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[54] STRIP TRANSMISSION LINE COUPLER

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[52] **U.S. Cl.**.......... **339/17 M**, 333/84 M, 339/177 R
[51] **Int. Cl.**........................... **H01p 3/08**, H05k 1/10
[58] **Field of Search**................. 339/17 R, 17 M, 14, 339/177 R, 177 E, 59; 333/84 M, 84 R, 97, 33

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[57] **ABSTRACT**

A coupling device for electrically connecting a strip transmission line to another transmission line, said device comprising a conductive shell having pressure means for forming electrically smooth connections with the ground planes of the strip transmission line and aperture means for permitting the center conductor of the strip transmission line to extend insulatingly into the shell, and a center pin symmetrically disposed in the shell and having means for electrically contacting the center conductor of the strip transmission line.

10 Claims, 4 Drawing Figures

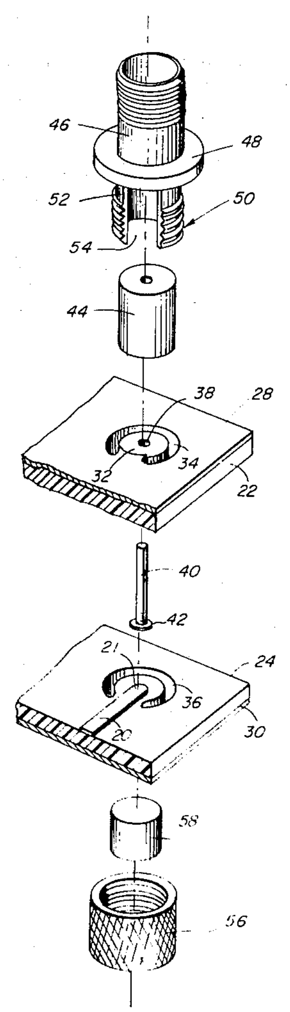
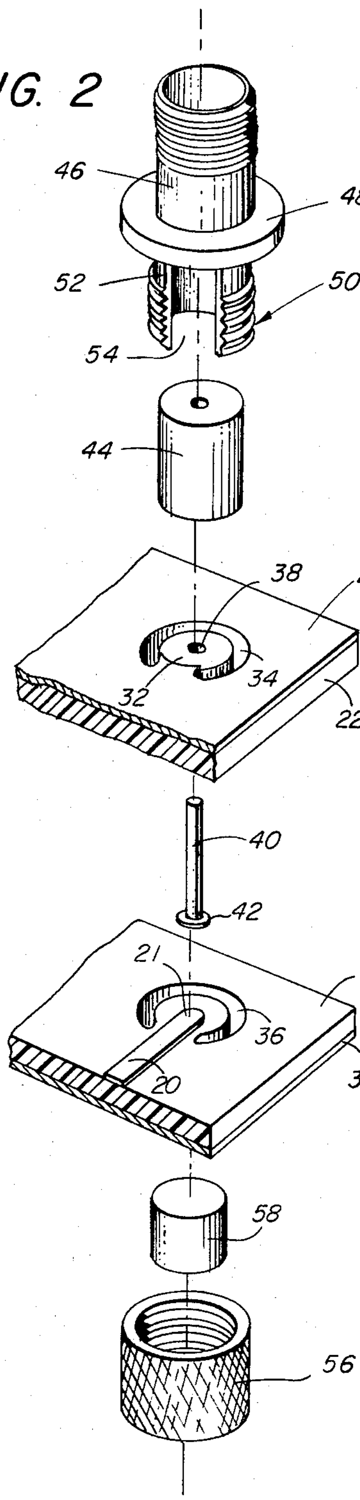


