United States Patent

Bogar

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[54] **CONNECTOR FOR INTERCONNECTION OF SYMMETRICAL AND ASYMMETRICAL TRANSMISSION LINES**

[72] Inventor: **Jerry Hench Bogar,** Harrisburg, Pa.

[73] Assignee: **AMP Incorporated,** Harrisburg, Pa.

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[52] **U.S. Cl.**.....**339/177 R,** 333/84 M, 333/21 R

[51] **Int. Cl.**.....**H01r 17/04,** H01p 5/10

[58] **Field of Search**.....333/33, 34, 84 M, 21 R; 339/17 R, 177 R, 177 E, 252 P, 274

[56] **References Cited**

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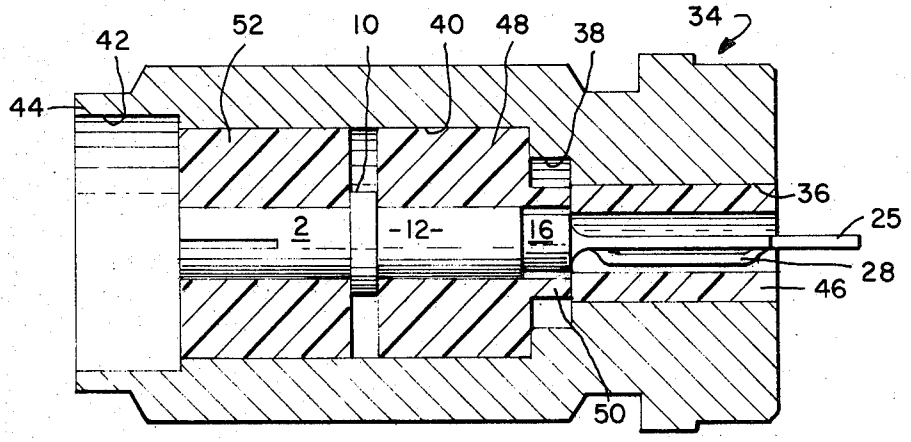
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Primary Examiner—Marvin A. Champion
Assistant Examiner—Lawrence J. Staab
Attorney—William J. Keating, Ronald D. Grefe, Gerald K. Kita, Frederick W. Raring, Jay L. Seitchik, John R. Flanagan and Allan B. Osborne

[57] **ABSTRACT**

An electrical terminal includes an extended tab for registration with the conductor of an asymmetrical transmission line. The terminal further includes an offset conductor portion of reduced cross section for connection to the symmetrical transmission line which shapes the normally uniform distribution of electromagnetic energy transmitted over the symmetrical transmission line to a non-uniform distribution which approximates that of the unsymmetrical transmission lines into which the electromagnetic energy is to be transmitted.

