United States Patent [19]

O' Donnell

[11] **3,825,861**

[45] **July 23, 1974**

[54] **COAXIAL LINE TO STRIP LINE CONNECTOR**

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[73] Assignee: **EG & G, Inc.,** Bedford, Mass.

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[21] Appl. No.: **395,486**

[52] **U.S. Cl.** .... **333/33,** 333/97 R

[51] **Int. Cl.** **H01p 5/08**

[58] **Field of Search** .... 333/21 R, 33, 84 M, 97 R

[56] **References Cited**

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Primary Examiner—Paul L. Gensler

Attorney, Agent, or Firm—Ralph L. Cadwallader, Esq.; Leo M. Kelly, Esq.

[57] **ABSTRACT**

A connector for coupling a coaxial cable and a strip line having compensating material in the launch area disposed in a slot extending diametrically across the face of a member that insulates a connecting rectangular tab from the connector body.

3 Claims, 13 Drawing Figures

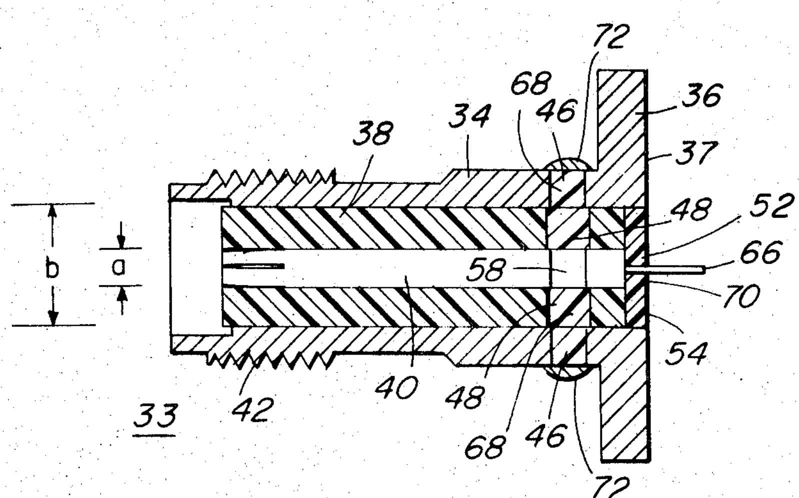


FIG. 1

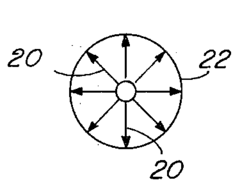


FIG. 2

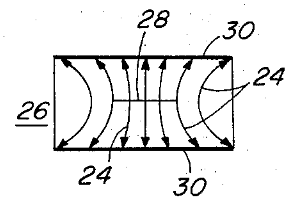
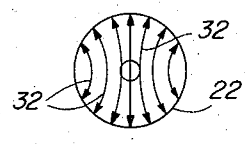


