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ADJUSTABLE IMPEDANCE STRIP TRANSMISSION LINE

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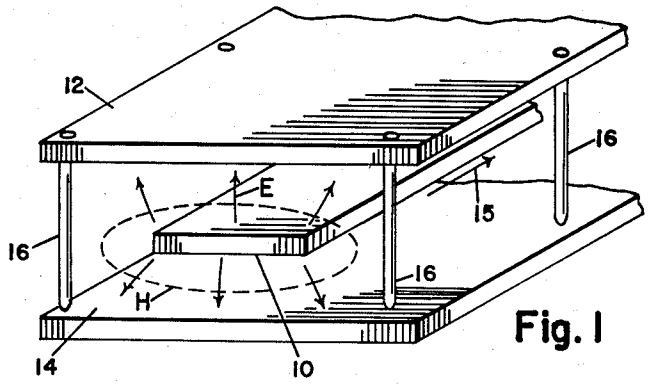


Fig. 1

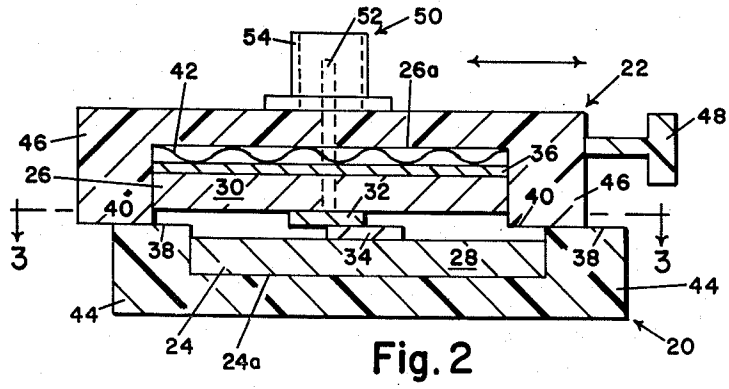


Fig. 2

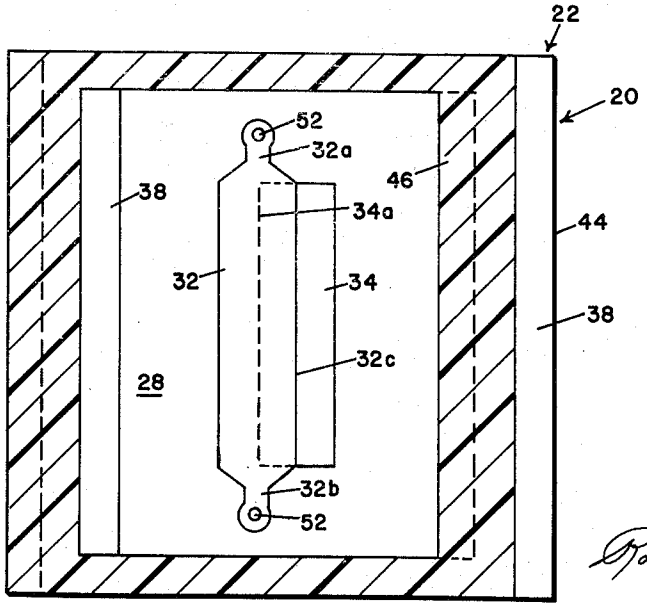


Fig. 3

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ADJUSTABLE IMPEDANCE STRIP TRANSMISSION LINE

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This invention relates to the art of high frequency transmission lines. More particularly, it relates to a variable quarter-wavelength transformer embodied in a strip transmission line configuration.

At high frequencies, transformers are used mainly as impedance matching devices. Thus, when a matching transformer is interposed between a source and a load having different impedances, the impedance connected to the terminals of the source is equal to the internal impedance of the source. Similarly, the load "sees" an impedance equal to the load impedance. The impedance match thus obtained provides optimum transfer of power between the source and load.

High frequency transformers generally take the form of quarter-wavelength sections of transmission line or waveguide. As is well known, a quarter-wavelength transformer will match impedances Z_1 and Z_2 connected to the ends thereof if the characteristic impedance Z_0 of the transformer is related to the matched impedances by,

$$Z_0=\sqrt{Z_1Z_2}$$

In many applications, it is desirable to vary the characteristic impedance of a quarter-wavelength section. For example, in laboratory experimentation, the impedances to be matched may vary considerably as different circuit connections are made. Even in field equipment it is often desirable to adjust the transformer in order to optimize a match between impedances which differ, within tolerance limits, from their nominal values.

Accordingly, it is a principal object of my invention to provide an improved quarter-wavelength transformer adapted to match impedances which may vary over a wide range.

Another object of my invention is to provide a transmission line unit having an adjustable characteristic impedance.

Yet another object of my invention is to provide a unit of the above type which is simple in construction and easy to adjust.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the features of construction, combination of elements and arrangement of parts which will be exemplified in the construction hereinafter set forth, and the scope of the invention will be indicated in the claims.