3 Claims, 9 Drawing Figures



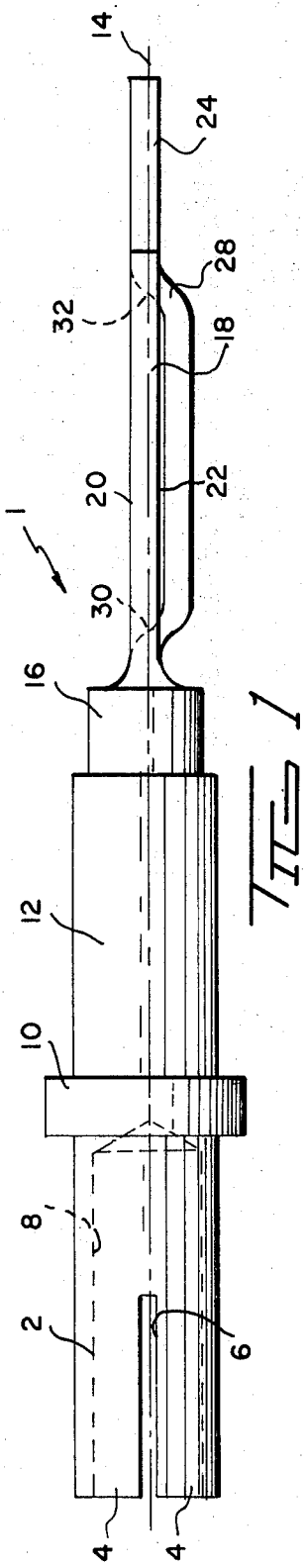


FIG 1

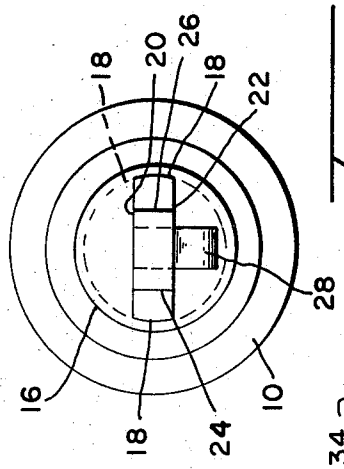


FIG 3

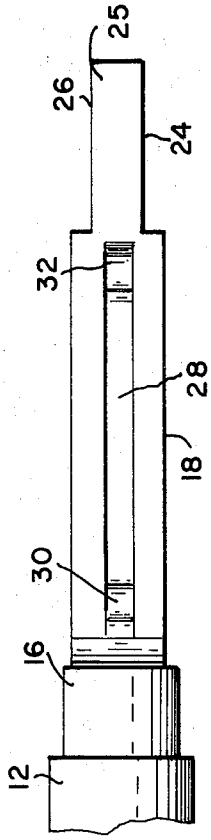


FIG 2

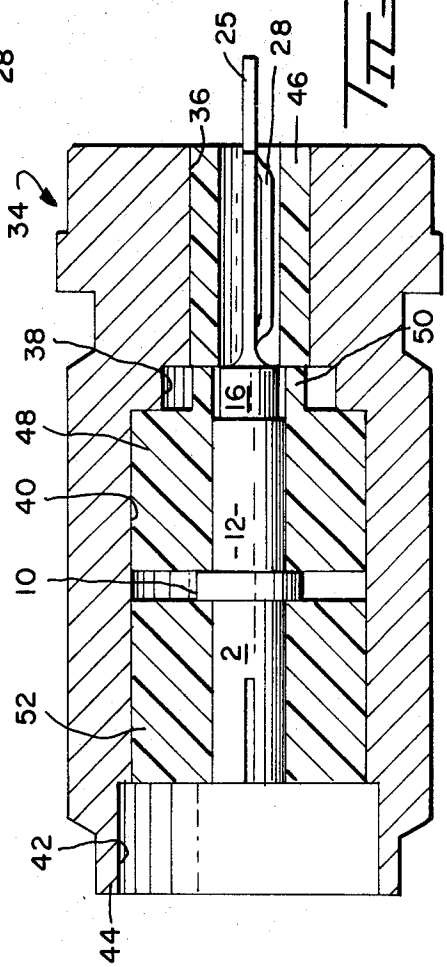


FIG 4

INVENTOR
JERRY HENCH BOGAR
BY Gerald K. Kita

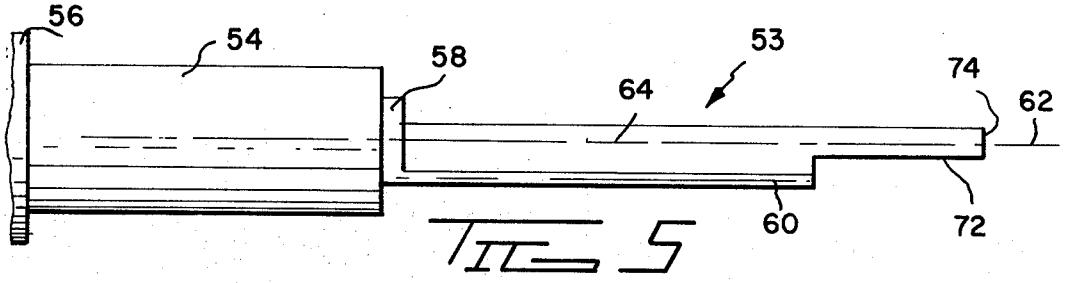


FIG 5

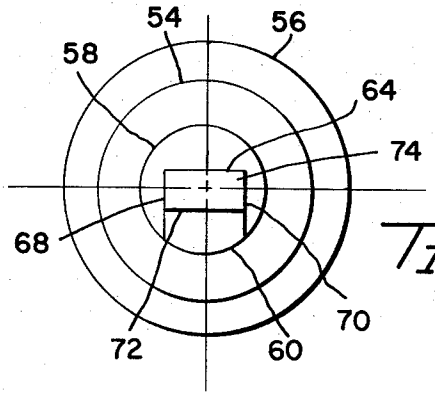


FIG 6

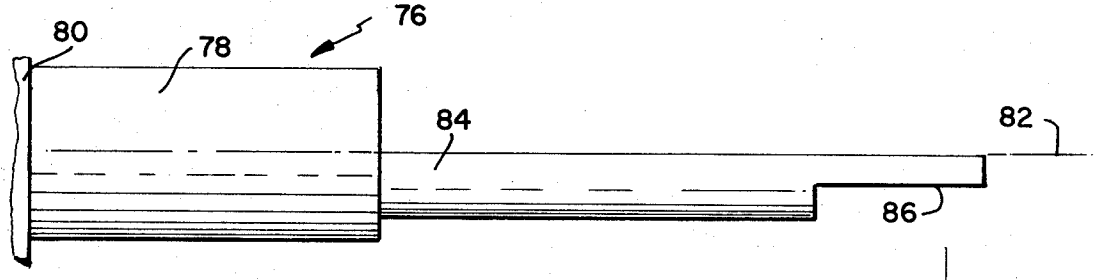


FIG 7

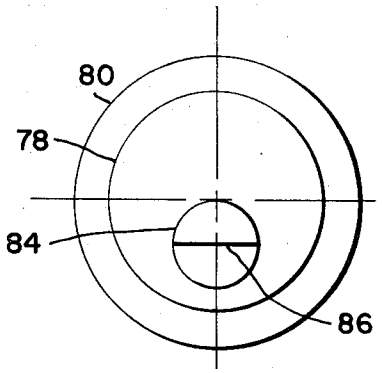


FIG 8

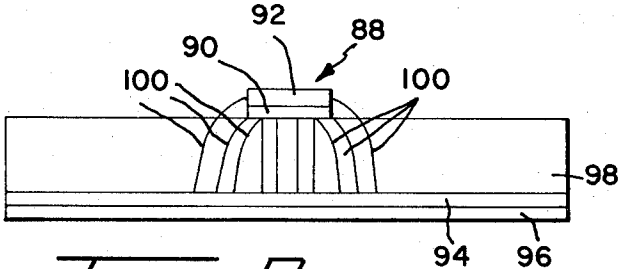


FIG 9

CONNECTOR FOR INTERCONNECTION OF SYMMETRICAL AND ASYMMETRICAL TRANSMISSION LINES

The present invention relates to an electrical connector, and, more specifically, to an electrical connector for providing a frequency independent interconnection of symmetrical and asymmetrical transmission lines. Development in printed circuit techniques has resulted in a generally unshielded flat configuration in the form of a strip conductor and a single plane, ground conductor separated by a dielectric layer. Since one side of the strip conductor is air and the other side is a high-dielectric material, the coaxial strip is an unbalanced, or asymmetrical, transmission line. The high-dielectric properties of the dielectric layer, or substrate, is designed to contain and shape the distribution of electromagnetic energy transmitted over the strip conductor. By contrast, in a symmetrical shielded transmission line, commonly in the form of a coaxial cable, the electromagnetic energy is distributed symmetrically within the encircling dielectric filling the shape between the center conductor and the shield or outer conductor. The invention comprises a connector for purposely shaping the symmetrical energy distribution of the shielded transmission system in such a way that the electromagnetic energy is no longer symmetrically distributed, but is distributed in a configuration which approximates that of the unsymmetrical transmission line into which such electromagnetic energy is to be transmitted.

