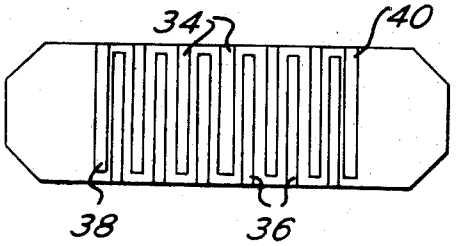


FIG.7

FIG.6



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INTERDIGITAL STRIPLINE FILTER MEANS WITH THIN SHORTING SHIM

The invention relates to electrical filter means and particularly stripline filter means employing printed circuits.

Interdigital filters are, in general, constructed of an array of metal stubs laid in spaced apart, side-by-side relation with alternate stubs being connected together by shorting bars extending across the ends of the connected stubs. This provides two sets of interdigited short-circuited stubs. Heretofore such filters have been constructed of machined, pressed or punched rods which are assembled together in the proper array. Since the electrical characteristics of such a filter are a function of the size and spacing between the interdigited stubs, the accuracy to which the stubs are formed and assembled is critical in order to achieve a filter having desired electrical characteristics. Since such filters have been formed of many parts which must be formed and assembled with great accuracy, the making of such filters has been a time consuming and expensive operation. Therefore, it is a principal object of the invention to provide a stripline interdigital filter construction formed of a minimum number of parts which can be easily and quickly assembled even by an unskilled person, and will still provide the desired electrical characteristics.

In order to achieve the above, as well as many more objects, the invention provides a stripline interdigital filter comprising a pair of metal housing bodies secured together and having opposed, mating surfaces. The housing bodies have opposed mating cavities in their mating surfaces. A separate stripline element is seated in each of the cavities. Each of the stripline elements comprises a sheet of insulating material having a metal film extending over and secured to the surface of the insulating sheet facing the bottom of the cavity. The other surface of the insulating sheet of one of the stripline elements has thereon a printed circuit interdigited array of filter resonator strips and a pair of coupling strips. A thin metal shorting shim is clamped between the mating surfaces of the housing bodies and extends around the stripline elements. The shorting shim has a plurality of tabs extending between the mating surfaces of the stripline elements with each of the tabs being clamped against a separate one of the resonator strips. A pair of coaxial conductors are mounted on at least one of the housing bodies. Each of the conductors has a conductor pin extending into contact with a separate one of the coupling strips on the stripline element.

For the purpose of illustrating the invention there is shown in the drawings forms which are presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIG. 1 is a perspective view of the stripline filter means of the present invention.

FIG. 2 is an exploded perspective view of the stripline filter means of FIG. 1.

FIG. 3 is a sectional view taken on line 3–3 of FIG. 1.

FIG. 4 is an exploded perspective view of a modification of the stripline filter means of the present invention.

FIG. 5 is a transverse sectional view of the assembled stripline filter means of FIG. 4.

FIG. 6 is a front plan view of the printed-circuit element of the stripline filter means of the present invention.

FIG. 7 is a curve showing the electrical characteristics of the stripline filter means of the present invention.

Referring initially to FIGS. 1—3 inclusive, the stripline filter means 10 of the present invention comprises a pair of rectangular, metal housing bodies 12*a* and 12*b*. The housing bodies 12*a* and 12*b* have rectangular cavities 14*a* and 14*b* respectively in their opposed inner flat surfaces. A pair of spaced semicylindrical recesses 16*a* and 18*a* extend across the inner surface of the housing body 12*a* from the upper edge of the housing body to the cavity 14*a*, and a corresponding pair of spaced, semicylindrical recesses 16*b* and 18*b* extend across the inner surface of the housing body 12*b* from the upper edge thereof to the cavity 14*b*. The cavities 14*a* and 14*b*, recesses 16*a* and 16*b*, and recesses 18*a* and 18*b* are positioned so as to

be in opposed mating relation when the housing bodies 12*a* and 12*b* are brought together. The recesses 16*a*, 16*b*, 18*a* and 18*b* are stepped in diameter having portions of largest diameter adjacent the upper edges of the housing bodies, and portions of smallest diameter adjacent the cavities. A plurality of spaced-apart aligning pins 20 are secured to and project from the inner surface of the housing body 12*a*, and are adapted to fit into aligning holes 22 in the housing base 12*b* to properly align the housing bases with respect to each other when they are brought together. Screws 24 are adapted to extend through holes 26*b* in the housing base 12*b* and to be threaded into threaded holes 26*a* in the housing base 12*a* to secure the housing bases together. Holes 26*b* are counterbored at the outer surface of the housing base 12*b* so as to receive the heads of the screws 24.