FIG. 3



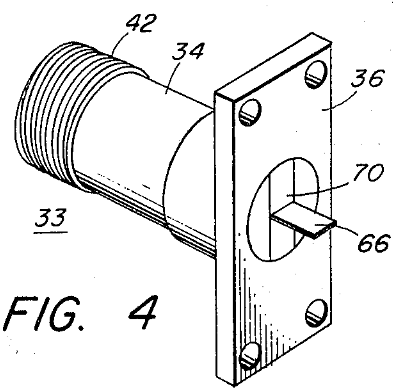


FIG. 4

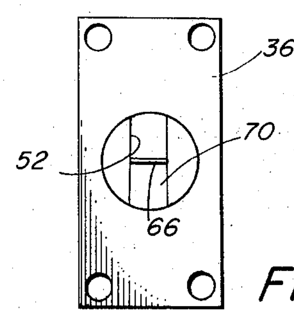


FIG. 6

FIG. 5

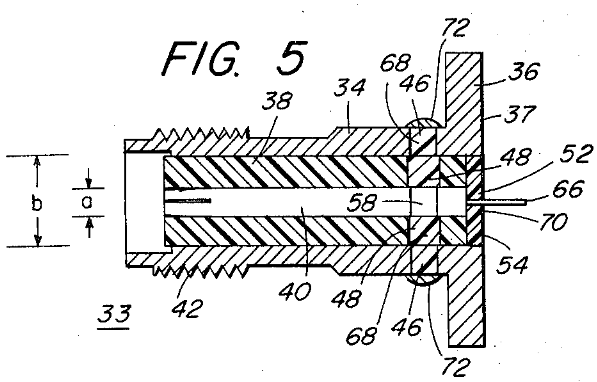


FIG. 7

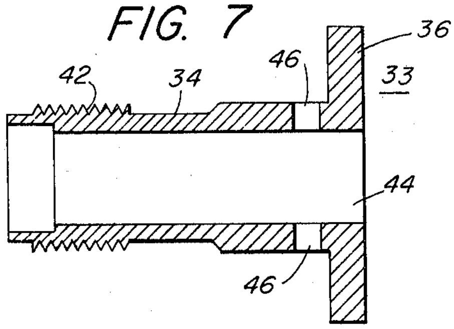


FIG. 8

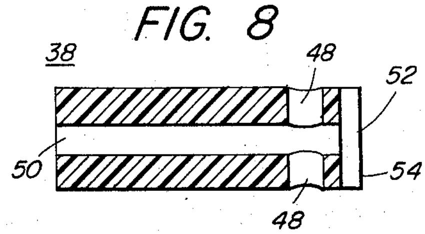
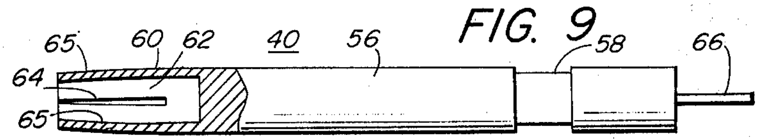