To accomplish such objectives, the interconnection of a symmetrical transmission line with an asymmetrical line must take place with minimum electrical discontinuity. A suitable connector is required which is capable of low VSWR transition from symmetrical line to asymmetrical line. There has been developed a number of connection techniques, all of which involve anchoring the shielded transmission line at a specific distance from the connection to the asymmetrical line. A flat tab interface connects the shielded transmission line to the flat unshielded line. The tab must be relatively thin to prevent capacitive effects with the conductors and dielectric of the unshielded line. Soldering or bonding may be used, or a clamping device may be used, to maintain a fixed gripping force of the tab to the asymmetrical line. Such technique prevents deflection of the interconnection beyond a desired minimum and maintains adequate gripping forces between the tab and unshielded line.

The present invention has been derived to accommodate and compliment the existing interconnection techniques, and enhances the desirable electrical properties of the interconnection, thereby improving the suitability for microelectronic applications at microwave frequencies, for example, in the form of microwave integrated circuits (MIC).

According to the invention, the connector is provided with a deformation in the form of a reduced cross sectional conductor portion which is positioned laterally offset from the longitudinal axis of the center conductor of a symmetrical transmission line. The offset conductor portion thus modifies and shapes the normally uniform distribution of electromagnetic energy transmitted over the symmetrical transmission line to a configuration similar to the shape of electromagnetic energy to be transmitted over the asymmetrical transmission line. Such a technique provides a connector which is suitable for an interconnection using coaxial cable, and which has a broad band frequency response to provide an interconnection which is frequency independent and capable of low VSWR transitions.

Accordingly, it is an object of the present invention to provide a frequency independent connector capable of interconnecting a symmetrical transmission line electrically of an asymmetrical transmission line.

Another object of the present invention is to provide a method and apparatus in the form of a connector for interconnecting a symmetrical transmission line to an asymmetrical transmission line with minimum electrical discontinuity.

Another object of the present invention is to provide a frequency independent connector for a symmetrical transmission line with an extended tab for registration with an asymmetrical transmission line, a deformed portion of the connector shaping the normally symmetrically distributed electromagnetic energy to a configuration which approximates the shape of the electromagnetic energy to be transmitted by the asymmetrical transmission line.

Other objects and many attendant advantages of the present invention will be apparent from perusal of the following detailed description taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is an enlarged elevation of a preferred embodiment of a connector according to the present invention;

FIG. 2 is an enlarged fragmentary plan of the preferred embodiment as shown in FIG. 1;

FIG. 3 is an enlarged side elevation of the preferred embodiment as shown in FIG. 1;

FIG. 4 is an enlarged elevation in section illustrating the connector as shown in FIG. 1 provided with encircling dielectric and electrical shielding in the form of an electrical coupling;

FIG. 5 is an enlarged fragmentary elevation of another preferred embodiment according to the present invention;

FIG. 6 is an enlarged end elevation of the embodiment as shown in FIG. 5;

FIG. 7 is an enlarged fragmentary elevation of yet another embodiment according to the present invention;

FIG. 8 is an enlarged end elevation of the preferred embodiment as shown in FIG. 7; and

FIG. 9 is a schematic illustrating an exemplary asymmetrical transmission line and the typical distribution of electromagnetic energy transmitted by the line.

With more particular reference to FIGS. 1–3 of the drawings, there is shown generally at 1 a preferred embodiment of a connector according to the present invention. The connector is in the form of an electrical terminal and includes a sleeve-shaped receptacle 2 having a plurality of circumferentially spaced, cantilever spring fingers 4 defined by slits therebetween, one of which is shown at 6. The receptacle is provided with an end recess 8 between the spring fingers for receiving the end of a center conductor of a shielded symmetrical transmission line, not shown. The terminal is provided with an enlarged diameter annular collar 10 located medially between the receptacle and a generally cylindrical conductor portion 12 of the terminal 1. The con-