FIG. 2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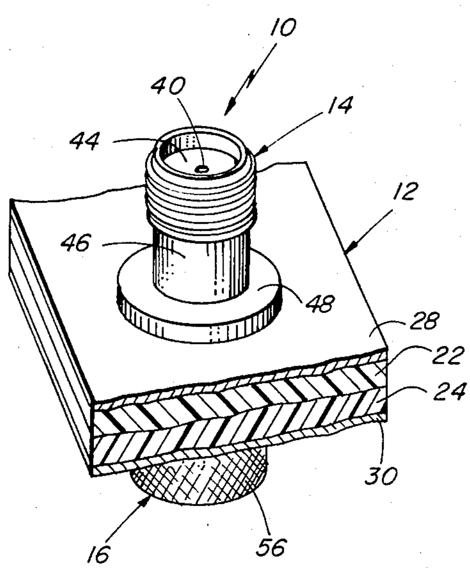
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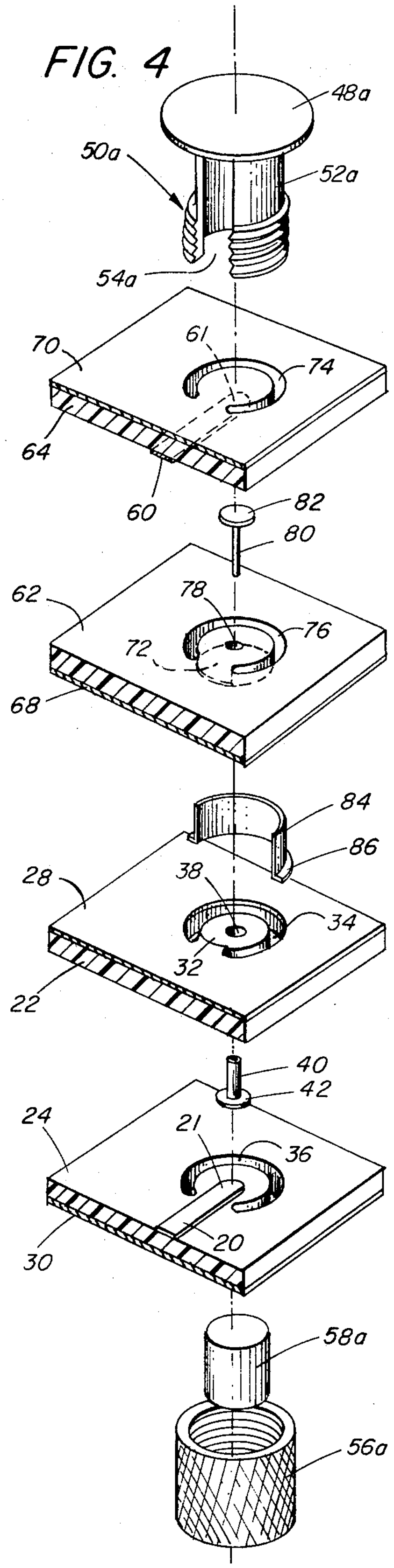
FIG. 1

FIG. 4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50a
52a
54a
70
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60
82
80
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34
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58a
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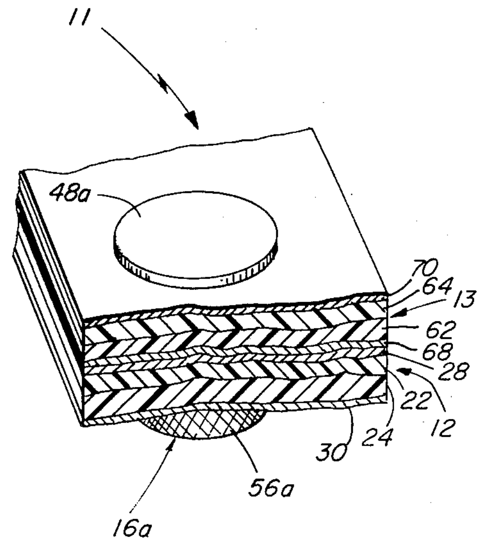
11
48a
70
64
13
62
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56a
16a

FIG. 3

STRIP TRANSMISSION LINE COUPLER

BACKGROUND OF THE INVENTION

This invention relates generally to electrical connectors, and is concerned more particularly with a coupling device for electrically connecting a strip transmission line to another transmission line.