FIG. 9



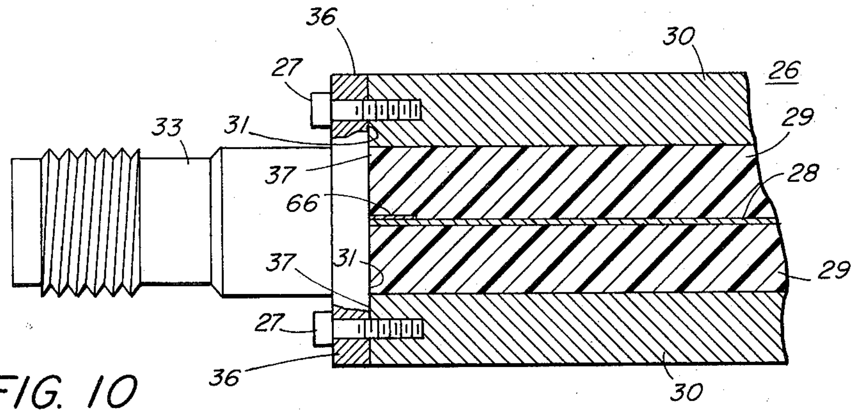


FIG. 10

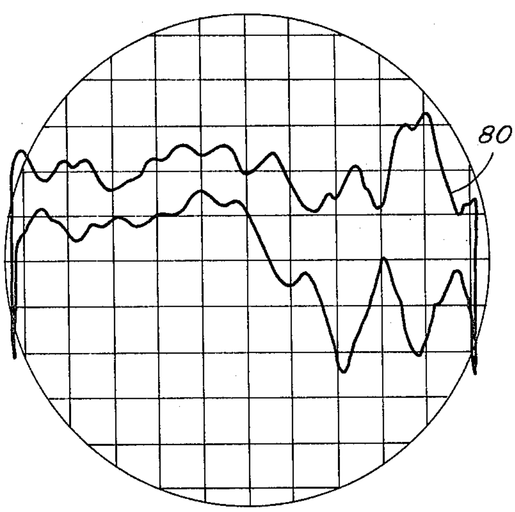


FIG. 12

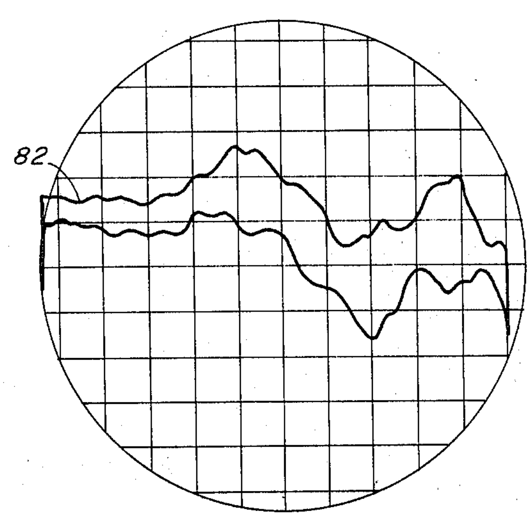
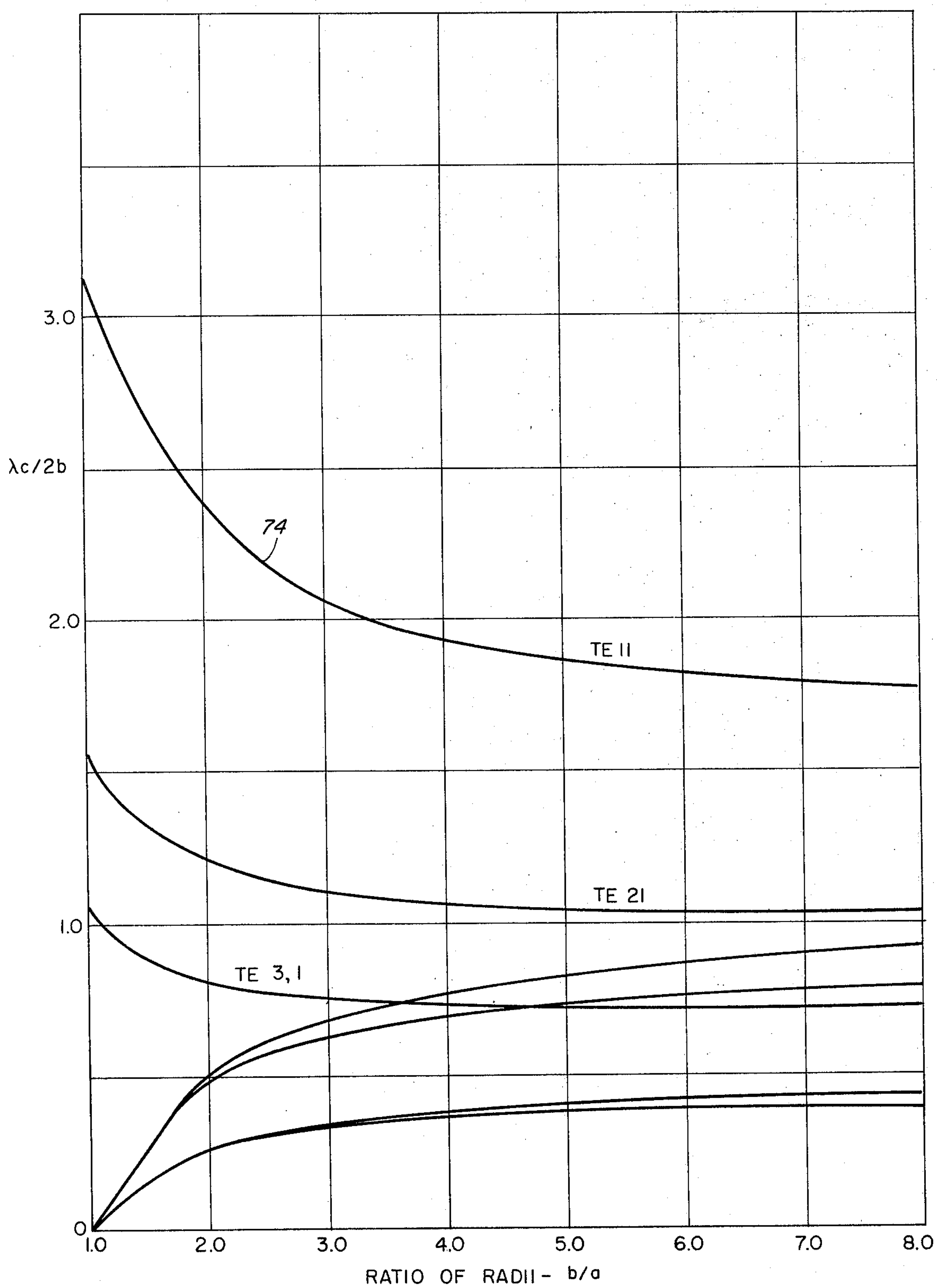


FIG. 13

FIG. 11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λc/2b
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74
TE 11
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TE 3,1
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RATIO OF RADII - b/a

COAXIAL LINE TO STRIP LINE CONNECTOR

BACKGROUND OF THE INVENTION

This invention relates to a coaxial line to strip line connector, and more particularly to a coaxial to strip line connector having compensating material in its launch area for compensating for impedance mismatch and phase shift.