ductor portion 12 is located coaxially with the center line 14 of the receptacle 2. Consequently, the cylindrical conductor portion 12 is additionally symmetrical with the center line of the shielded symmetrical transmission line. The conductor portion 12 is provided with a coaxial extending conductor portion 16 of reduced circular cross section. As shown in FIG. 3, the reduced conductor portion 16 is provided with an extending, further reduced cylindrical portion 18, which is provided with a pair of recessed opposed planar surfaces 20 and 22, resulting in a further reduced conductor portion generally of rectangular configuration. In addition, the reduced rectangular configuration is further reduced in cross section by a pair of opposed, laterally recessed planar surfaces 24 and 26 defining a projecting rectangular tab for registration with the center conductor of an asymmetrical transmission line, not shown. In addition, the terminal is provided with a lanced-out portion 28 which is parallel to but offset from the longitudinal axis 14 of the symmetrical transmission line conductor and the receptacle 2. The lanced-out portion 28 is connected at its ends to the rectangular conductor portion by arcuate conductor portions 30 and 32. Such arcuate portions, together with the reduced cylindrical portion 16, are provided in tandem relationship for a deformation of enlarged symmetrical terminal geometry to the unsymmetrical and offset reduced cross section geometry of the lanced-out portion 28. Accordingly, electromagnetic energy transmitted from the symmetrical transmission line will be gradually shaped to an unsymmetrical configuration as such energy is transmitted over the tandem reduced cylindrical portion and the offset lanced-out portion 28.

With reference to FIG. 4, a coupling for receiving the terminal and providing a cylindrical outer conductor which is electrically contacted at respective opposite ends by the outer conductor of the symmetrical transmission line and the ground conductor of the asymmetrical transmission line. 1 is illustrated generally at 34. The coupling includes a reduced diameter bore 36 communicating with a first enlarged diameter recess 38, which, in turn, communicates with an elongated second stepped enlarged diameter recess 40, which communicates with another enlarged diameter stepped recess 42 provided in one end 44 of the coupling 34. The bore 36 is provided with a sleeve liner 46 of dielectric material. The recess 40 is provided with a sleeve dielectric 48, a portion 50 of which is received in the recess 38. The terminal 1 is inserted within the coupling such that the dielectric sleeve 48 mechanically supports the conductor portion 12 of the terminal. The offset portion 28 of the conductor is received freely within the dielectric sleeve 46, and the tab 25 of the terminal protrudes from the coupling member for registration with the conductor of an asymmetrical transmission line, not shown. The collar 10 of the terminal is in registration against the dielectric 48, and another dielectric sleeve 52 is received in the recess 40 in registration against the collar 10 for supporting the receptacle 2 of the terminal. In operation, a coaxial cable, not shown, may be inserted in a plug type connector which is received in the recess 42 with the center conductor thereof protruding and received in the receptacle 2. With the exception of the tab 25 which protrudes from the coupling, the entire length of the connector 1 is received in encircling dielectric material contained within the coupling. Thus the conductor portions 2 and 12 are a continuation of, and are symmetrical with, the longitudinal axis of the center conductor of the symmetrical transmission line. The offset center conductor portion 28 however is not symmetrical, although it is shielded when received within the surrounding dielectric and the coupling. Accordingly, electromagnetic energy transmitted over the symmetrical transmission line remains symmetrically distributed as it is transmitted over the conductor portions 2 and 12. However, the cylindrical portion 12 has been deformed to form a transition into a reduced cylindrical conductor portion 16 and the conductor portion 28 which is offset from the longitudinal axis 14 of the symmetrical transmission line. Accordingly, the symmetrical distribution of the transmission of electromagnetic energy is shaped by the offset reduced cross sectional portion of the connector to an asymmetric configuration substantially equal to or approximating the distribution of the electromagnetic energy to be transmitted through the asymmetric transmission line. Accordingly, the connector 1 provides an interconnection between a symmetrical and an asymmetrical transmission line with a minimum electrical discontinuity. Such connector is well suited for a miniature coaxial cable interconnection capable of low VSWR transitions between the cable and the asymmetrical transmission line.

In a modification of the terminal 1, the receptacle 2 and the collar 10 may be eliminated, and the conductor portions 12, 16 and 18, together with the tab 25 may be fabricated directly on the conductor of a shielded symmetrical transmission line. Thus the connector 1 may be fabricated as the part of the symmetrical transmission line conductor, or a separate terminal for connection to the conductor.