A strip transmission line generally comprises a center strip conductor sandwiched between two, comparatively wide, dielectric panels which have their broad outer surfaces clad with conductive material to form spaced opposing ground planes. The center strip conductor advantageously may be formed on the inner broad surface of one of the panels by utilizing printed circuit techniques. Then, the inner broad surfaces of both panels may be clamped together thereby positioning the center strip conductor symmetrically between the ground planes. The resulting compact structure, among other advantages, makes the strip transmission line especially suitable for transmitting microwave frequencies, such as in the one-to-ten gigahertz range, for example. When transmitting microwave energy, a strip transmission line generally is operated in the TEM mode whereby the microwave signals follow the center conductor while passing longitudinally between the opposing surfaces of the ground planes.

A strip transmission line may be energized by microwave signals emanating from another transmission line having a dissimilar structure, such as a coaxial type transmission line, for example. Furthermore, output signals from the strip transmission line may be fed to the input of a third transmission line, such as another strip transmission line, for example. Thus, there are numerous occasions where a microwave coupling device or connector is required to establish a low-loss, transitional junction between a strip transmission line and another transmission line. However, if the transitional junction constitutes a variation in line impedance where reflected waves are generated, standing waves may be set up which have an adverse effect on the voltage standing wave ratio (USWR) and result in a corresponding loss of power in the line. Also, the transitional junction may excite higher propagation modes which tend to transmit microwave energy away from the center conductor thereby draining power from the line. Therefore, in order to reduce power losses in the microwave connector or coupling device, variations in line impedance should be minimized at the transitional junction and propagation modes higher than the dominant mode should be suppressed as close to the junction as possible.

It has been the practice to connect a strip transmission line electrically to another transmission line by means of a coaxial type connector having a center pin terminal which extends insulatingly through one of the panels to contact the center conductor of the strip transmission line. The connector usually is provided with a concentric outer conductor having a radial flange which interfaces with one of the ground planes of the strip transmission line. However, an undesirable feature of this connection is that the other ground plane generally is connected to the radial flange by means of cylindrical array of closely spaced screws which extend through both panels of the strip transmission line to threadingly engage respective tapped holes in the radial flange. These screws serve the dual purpose of attaching the coaxial type connector to the strip

transmission line and suppressing any higher propagation modes generated at the junction by shorting them to ground.

Unfortunately, the cylindrical array of screws for each coaxial type connector requires a great deal of time to install. Not only are the screws relatively small in size and spaced rather closely together but each screw must be torqued substantially the same amount as the other screws in the cylindrical array in order to avoid compressing the ground planes more in one area than in another area and thereby introducing localized variations in line impedance at the junction. Furthermore, when interconnecting two strip transmission lines, each of the transmission lines first must be provided with a respective coaxial-type connector, as described. Then, the coaxial-type connectors generally are coupled electrically to one another by means of a coaxial-type nipple. However, the resulting excessive spacing between the two strip transmission lines is not compatible with the relatively compact structures of these transmission lines.

Thus, a definite need exists for a coupling device which readily connects a strip transmission line to another transmission line in a compact manner, without introducing objectionable variations in the USWR, and which effectively suppresses any higher propagation modes generated at the junction.

SUMMARY OF THE INVENTION

Accordingly, the foregoing objectives are achieved by this invention which provides a coupling device for electrically connecting a strip transmission line to another transmission line. This coupling device comprises a center pin and a symmetrically spaced, conductive shell having a cylindrical wall wherein an open-ended slot extends longitudinally from one end of the shell and having adjacent the other end an outwardly extending annular flange. The center pin of the coupling device has one end disposed in electrical contact with a terminal end portion of the center strip conductor and extends insulatingly through aligned apertures in one of the panels and the contiguous ground plane to protrude longitudinally from the strip transmission line.