A stripline and filter element 28*a* fits in the cavity 14*a* in the housing body 12*a*, and a stripline element 28*b* fits in the cavity 14*b* in the housing body 12*b*. Stripline and filter element 28*a* comprises a rigid, substantially rectangular sheet 30*a* of an electrical insulating material, such as a plastic, of a size and thickness equal to the size and depth of the cavity 14*a*. The corners of the sheet 30*a* are cut off to provide for greater ease of inserting and removing the stripline and filter element 28*a* from the cavity 14*a*. A thin layer 32*a* of an electrically conductive metal, such as copper, extends over and is secured to one surface of the sheet 30*a*. The metal layer 32*a* may be suitably plated on the surface of the sheet 30*a*, or may be a thin metal foil bonded to the sheet 30*a* by a suitable cement. The metal layer 32*a* provides one ground plane of the stripline.

Two sets of narrow strips 34 and 36 of an electrically conductive metal, such as copper, are secured to and extend transversely across the other surface of the sheet 30*a* parallel to but spaced from each other. The strips 34 and 36 are arranged along the sheet 30*a* in alternating relation with the strips 34 extending from a first edge of the sheet 30*a* to a point short of the second opposite edge, and the strips 36 extending from the second edge to a point short of the first edge. The strips 34 and 36 provide the resonator bars of an interdigital band pass filter. Input and output coupling strips 38 and 40 of an electrically conductive metal extend across the sheet 30*a* at respective ends of and parallel to the resonator bars 34 and 36. The coupling strips 38 and 40 extend from the first edge of the sheet 30*a* to a point short of the second opposite edge. The spacing between the coupling strips 38 and 40 is equal to the spacing between the conductor recesses 16*a* and 18*a* in the housing body 12*a*.

The resonator strips 34 and 36 and the coupling strips 38 and 40 are formed by any of the well-known techniques for forming a printed circuit. For example, a layer of the metal is applied over the entire surface of the sheet 30*a* either by plating the metal on the sheet or by bonding a metal foil to the sheet by a suitable cement. A resist material is coated on the surface of the metal film over the areas which will provide the resonator strips 34 and 36 and the coupling strips 38 and 40. The uncoated portions of the metal film is removed, such as by chemical etching, leaving the resonator strips and coupling strips. The resist material is then removed.

As shown in FIG. 6, the coupling strips 38 and 40 are slightly wider than the resonator strips 34 and 36, and are spaced closer to their adjacent resonator strips than the spacing between the interleaved resonator strips. The resonator strips 34 and 36 and the coupling strips 38 and 40 are made approximately one-quarter wavelength of the midband frequency. The spacing between the resonator strips is critical since the bandwidth is a function of this spacing. The spacing between the resonator strips is symmetrical about the centermost resonator strip with the spacing between the end strips being slightly less than the spacing between the center strips.

The stripline element 28*b* comprises a rectangular, rigid sheet 30*b* of an electrical insulating material of the same size and shape as the sheet 30*a* of stripline and filter element 28*a*. A thin layer 32*b* of an electrically conductive metal, such as

copper, extends over and is secured to one surface of the sheet 30*b*. The metal layer 32*b* may be suitably plated on the sheet 30*b*, or may be a thin metal foil bonded to the sheet by a suitable cement. The metal layer 32*b* provides the other ground plane of the stripline. The stripline elements 28*a* and 28*b* are mounted in the cavities 14*a* and 14*b* of the housing bases 12*a* and 12*b* with the ground planes 32*a* and 32*b* being seated against the bottom of the cavities.