In certain applications, it is necessary to connect a coaxial transmission line (hereafter referred to as "coaxial line") to a strip transmission line (hereafter referred to as "strip line"). Usually as a result of such a connection, an impedance mismatch of the lines occurs and a phase shift is introduced into a signal being transmitted along the over-all line made up of the coaxial and strip lines. Sometimes impedance mismatch and phase shift are tolerable; however, in certain instances, it is critical that impedance mismatch and phase shift be corrected.

One procedure in the prior art for correcting this impedance mismatch and phase shift is to disconnect the lines from a connector and to machine the connector by trial and error thereby altering the physical dimensions of the connector to adjust for impedance mismatch and phase shift. It is manifest that such a complicated procedure produces a connector tailored to operate only with a particular coaxial line and strip line.

BRIEF DESCRIPTION OF THE INVENTION

An object of this invention is to provide a new and improved coaxial line to strip line connector.

Another object is to provide a coaxial line to strip line connector having compensation for impedance mismatch and phase shift.

Briefly stated the foregoing and other objects and advantages of the invention are achieved through the provision of a hollow, tubular body terminating in a rectangular flange, a tubular insulator disposed therein provided with an axial bore and a contact member received in the axial bore. The contact member terminates in a narrow, rectangular tab to facilitate connection to the strip line conductor. Compensation is provided in the launch area by a strip of material having a dielectric constant greater than that of the insulator located in a slot extending diametrically across the face of the insulator in a direction preferably perpendicular to the plane of the rectangular tab. The effect of the compensating material is to pull the electric field of the coaxial cable (TEM mode) into a field concentration conducive to the propagation of the TE_{11} mode and similar to the actual mode configuration of a strip line. Additionally, introduction of the compensating material very close to the discontinuity introduced by a captivating plug has the effect of minimizing loss.

BRIEF DESCRIPTION OF THE DRAWING

An understanding of additional aspects of the invention may be gained from a consideration of the following detailed description of a preferred embodiment in conjunction with the accompanying figures of the drawing, in which:

FIG. 1 illustrates the electric field configuration (TEM mode) in a coaxial cable;

FIG. 2 illustrates the electric field configuration in a strip line;

FIG. 3 illustrates the electric field configuration (TE_{11} mode) in a coaxial cable;

FIG. 4 illustrates a perspective view of a connector embodying the present invention;

FIG. 5 shows a sectional view of the connector of FIG. 4;

FIG. 6 illustrates an end view of the connector of FIG. 4;

FIG. 7 illustrates a sectional view of the body of the connector of FIG. 4;

FIG. 8 illustrates in section the tubular insulator of the connector of FIG. 4;

FIG. 9 illustrates the center contact, partially in section, of the connector of FIG. 4;

FIG. 10 illustrates, partially in section, connection of the connector of FIG. 4 to a strip line;

FIG. 11 presents curves useful in calculating cut-off wavelengths of higher modes of propagation of electric fields in coaxial transmission lines; and

FIGS. 12 and 13 present VSWR curves of the connector without and with compensating material in the launch area respectively.

Corresponding reference characters indicate corresponding parts throughout the several figures of the drawing.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 presents the conventional illustration of the electric lines of force **20** of the electric field of an electric wave propagating along a coaxial transmission line **22** in the TEM mode. Similarly FIG. 2 presents the conventional illustration of the electric lines of force **24** of the electric field of an electric wave propagating along a strip line **26** having planar center conductor **28** and outer conductors **30**. Likewise, FIG. 3 presents the conventional illustration of the electric lines of force **32** of the electric field of an electric wave propagating along coaxial transmission line **22** in the TE_{11} mode. In effect the present invention tends to pull the electric field of FIG. 1 into the field configuration of FIG. 3 thus matching the actual mode of propagation in strip line **26** of FIG. 2.