Symmetrically disposed with respect to a terminal end portion of the center strip conductor are mutually aligned, horseshoe-shaped slots in the respective ground planes and panels of the strip transmission line. The slotted portion of the conductive shell extends longitudinally through the aligned horseshoe-shaped slots such that the annular flange of the coupling device abuts the adjacent ground plane and the slotted end portion of the conductive shell protrudes from the opposing ground plane of the strip transmission line. This protruding end portion of the shell is engaged by a cylindrical fastening device which, in cooperation with the annular flange, exerts a uniform annular pressure on the interposed ground planes, thereby avoiding the localized variations in line impedance introduced by screw-type fastening devices. Since the conductive shell is connected to ground and provides a cylindrical cavity wherein a transitional junction is established between the center conductor of the strip transmission line and the center pin of the coupling device, it constitutes an efficient means for suppressing any higher propagation modes generated at the junction.

In one embodiment of this invention, the protruding portion of the center pin serves as the center pin terminal of a coaxial connector, and the adjacent end portion of the conductive shell terminates in the outer concentric conductor of the coaxial connector, thus providing means for readily connecting the strip transmission line to a coaxial-type transmission line in a compact manner.

In another embodiment of this invention, the annular flange extends transversely across the cylindrical wall to form a closed end of the shell and abuts a ground plane of a second strip transmission line. The slotted cylindrical wall of the shell extends longitudinally through a conductive collar disposed in aligned horseshoe-shaped slots of the second strip transmission line and then through the aligned horseshoe-shaped slots of the first strip transmission line to protrude therefrom. The conductive collar has an outwardly extending lip which is compressed between respective ground planes of the first and second strip transmission lines, and the center pin conductor of the first strip transmission line slidingly engages a similar center pin conductor protruding from the second strip transmission line. When the cylindrical fastening device engages the protruding end portion of the cylindrical wall, it cooperates with the annular flange at the closed end of the shell in exerting a uniform annular pressure on the interposed ground planes of the respective strip transmission lines thereby avoiding localized variations in line impedance. Thus, the first strip transmission line is readily connected to a second strip transmission line in a manner which provides an efficient means for suppressing any higher propagation modes generated at the junction.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of this invention, reference is made to the accompanying drawings, wherein:

FIG. 1 is a perspective fragmentary view showing a connector assembly embodying the coupling device of this invention;

FIG. 2 is an exploded view of the connector assembly shown in FIG. 1;

FIG. 3 is a perspective fragmentary view showing another connector assembly embodying the coupling device of this invention; and

FIG. 4 is an exploded view of the connector assembly shown in FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring more particularly to the drawings wherein like characters of reference designate like parts, there is shown in FIG. 1 a connector assembly 10 comprising a strip transmission line 12 which is electrically connected to a coaxial connector 14 by means of a coupling device 16.

As shown more clearly in FIG. 2, the strip transmission line 12 includes a center conductor 20 which is sandwiched between juxtaposed inner broad surfaces of respective dielectric panels 22 and 24. The center conductor 20 may be plated, as by utilizing well-known printed circuit techniques, for example, on the inner broad surface of one of the panels, such as panel 24, for example. The respective broad outer surfaces of panels 22 and 24 are coated with conductive material, such as plated copper, for example, to form spaced parallel ground planes 28 and 30, respectively. 32. The ground plane 28 is provided with a circular opening 32 which is disposed within the inner periphery of a horseshoe-shaped slot 34. The slot 34 extends through the panel 22 and is aligned with a similar horseshoe-shaped slot 36 which is disposed in panel 24 and extends through ground plane 30. The slot 36 is symmetrically disposed in spaced relationship with a terminal end portion 21 of center strip conductor 20 which extends longitudinally between spaced ends of the slot 36. The terminal end portion 21 of center strip conductor 20 is aligned with a bore 38 in panel 22 which terminates at the other end within the circular opening 32 and in symmetrically spaced relationship with the slot 34.

A tubular center pin 40 of coupling device 16 has a radially extending head 42 at one end which is disposed in electrical engagement, as by pressure contact, for example, with the terminal end portion 21 of center strip conductor 20. The pin 40 extends longitudinally through the bore 38 and the circular opening 32 to protrude insulatingly from the ground plane 28. This protruding portion of the center pin 40 serves as the center conductor of the coaxial connector 14 and extends into a dielectric bushing 44 which is press-fitted into the outer concentric conductor 46 of the connector 14.