A shorting shim 42 is mounted between the mating surfaces of the housing bodies 12*a* and 12*b*. Shorting shim 42 comprises a thin, rectangular foil of an electrically conductive metal, such as copper, of the same dimensions as the mating surfaces of the housing bodies. The shorting shim 42 has a rectangular opening 44 therethrough of the same dimensions as the cavities 14*a* and 14*b*. Holes 46 are provided through the shim 42 to permit the screws 24 to pass therethrough, and smaller alignment holes 48 are provided to receive the aligning pins 20. A pair of spaced gaps 50*a* and 50*b* extend trough the shim 42 from the upper edge thereof to the edge of the opening 44. The gaps 50*a* and 50*b* are positioned and shaped to correspond with the conductor recesses 16*a* 16*b* and 18*a* and 18respectively in the housing bodies 12*a* and 12*b*.

A plurality of spaced tabs 52 extend downwardly from the upper edge of the opening 44 in the shim 42, and a plurality of spaced tabs 54 extend upwardly from the lower edge of the opening 44. The number and positioning of the tabs 52 correspond to the number and positioning of the resonator strips 34 of the stripline and filter element 28*a*. The number and positioning of the tabs 54 correspond to the number and positioning of the resonator strips 36. Thus, when the shim 42 is clamped between the housing bodies 12*a* and 12*b*, the tabs 52 and 54 extend over the ends of their respective resonator strips 34 and 36, and are clamped into contact with the resonator strips by the stripline element 28*b*.

When the housing bodies 12*a* and 12*b* are clamped together, the conductor recesses 16*a* and 18*a* in the housing body 12*a* mate with the conductor recesses 16*b* and 18*b* in the housing body 12*b* to provide a pair of cylindrical conductor openings. An electrical insulator 56 having a hole therethrough is seated in the upper portion of each of the conductor openings. A pair of coaxial conductors 58 are mounted on the upper edges of the housing bodies 12*a* and 12*b* by screws 60 with each of the conductors being in alignment with a separate one of the conductor openings. Each of the conductors 58 has a conductor pin 62 extending through its respective conductor opening and contacting one of the coupling strips 38 or 40 of the stripline and filter element 28*a*.

The printed-circuit-type of construction of the stripline and filter element 28*a* of the present invention provides for greater ease of making the filter element with very high accuracy of the positioning of the resonator and coupling strips. Since the dimensions and spacing of the resonator strips is critical in order to obtain the desired electrical characteristics of the filter, the ease with which these elements can be formed with a high degree of accuracy is an important factor in the manufacture of this type of filter. Even though the resonator strips are very thin, they provide a filter having excellent electrical characteristics as shown in FIG. 7.

The printed circuit construction of the stripline and filter element 28*a* and the shorting shim construction of the present invention also provides a stripline filter which can be easily and quickly assembled even by an unskilled person. To assemble the stripline filter 10 of the present invention at the stripline elements 28*a* and 28*b* are first inserted in the cavities 14*a* and 14*b* of their respective housing bodies 12*a* and 12*b* with the metal ground planes 32*a* and 32*b* facing the bottom of the cavities. The shorting shim 42 is then placed on the inner surface of the housing body 12*a* with the shim being properly aligned by the aligning pins 20 fitting through the alignment holes 48. The housing body 12*b* is then mounted on the housing body 12*a* with proper alignment being achieved by the aligning pins 20 fitting into the aligning holes 22. The screws 24 are inserted and tightened to secure the housing bodies 12*a* and 12*b* together. This automatically clamps the shorting tabs 52 and 54 between the stripline elements 28*a* and 28*b* and in electrical contact with the resonator strips 34 and 36. The insulators 56 are inserted in the conductor openings, and the conductors 58 are mounted on the housing bodies 12*a* and 12 to complete the assembly.

Referring to FIGS. 5 and 6, a modification of the stripline filter means of the present invention is generally designated as 10′. Stripline filter means 10′ is of the same construction as the stripline filter means 10 of FIGS. 1—3 except as to the manner of mounting the coaxial conductors 58′.