FIGS. 4, 5 and 6 illustrate connector **33** of the present invention as comprising a hollow, tubular body **34** terminating in rectangular flange **36**, a tubular insulator **38** provided with an axial bore and a contact **40** received in the axial bore. FIGS. 4 and 7 show that body **34** has an exterior threaded portion **42** adapted for connection to a coaxial cable, not shown; a centerbore **44** dimensioned to receive insulator **38** and a pair of diametric holes **46** communicating with bore **44** and located next to flange **36**. FIGS. 5 and 8 show that tubular insulator **38** likewise has a pair of diametric holes **48** communicating with bore **50** and a slot **52** located in end face **54** of tubular insulator **38**. Insulator **38** may be made of teflon. FIG. 9 illustrates contact **40** as having elongated cylindrical body **56** with a cylindrical slot **58** of reduced diameter, an end portion **60** having a counterbore **62** with a diametric slot **64** cut therein and the other end portion terminating in a narrow, rectangular tab **66**.

In assembling connector **33**, the side portions **65** opposite slot **64** of contact **40** are compressed slightly and contact **40** is then inserted into bore **50** of insulator **38** until cylindrical slot **58** and holes **48** are in register with tab **66** extending beyond end face **54**. The combination is then inserted into bore **44** of body **34** until holes **46**, holes **48** and slot **58** are in register, forming an aperture, with end face **54** flush with surface **37** of flange **36,** as best seen in FIG. **5.** Contact **40** is then turned until the plane of tab **66** has an orientation preferably perpendicular to slot **52,** as shown in FIG. **6,** although a parallel orientation has worked satisfactorily in one application, and other orientations may prove adequate in practice. Holes **46** and **48** and slot **58** are held in register and the aperture formed thereby is filled with a material that can be poured and hardened and which has a higher dielectric constant than that of insulator **38.** The hardened material forms plug **68.** Slot **52** is also filled with the same material denominated compensating material **70** in the drawing. After hardening of this material holes **46** are capped with a conductive material **72.** Connector **33** is then ready for test and use. Tab **66** and slot **52** filled with compensating material **70** are denominated the launch area of connector **33.**

FIG. **10** illustrates very diagrammatically the use of connector **33** with strip line **26.** Strip line **26** has center conductor **28** spaced by insulating members **29** from outer conductive members **30.** As shown, a pair of screws **27** form an electrical contact between flange **36** and conductive members **30** while, at the same time, maintaining tab **66** in good, tight, surface-to-surface, electrical contact with planar conductor **28** of strip line **26.**

As stated above, the salutary effect of compensating material **70** is to pull the electric field of the coaxial cable (TEM mode) into a field concentration conducive to propagation of the TE_{11} mode and similar to the actual mode of propagation as shown in FIG. **2.**

Those skilled in the art will recognize the captivation function of plug **68** and that this introduces a discontinuity between the coaxial and strip line conductors. A further salutary effect of compensating material **70** is that it is placed sufficiently close to this discontinuity to minimize loss, as hereinafter described.

Coaxial lines are usually operated with energy propagated in the principal, or TEM mode, and will transmit a wave of any frequency in this mode. But higher order modes of propagation can also exist. For these higher modes the coaxial line acts like a high-pass filter, and a given line will carry energy in one of the higher modes only if excited at a frequency above the critical or cutoff frequency for the given mode. This cut-off frequency depends upon the mode in question. At frequencies below cut-off, the higher modes may be excited at a source of energy or at a discontinuity in the line. In the present case such a discontinuity consists of plug **68.** Such higher modes attenuate rapidly with distance and draw no real power. However, if another discontinuity is introduced at a point close enough to the first discontinuity, the loss is minimized. In the present case, such a second discontinuity consists of compensating material **70** in the launch area of connector **33.** As shown in the example below for a 50 ohm connector the loss is less than 1 db.

As an example, in connector **33** designed to connect a 50 ohm coaxial line to a strip line, the inner diameter of the outer conductor, denoted "b" in FIG. **5,** is 0.161 inch and the outer diameter of the inner conductor, denoted "a," is 0.050 inch. Hence the b/a ratio is 0.161/0.050 or 3.22.