The outer conductor 46 is open at one end and terminates at the other end in an outwardly extending annular flange 48 of a conductive shell 50. The shell 50 is a component part of the coupling device 16 and includes a cylindrical wall 52 having a longitudinal slot 54 therein. The wall 52 extends through the respective slots 34 and 36 until the flange 48 abuts the ground plane 28 and an end portion of the wall 52 protrudes from the ground plane 30. This protruding portion of the wall 52 may be provided with fastening means, such as threads, for example, and is engaged by a cylindrical fastening device, such as a knurled end cap 56 having internal threads, for example, which also constitutes a part of the conductive shell 50.

A pressure device, such as cylindrical plug 58, for example, may be inserted into the end cap 56 prior to assembling the end cap onto the protruding end portion of the wall 52. When the end cap 56 is threaded onto the protruding end portion of wall 52 and tightened against the ground plane 30, the end cap 56 in conjunction with the annular flange 48 exerts a uniform annular pressure on the respective ground planes 28 and 30 thereby avoiding localized variations in line impedance. Simultaneously, the plug 58 presses against the area of ground plane 30 located within the inner periphery of slot 34, thereby urging the terminal end portion 21 of center strip conductor 20 against the head 42 of center pin 40 and pressing the pin 40 longitudinally still further into the dielectric bushing 44 of connector 14. Also, the pressure of the plug 58 serves to reinforce the center pin 40 when the connector 14 is mated with another coaxial connector (not shown).

Thus, the conductive shell 50 forms a cylindrical cavity which is connected to ground through the annular flange 48 and the end cap 58, respectively. By means of the longitudinal slot 54 in the cylindrical wall 52 of shell 50, the center strip conductor 20 extends insulatingly into the cavity to establish a transitional junction with the center pin 40. Consequently, the shell 50 constitutes an efficient suppressor of higher propagation modes which may be generated at the junction.

As shown in FIGS. 3 and 4, a connector assembly 11 may include a similar coupling device 16a for electrically connecting the strip transmission line 12 to another strip transmission line **13**. The strip transmission line **13** comprises a center strip conductor **60** which is sandwiched between juxtaposed inner broad surfaces of two dielectric panels **62** and **64**, respectively. The panels **62** and **64** have their respective broad outer surfaces plated with conductive material, such as copper, for example, to form spaced parallel ground planes **68** and **70**, respectively. The ground plane **70** is provided with a horseshoe-shaped slot **74** which extends through panel **64** and is aligned with a similar horseshoe-shaped slot **76** in panel **62**.

The slot **74** is symmetrically disposed in spaced relationship with a terminal end portion **61** of center conductor **60** which extends longitudinally between spaced ends of the slot **74**. The slot **76** extends through panel **62** and ground plane **68** which has a circular opening **72** disposed within the inner periphery of the slot **76**. Centrally disposed within the opening **72** is one end of a bore **78** which extends through the panel **62** and is aligned with the terminal end portion **61** of center conductor **60**. The terminal end portion **61** is electrically engaged such as by pressure contact, for example, by a radially extending head **82** of a center pin **80**. The pin **80** extends through the bore **78** and the circular opening **72** to protrude insulatingly from the ground plane **68**. A conductive collar **84** having an outwardly extending lip **86** is pressed into the aligned slots **74** and **76**, respectively, until the lip abuts the ground plane **66**. The length of the collar **84** is such that it does not protrude through the ground plane **70**.

In this embodiment, the annular flange **48a** of coupling device **16*a*** extends transversely across one end of the cylindrical wall **52*a*** to form a closed end of the conductive shell **50*a***. The cylindrical wall **52*a*** has a slot **54*a*** longitudinally disposed therein and extends longitudinally through the collar **84** within the aligned slots **74** and **76**, respectively. The cylindrical wall **52*a*** also extends through the aligned slots **34** and **36**, respectively, until the annular flange **48*a*** abuts the ground plane **70** of strip transmission line **13** and an end portion protrudes from the ground plane **30** of strip transmission line **12**. Simultaneously the center pin **80** is slidingly engaged by the tubular center pin **40** and the lip **86** of collar **84** is compressed between the ground planes **28** and **68** of strip transmission lines **12** and **13**, respectively. A pressure device, such as plug **58*a***, for example, may be pressed against the area of ground plane **30** within the inner periphery of slot **36** by a cylindrical fastening device, such as **56*a***, for example, which threadingly engages the protruding end portion of cylindrical wall **52*a***. The resulting laminated connector assembly **11**, as shown in FIG. **3**, is very compact and compatible with the planar structures of the respective strip transmission lines **12** and **13**.