In general, a variable transformer incorporating the principles of my invention is formed as a section of strip transmission line of the type in which an inner conductor is disposed midway between a pair of outer ground plane conductors. The unit is constructed in two parts, one of which includes one ground plane conductor and the transmission line inner conductor, with an insulator disposed between them. The other part includes the other ground plane conductor, an inner conducting strip and

a second insulator disposed between them. The two parts are disposed with the conducting strip extending lengthwise along and contacting the inner conductor. The length of the strip is a quarter-wavelength at the operating frequency, and the inner conductor is approximately the same length. The two parts are arranged for movement of one over the other with the conducting strip moving in a transverse direction with respect to the inner conductor. Such movement effectively widens or narrows the inner conductor, depending on the direction of movement, and, since the characteristic impedance of the strip transmission line is a function of the width of the inner conductor, it is changed by the relative movement of the two parts.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

FIGURE 1 is a simplified perspective view of a section of strip transmission line,

FIGURE 2 is a vertical section of a variable transformer embodying the principles of my invention, and

FIGURE 3 is a horizontal section taken along line 3—3 of FIGURE 2 and showing in plan the inner conductor and auxiliary conducting strip of the transformer.

In FIGURE 1, I have illustrated the field distribution in a typical strip transmission line. The line has an inner conductor **10** situated between and parallel to a pair of outer or ground plane conductors **12** and **14**. The conductors **10**, **12**, and **14** are flat and may be quite thin. For example, they may be formed of foil bonded to dielectric material (not shown) filling the space between them. At an instant of time when the conductor **10** is positive with respect to the ground planes **12** and **14** and the current in the conductor **10** is in the direction of the arrow **15**, the field distribution in the transmission line is as shown in FIGURE 1, with the solid arrows representing the electric field E and the dash lines representing the magnetic field H.

The field configuration of FIGURE 1 is indicative of the TEM propagation mode, more fully discussed in the U.S. Patent No. 2,812,501 which issued November 5, 1957, to D. J. Sommers for "Transmission Line." However, it is possible to transmit other modes on the line under certain conditions. For example, if the inner conductor **10** is offset from its nominal position midway between the ground planes **12** and **14**, the ground planes will be at somewhat different potentials. This difference in voltage will support a parallel plate mode. Accordingly, the ground planes are "shorted" together by a plurality of pins **16** spaced along both edges of the inner conductor. The pins impose an equipotential condition on the planes and thereby suppress this mode. For effective suppression, the spacing of the pins in the lengthwise direction of the line should be less than a half wavelength. Ordinarily, this spacing is on the order of one-eighth wavelenth or less.

Another limitation on pin spacing results from the desirability of avoiding a resonant condition in any loop defined by the ground planes and a pair of adjacent pins. A resonant loop will distort the transmission characteristics of the line as well as facilitate radiation of energy therefrom. Resonance occurs when the length of the loop is an integral number of wavelengths, and, accordingly, the distance betwen adjacent pins should be considerably less than the spacing providing a wavelength loop.

If either of the transverse dimensions, i.e., ground plane-to-ground plane or pin-to-pin spacing is greater than a half wavelength, a transverse electrical waveguide mode may be excited. Therefore, both these dimensions should be less than a half wavelength. There is also a restriction on the length of the circumferential path around the inner conductor **10** and passing midway between the inner conductor and the ground planes **12** and **14** and pins **16**. This path should be less than a wavelength. Otherwise, the line will support a higher order transverse electric transmission line mode.

As seen in FIGURE 2, my transformer is contained in a pair of metallic housing members generally indicated at **20** and **22**. The members **20** and **22** are provided with recesses **24** and **26** containing insulators **28** and **30**. A strip transmission line inner conductor **32** is bonded to the insulator **30** and an auxiliary conducting strip **34** is similarly affixed to the insulator **28**. The surface **24***a* of the recess **24** serves as one of the ground plane conductors of a strip transmission line unit; a metallic sheet **36** bearing against the insulator **30** is the other ground plane conductor.

Still referring to FIGURE 2, the opposing surfaces **38** and **40** of the housing members **20** and **22** are in sliding contact with each other. At the same time, contact between the conducting strip **34** and the inner conductor **32** is ensured by a metallic spring **42** bearing on the sheet **36** and the surface **26***a* of the recess **26**. It will be noted that with contact between the members **20** and **22**, the vertical walls **44** and **46** thereof provide essentially the same functions as the shorting pins **16** of FIGURE 1. If desired, the members **20** and **22** may be held together by suitable clamping means (not shown) which permit relative movement of the members in the direction of the arrow, transversely to the inner conductor **32** and conducting strip **34**. Adjustment of the transformer, which is accomplished by such movement, is facilitated by a knob **48**, attached to the member **22**.