In the stripline filter means 10′, the conductor holes 16′ and 18′ extend through the housing body 12*b*′ from the outer surface to the inner surface with the bottom one-half of each of the conductor holes extending horizontally directly into the cavity 14*b*′. The stripline element 28*b*′, which is seated in the cavity 14*b*′ in the housing body 12*b*′, has a pair of semicylindrical notches 64*a* and 64*b* in its upper edge which are in alignment with the conductor holes 16′ and 18′ respectively. The shorting shim 42′ has a pair of semicylindrical notches 66*a* and 66*b* in the upper edge of the opening 44′ therethrough which are also in alignment with the conductor holes 16′ and 18′. The conductor pins 62′ extend through the holes 16′ and 18′, the notches 64*a* and 64*b* in the stripline element 28*b*, and the notches 66*a* and 66*b* in the shim 42′. The ends of the conductor pins 62′ contact the coupling strips 38′ and 40′ of the stripline and filter element 28*a*′. As in the stripline filter means 10 of FIGS. 1—3, the shorting tabs 52′ and 54′ of the shorting shim 44′ are clamped between the stripline and filter element 28*a*′ and the stripline element 28*b*′, and are held in contact with the resonator strips 34′ and 36′. The construction of the stripline filter means 10′ provides for greater ease of making contact between the conductor pins 62′ and the coupling strips 38′ and 40′. Also, it provides a completely one piece shorting shim 42′ which is easier to handle during the assembling of the stripline filter means.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

I claim:

1. A stripline filter means comprising a pair of sheets of an electrical insulating material having inner opposed mating surfaces, conductive means extending along the outer surface of each of said sheets, said conducting means providing the ground planes of the stripline filter means, a plurality of thin narrow strips of an electrically conductive metal secured to and extending across the mating surface of one of said sheets in side-by-side spaced parallel relation, said strips providing the resonators of the stripline filter means, a pair of narrow coupling strips of an electrically conductive metal secured to and extending across the mating surface of said one sheet parallel to said resonator strips, each of said coupling strips being at an opposite end of the array of the resonator strips, a thin shorting shim of an electrically conductive metal extending around the periphery of said sheets, said shorting shim having a plurality of spaced tabs extending between the mating surfaces of said sheets with each of said tabs contacting a separate one of said resonator strips and electrically connecting together a plurality of said resonator strips, means securing said sheets together with the shorting shim tabs being clamped between said sheets and into contact with their respective resonator strips, and a pair of conductors each electrically connected with a respective one of the coupling strips.

2. The means of claim 1 in which the shorting shim has two sets of tabs, one set of the tabs extending between said sheets from one edge of the sheets and contacting alternate resonator strips, and the other set of tabs extending between said sheets from the opposite edge of the sheets and engaging the other resonator strips.

3. The means of claim 1 in which said pair of conductors each have a conductor pin extending into contact with a respective one of said coupling strips.

4. The means of claim 1 in which said conductive means comprises first and second layers of electrically conducting metal respectively extending over and secured to the outer surface of each of said sheets.

5. The means of claim 4 in which the means securing the sheets together comprises a pair of housing bodies having opposed mating surfaces, opposed mating cavities in the mating surfaces of the housing bodies, each of said sheets being seated in a separate one of said cavities with the ground plane layer facing the bottom of the cavity, and means securing said housing bodies together.

6. The means of claim 5 in which the shorting shim is clamped between the mating surfaces of said housing bodies.

7. The means of claim 6 in which a plurality of alignment pins are secured to and extend perpendicularly from the mating surface of one of said housing bodies, the shorting shim and the mating surface of the other housing body each has alignment holes therethrough through which the alignment pins extend to align the housing bodies and the shorting shim with respect to each other.

8. The means of claim 7 in which the mating surface of each of said housing bodies has a pair of spaced conductor recesses extending from an edge of the housing body to an edge of the cavity, each of the conductor recesses in one of the housing

bodies being in opposed mating relation with a separate one of the conductor recesses in the other housing body, the conductors are mounted on said edges of the housing bodies with each conductor being in alignment with a respective set of mating conductor recesses, said conductors each having a conductor pin extending through its said conductor recess into contact with its respective coupling strip.

9. The means of claim 8 in which the shorting shim is broken along the edges of the two sets of the conductor recesses.

10. The means of claim 7 in which one of the housing bodies has a pair of spaced conductor holes extending therethrough from its outer surface and opening into the cavity in said one housing body, the sheet in the cavity of said one housing body has a pair of spaced notches in an edge thereof with each notch being in alignment with a separate one of said conductor holes, the conductors are mounted on the outer surface of said one housing body with each conductor being in alignment with a separate one of the connector holes, said conductors each having a conductor pin extending through its said conductor hole and the notch in said sheet into contact with its respective coupling strip.