When the cylindrical fastening device **56*a*** is tightened, it cooperates with the annular flange **48*a*** in exerting a uniform annular pressure on the interposed ground planes and pressing the ground planes **28** and **66**, respectively, more firmly into contact with the lip **86** of the collar **84**. Thus, localized variation in line impedance are avoided and power losses are minimized. Simultaneously, the plug **58*a*** urges the terminal end portion **21** of center strip conductor **20** against the head **42** of center pin **40** thereby pressing the pin **40** into further engagement with the center pin **80**. As a result, respective transitional junctions are established within a conductive cavity formed by the shell **50*a*** which is connected to ground and wherein the respective center strip conductors **20** and **60** extend insulatingly by means of the slot **54*a*** in the cylindrical wall **52*a***. Consequently, the shell **50*a*** constitutes a very efficient suppressor of any higher propagation modes which may be generated at the enclosed transitional junctions.

Thus, there has been disclosed herein a coupling device for electrically connecting a strip transmission line to another transmission line. This novel coupling device comprises a center pin longitudinally disposed in spaced relationship within a conductive shell having a cylindrical wall with a longitudinal slot disposed therein whereby a center strip conductor extends insulatingly into the shell to form a transitional junction with the center pin. The shell is provided with an outwardly extending flange at one end and is engaged by a cylindrical fastening device at the other end such that a uniform annular pressure is exerted on the spaced parallel ground planes of the strip transmission line. Since the shell is connected to ground and forms a cylindrical cavity wherein a transitional junction is established between the center pin and the center strip conductor, it constitutes an efficient suppressor of any higher propagation modes which may be generated at the junction.

The coupling device of this invention may be used for electrically connecting a strip transmission line to transmission lines having dissimilar structures other than the coaxial one shown herein, such as a waveguide transmission line, for example, wherein the center pin of this novel device may serve as a coupling probe. Also, the coupling device of this invention may be used for electrically connecting a strip transmission line to other transmission lines having similar structures other than the second strip transmission line shown herein, such as an air dielectric strip transmission line, for example. Although the cylindrical fastening device is shown herein as a knurled end cap, other cylindrical fastening devices, such as a nut, for example, also would be suitable. Furthermore, the cylindrical fastening means also may include other types of cylindrical hardware, such as a lock washer, for example. Also, the protruding portion of the conducting shell may be furnished with other types of fastening means than the threaded portion shown herein, such as landings or bosses suitable for engaging quick-disconnect fastening devices, for example.

From the foregoing, it will be apparent that all of the objectives of this invention have been achieved by the structures shown and described. It will also be apparent, however, that various changes may be made by those skilled in the art without departing from the spirit of the invention as expressed in the appended claims. It is to be understood, therefore, that all matter shown and described is to be interpreted as illustrative and not in a limiting sense.

We claim:

1. in combination:

first and second dielectric panels having juxtaposed broad surfaces and respective opposing broad surfaces;

a center strip conductor disposed between the juxtaposed broad surfaces of the first and second panels and having a terminal portion;

first and second ground planes supported on the respective opposing broad surfaces of the first and second panels;

the first panel and first ground plane having respective slots therein aligned with one another and symmetrically spaced from the terminal portion of the center strip conductor;

the second panel and second ground plane having respective openings therein aligned with the terminal portion of the center strip conductor and having respective slots therein aligned with the slots in the first panel and the first ground plane;

an elongated conductive member extended longitudinally through the aligned openings in the second panel and the second ground plane and having one end portion disposed in electrical contact with the terminal portion of the center strip conductor and an opposing end portion protruding insulatingly from the second ground plane; and

a conductive shell having a wall portion extended longitudinally through the aligned slots in the panels and the ground planes and symmetrically spaced from the elongated member and the terminal portion of the center strip conductor, the wall having a protruding end portion and an opposing end,

the shell having pressure means for electrically connecting the shell to the first and second ground planes and aperture means for permitting the center strip conductor to extend insulatingly into the shell.