The inner conductor **32** may be provided with terminal portions **32***a* and **32***b* as shown in FIGURE 3. Access to each of the terminal portions may be by means of the conventional coaxial connector **50** in FIGURE 2. This connector has an inner central conductor **52** extending through the housing member **22**, ground plane conducting sheet **36** and insulator **30** to the terminal portions **32***a* and **32***b*. The connector **50** also includes an outer shell **54** secured to the housing member **22**.

Referring to FIGURE 3, the auxiliary conducting strip **34** is preferably a quarter-wavelength long at the operating frequency. Also, the terminal portions **32***a* and **32***b* are preferably much shorter than the remainder of the inner conductor **32** so that the latter may also be considered as a quarter wavelength section. Thus, the entire unit is operable as a quarter wavelength transformer, and adjustment in the manner indicated above serves to vary the impedances which can be matched by the transformer.

More particularly, assuming that the width of a strip transmission line inner conductor is much greater than the thickness thereof, the characteristic impedance of the transmission line is much more dependent on inner conductor width than on thickness. That is, a given percentage change in width will have a much greater effect on characteristic impedance than the same relative change in thickness. As an example of a change of this type, when the inner conductor **32** is moved from its right-most position (FIGURE 3) overlying the auxiliary conducting strip **34** to its left-most position where its edge **32***c* contacts the edge **34***a* of the inner conductor, the width of the composite conductor comprising the conductor **32** and the strip **34** is doubled, and the thickness is halved. The characteristic impedance of this section can be decreased by better than one-third, depending on the characteristic impedance of the section when the conductor **32** wholly overlies the strip **34**. Assuming a given source impedance, this means that loads varying over a 2 to 1 impedance range can be matched with a single quarter wavelength transformer.

By way of illustration, the conductor **32** and strip **34**, which preferably have the same transverse dimensions, may each be 0.14 inch wide and 0.0014 inch thick. If the insulators **28** and **30** are of glass cloth, having a dielectric constant of approximately 2.5, and the spacing between the ground planes is 0.125 inch, the characteristic impedance will approximately be 37 ohms when the conductor **32** fully overlies the strip **34** and 21 ohms when the transformer is in the fully extended position. Thus, a 50 ohm source impedance can be matched to a load impedance between 9 ohms and 27 ohms. It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above construction without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

What is claimed is:

1. A variable impedance strip transmission line section comprising, in combination, a first unit including a first ground plane conductor, an elongated flat strip inner conductor, forming part of a composite inner conductor, parallel to said first ground plane conductor and a first insulator disposed between said flat strip inner conductor and said first ground plane conductor, a second unit comprising a second ground plane conductor parallel to said first ground plane conductor, an elongated auxiliary conducting strip, forming a second part of said composite inner conductor, parallel to said second ground plane conductor and a second insulator disposed between said strip and said second ground plane conductor, said strip extending along and in overlapping sliding contact with said inner conductor, said first and second units being movable with respect to each other in a direction transverse to said inner conductor, whereby movement of said conductor strip over said inner conductor varies the amount of overlap and thereby changes the effective width of said composite inner conductor, the width of said flat strip inner conductor and auxiliary strip being substantially greater than the thickness thereof.

2. The combination defined in claim 1 in which said auxiliary strip is substantially a quarter-wavelength long at the operating frequency of said section.

3. A variable impedance strip transmission line section comprising, in combination, first and second housing members provided respectively with first and second opposing recesses, a ground plane conductor in each recess, an inner conductor between said ground plane conductors comprising an elongated flat conducting strip, a first insulator bonded to said flat strip inner conductor and disposed in said first recess and between said flat strip conductor and said first housing member, an elongated flat strip auxiliary conductor, a second insulator bonded to said auxiliary conductor and disposed in said second recess between said auxiliary conductor and said second member, said auxiliary conductor extending along said strip conductor and in overlapping sliding contact therewith, said housing members being in sliding contact with each other and movable relative to each other to move said auxiliary strip transversely over said flat strip inner conductor thereby to vary the amount of overlap and change the effective width of said inner conductor, the widths of said auxiliary conductor and strip conductor being substantially greater than the thickness thereof.

4. The combination defined in claim 3 in which said flat strip inner conductor includes a central portion disposed

between a pair of terminal portions, said auxiliary conductor being coextensive with said central portion and being a quarter wavelength long at the frequency of operation of said section.

5. The combination defined in claim 4 including a pair of coaxial connectors having outer shells secured to said first housing member, and inner central conductors extending through said housing member through but out of contact with the ground plane conductor therein and through said first insulator and connecting with said terminal portions of said strip conductor.

6. The combination defined in claim 3 wherein a spring within the recess in the first housing member is interposed between the ground plane conductor in said first housing and the bottom of the recess in said first housing

to urge the flat strip conductor into firm contact with said auxiliary conductor.

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