In FIG. **11,** abscissas represent b/a ratios and ordinates represent ratios of $\lambda_c/2b$ where λ_c is the wavelength at the cutoff frequency for a particular mode of propagation in a coaxial line. Referring to curve **74** for the TE_{11} mode one finds that the $\lambda_c/2b$ ratio for a b/a ratio of 3.22 is 2.0. Thus:

$$\lambda_c/2b = 2 \text{ or } \lambda_c = 4b \text{ or } \lambda_c = 0.644 \text{ inch.}$$

One then may solve for the cut-off frequency, F_c, using the equation:

$$F = 11.808/\lambda$$

where F is in gigaherz.
Thus:

$$F_c = 11.808/\lambda_c = 11.808/\mathbf{0.644} = 18.34 \text{ Ghz}$$

Alternatively one may use the formula:

$$\lambda_c = \pi\ [b + a] = 3.1416\ [0.161 + 0.050]$$
$$= 3.1416 \times 0.211$$
$$= 0.6629 \text{ inch}$$

and

$$F_c = 11.808/\mathbf{0.6629} = 17.81 \text{ Ghz}$$

The attenuation of any mode in the cut-off region is given by the formula:

$$\alpha = 54.6/\lambda_c\ [1-(\lambda_c/\lambda)^2]^{1/2}$$

where α is attenuation in db/unit length;

λ_c is the wavelength of cut-off frequency; and

λ is the wavelength of the frequency of interest. Thus, at 17 Ghz using the above λ_c of 0.644:

$$\lambda = 11.808/17 = 0.6945 \text{ inch; and}$$

$$\alpha = 54.6/0.644\ [1-(0.644/0.6945)^2]^{1/2}$$
$$= 31.78 \text{ db/unit length.}$$

The attenuation per wavelength at 17 Ghz thus is 31.73 × 0.6945 or 22.04 db/wavelength.

In one actual connector, built in accordance with the principles herein disclosed, the distance between captivation material **68** and compensating material **70** was 0.029 inch. Using the above value of α at 17 Ghz the attenuation therebetween was 31.73 × 0.029 or 0.92 db.

Comparative tests were made with the connector illustrated in FIGS. **4** and **5** and one having the same dimensions but without slot **52** in the end face **54** of tubular insulator **38,** and thus, without compensating material **70.** Curve **80** of FIG. **12** illustrates the VSWR of the connector without compensating material. Curve **82** of FIG. **13,** to the same scale as curve **80,** illustrates significant improvement in VSWR achieved with the connector employing the present invention.

The width and depth of slot **52** vary inversely with the dielectric constant of compensating material **70.** Compensating material **70** must have a dielectric constant greater than that of insulator **38.** The dielectric constant of teflon is about 2.04. I have used an epoxy resin having a dielectric constant of 4.0. With materials having even greater dielectric constants, the width and depth of slot **52** would be decreased. It is believed that the effect of the increased dielectric constant is to more efficiently pull the electric field into the TE_{11} mode.

In view of the foregoing, it may be seen that the several objects of the present invention are achieved and other advantageous results have been attained. While a preferred embodiment of the invention has been shown and described, it will be apparent to those skilled in the art that changes can be made in this embodiment without departing from the principles and spirit of the invention, the scope of which is defined in the appended claims.

I claim:

1. A connector for coupling a coaxial cable to a stripline comprising:

a tubular outer conductor terminating at one end in a flange;

a solid dielectric core member, having a dielectric constant, located within the outer conductor and having an axially extending central bore;

the outer conductor and the core member having a radially extending aperture adjacent the flange;

a cylindrical center conductor located within the central bore and having a reduced diameter section located within the aperture;

a solid plug, having a dielectric constant greater than the dielectric constant of the core member, filling the aperture and reduced diameter portion and holding the reduced diameter portion for preventing relative axial movement between the outer conductor, the core member and the center conductor;

the plug being formed from a material having a fluid state and pourable into the aperture to define, upon hardening, the solid plug;

the center conductor terminating in a thin rectangular, planar tab extending beyond the flange; and

the core member terminating at the tab in a slot filled with said hardened material.

2. A connector as in claim 1 in which the plane of the tab has an orientation perpendicular to the slot.

3. A connector as in claim 1 in which the plane of the tab has an orientation parallel to the slot.

* * * * *