2. The combination as set forth in claim **1** wherein the wall is cylindrical and has a cross-sectional configuration conforming to the aligned slots in the panels and ground planes.

3. The combination as set forth in claim **1** wherein the terminal portion of the center strip conductor is an end portion, the slots in the panels and ground planes are each horseshoe-shaped, and the aperture means includes an open-ended slot extending longitudinally in the wall from the protruding end thereof.

4. The combination as set forth in claim **1** wherein the pressure means includes fastening means at the protruding end portion of the cylindrical wall and radially extending means adjacent the opposing end thereof.

5. In combination:

first and second dielectric panels having juxtaposed broad surfaces and respective opposing broad surfaces;

a center strip conductor disposed between the juxtaposed broad surfaces of the first and second panels and having a terminal portion;

first and second ground planes supported on the respective opposing broad surfaces of the first and second panels;

the first panel and first ground plane having respective arcuate slots therein aligned with one another and symmetrically spaced from the terminal portion of the center strip conductor;

the second panel and second ground plane having respective coaxial openings therein aligned with the terminal portion of the center strip conductor and having respective arcuate slots therein aligned with the slots in the first panel and the first ground plane;

a conductive pin extended longitudinally through the coaxial openings in the second panel and the second ground plane and having one end portion disposed in electrical contact with the terminal portion of the center strip conductor and an opposing end portion protruding insulatingly from the second ground plane; and

a conductive shell including a cylindrical wall having a cross-sectional configuration conforming to the aligned slots in the panels and the ground planes and extended longitudinally therethrough in symmetrically spaced relationship with the conductive pin and the terminal portion of the center strip conductor, the wall having a protruding end portion and an opposing end,

the shell having pressure means for electrically connecting the shell to the first and second ground panels and aperture means for permitting the center strip conductor to extend insulatingly into the shell.

6. The combination as set forth in claim **5** wherein the opening in the second ground plane is larger than the coaxial opening in the second panel.

7. The combination as set forth in claim **5** wherein the end portion of the wall adjacent the second ground plane is electrically connected to a corresponding conductor of another transmission line.

8. The combination as set forth in claim **7** wherein the protruding end portion of the conductive pin is the center conductor of a coaxial connector and the adjacent end portion of the wall is electrically connected to the concentric outer conductor of the coaxial connector.

9. The combination as set forth in claim **7** wherein the protruding end portion of the conductive pin engages the center conductor of the other transmission line.

10. In combination:

first and second dielectric panels having juxtaposed broad surfaces and respective opposing broad surfaces;

first and second ground planes supported on the respective opposing broad surfaces of the first and second panels;

a first center strip conductor disposed between the juxtaposed broad surfaces of the first and second panels and having a terminal end portion;

third and fourth dielectric panels having juxtaposed broad surfaces and respective opposing broad surfaces;

third and fourth ground planes supported on the respective opposing broad surfaces of the third and fourth panels, the third ground plane being disposed in juxtaposed relationship with the second plane;

first means for conductively connecting the third ground plane to the second ground plane;

second means for conductively connecting the second center strip conductor to the first center strip conductor and passing insulatingly through the second and third ground planes;

all of said panels and ground planes having respective horseshoe-shaped slots therein aligned with one another in symmetrically spaced relationship with the respective terminal end portions of the first and second center strip conductors; and

a conductive shell including a wall having a cross-sectional configuration conforming to the aligned horseshoe-shaped slots and extended longitudinally therethrough, and pressure means disposed at opposing ends of the cylindrical wall for electrically connecting the shell to the ground planes.

* * * * *