An additional preferred embodiment is illustrated in FIGS. 5 and 6, wherein a modified connector is shown generally at 53 and is formed directly on the center conductor of a shielded symmetrical transmission line, the center conductor of which is shown at 54 the encircling dielectric shown in part at 56 and the outer conductor not shown. The center conductor 54 is provided with a reduced diameter elongated end portion 58 defined by cylindrical surface 60. The reduced diameter portion 58 is thus of reduced circular cross section and is coaxial with the longitudinal axis 62 of the shielded symmetrical transmission line. A substantially elongated portion of the reduced cylindrical conductor portion 58 is provided with a planar surface 64 formed by milling, for example. The conductor portion 58 is further provided with a pair of opposed laterally recessed planar surfaces 68 and 70, which may be formed simultaneously by a straddle milling operation, for example. Accordingly, the conductor portion 58 is provided with an elongated conductor portion which is further reduced in cross section and is generally of D-shaped configuration as defined by the surfaces 64, 70, 60 and 68, as shown clockwise in FIG. 6. In addition, the D-shaped conductor portion is offset from the center line 62 of the shielded, symmetrical transmission line. As a further addition, the D-shaped conductor portion is provided with an inverted planar recess surface 72 which cooperates with the planar surface 64 to

form a generally rectangular tab **74** which is contiguous with the laterally offset portion of the conductor and which is positioned coaxially with the longitudinal axis **62**.

The connector **53** may also be formed as a separate terminal for connecting a symmetrical transmission line conductor, the center being formed directly on the conductor as shown. For example, the conductor portions **54** and **58**, and the tab **74**, may be fabricated into an electrical terminal having the enlarged annular collar **10** and the receptacle **2** as shown in FIG. **1**, formed on the end of the conductor portion **54**. Accordingly, the connector **53** is suitable for fabrication as part of a transmission line conductor for an electrical terminal for connection to the transmission line conductor.

With reference to FIGS. **7** and **8**, a modification of the connector shown in FIG. **5** will be described in detail. The modified connector, generally indicated at **76**, includes a generally cylindrical conductor portion **78** which may be formed directly on the shielded conductor of a symmetrical transmission line. The outer conductor is not shown and the partially shown encircling dielectric of the transmission line is indicated at **80**, with the center line or longitudinal axis of the transmission line indicated at **82**. The conductor portion **78** is provided with an extending elongated conductor portion **84** which is laterally offset from the center line **82** and is of reduced circular cross section. A reduced cross section conductor portion **84** may be formed by milling, for example, and is provided with an inverted planar surface **86**, also formed by milling, for example. The planar surface **86** cooperates with the cylindrical surface of the conductor portion **84** to form a D-shaped cross section tab adjacent to the longitudinal axis **82** for registration with the conductor of an asymmetric transmission line. The conductor portion **84** adjacent to the planar surface **86** is also of D-shaped cross section and is in tandem relationship to the remainder of the reduced circular cross section conductor portion **84**.

Instead of being formed directly on the symmetrical transmission line conductor, the connector **76** may be fabricated into a separate electrical terminal for connection to the conductor. For example, the conductor portions **78** and **84** and the tab **86** may be fabricated into an electrical terminal having the enlarged annular collar **10** and the receptacle **2** as shown in FIG. **1**, formed on the end of the conductor portion **78**.

Either of the terminals **53** or **76** may be inserted within the exemplary coupling **34** with the tabs **74** and **86** thereof in registration with the conductor of an asymmetrical transmission line. Electromagnetic energy transmitted through the connectors **53** or **76** will be distributed and shaped by the reduced cross sectional conductor portions **58** and **84**, and further by the offset conductor portions **64** and **84**, to an unsymmetrical configuration approximating the configuration of electromagnetic energy to be transmitted through the asymmetrical transmission line.

A schematic representation of a typical asymmetrical transmission line is shown generally at **88** in FIG. **9**. The transmission line includes a composite center conductor fabricated from a chrome layer **90** and a gold or copper layer **92**. A ground plane is also formed of composite metal layers **94** of chrome and **96** of gold or copper. A relatively thick layer of dielectric material **98** is interposed between the conductor and ground plane and is designed to contain the electromagnetic energy to be transmitted over the center conductor. Additionally, the dielectric **98** distributes and shapes the transmitted electromagnetic energy into a configuration of flux lines such as that shown in **100**, which distribution is unsymmetrical about the center conductor. Thus in each preferred embodiment of a connector according to the present invention, each terminal is deformed to provide a reduced cross sectional conductor portion and a tandem offset conductor portion for gradually shaping the electromagnetic energy transmitted over the connector from a symmetrical distribution to an unsymmetrical distribution equal to or approximating the distribution of flux lines, shown by the exemplary flux lines **100**, of the unsymmetrical transmission line into which such electromagnetic energy is to be transmitted. Accordingly, each connector according to the present invention provides an interconnection for transmitted electromagnetic energy originating in either of the symmetrical or asymmetrical transmission lines and transferred to the other.

Although several preferred embodiments and modifications of the present invention have been described and illustrated in detail, other embodiments and modifications are apparent to one having ordinary skill in the art and as defined in the spirit and scope of the present invention contained in the appended claims. For example, in applications wherein the conductor is of relatively small diameter, the reduced diameter conductor portion may be eliminated with the result that the connector includes only the offset conductor portion which shapes the transmitted electromagnetic energy to a desired configuration.

What is claimed is:

1. A connector housed within a tubular coupling for a transition connection between a center conductor of a symmetrical transmission line and a corresponding conductor of an asymmetrical transmission line, said connector comprising:

a substantially symmetrical conductor portion of said connector being electrically connected to and coaxially aligned with said center conductor of said symmetrical transmission line,

a reduced cross sectional conductor portion being generally parallel with and extending outwardly from said symmetrical conductor portion,

an offset portion of said reduced cross sectional conductor portion being offset from the longitudinal axis of said symmetrical conductor portion, said offset portion of said reduced cross sectional conductor portion being lanced-out of said reduced cross sectional conductor portion,

a tab extending outwardly from the end of said reduced cross sectional conductor portion and generally parallel with said symmetrical conductor portion for registration with said corresponding conductor of said asymmetrical transmission line whereby,

said offset portion of said reduced cross sectional conductor portion purposely shapes the normally uniform distribution of electromagnetic energy transmitted over said connector to an unsymmetrical distribution of a configuration similar to that of the electromagnetic energy to be transmitted over said asymmetrical transmission line.

2. A connector housed within a tubular coupling for a transition connection between a center conductor of a symmetrical transmission line and a corresponding conductor of an asymmetrical transmission line, said connector comprising:

a substantially symmetrical conductor portion of said connector being electrically connected to and coaxially aligned with said center conductor of said symmetrical transmission line,

a reduced cross sectional conductor portion being generally parallel with and extending outwardly from said symmetrical conductor portion,

an offset portion of said reduced cross sectional conductor portion being offset from the longitudinal axis of said symmetrical conductor portion,

a tab extending outwardly from the end of said reduced cross sectional conductor portion and generally parallel with said symmetrical conductor portion for registration with said corresponding conductor of said asymmetrical transmission line,

said tab being of rectangular cross section and said offset portion of said reduced cross sectional conductor portion being generally of D-shaped configuration whereby, said offset portion of said reduced cross sectional conductor portion purposely shapes the normally uniform distribution of electromagnetic energy transmitted over said connector to an unsymmetrical distribution of a configuration similar to that of the electromagnetic enerby to be transmitted over said asymmetrical transmission line.

3. A connector housed within a tubular coupling for a transition connection between a center conductor of a symmetrical transmission line and a corresponding conductor of an asymmetrical transmission line, said connector comprising:

a substantially symmetrical conductor portion of said connector being electrically connected to and coaxially aligned with said center conductor of said symmetrical transmission line,

a reduced cross sectional conductor portion being generally parallel with and extending outwardly from said symmetrical conductor portion,

said reduced cross sectional conductor portion being offset from the longitudinal axis of said symmetrical conductor portion,

a tab extending outwardly from the end of said reduced cross sectional conductor portion and generally parallel with said symmetrical conductor portion for registration with said corresponding conductor of said asymmetrical transmission line,

said tab being D-shaped and said reduced cross section conductor being cylindrical whereby, said reduced cross sectional conductor portion purposely shapes the normally uniform distribution of electromagnetic energy transmitted over said connector to an unsymmetrical distribution of a configuration similar to that of the electromagnetic energy to be transmitted over said asymmetrical transmission line.

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