

May 6, 1958

M. ARDITI ET AL

2,833,995

MICROWAVE TRANSMISSION LINE

Filed May 8, 1952

2 Sheets-Sheet 1

Fig. 1

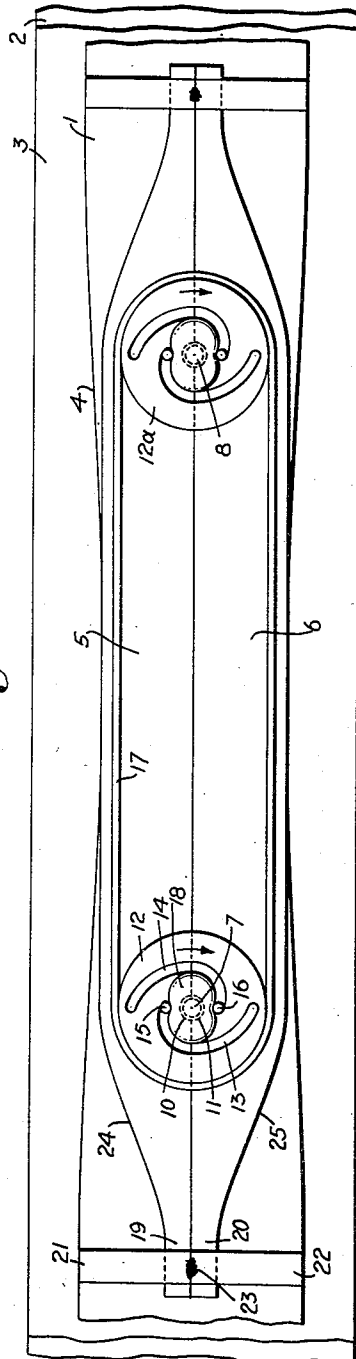


Fig. 3

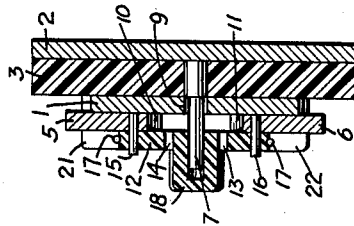
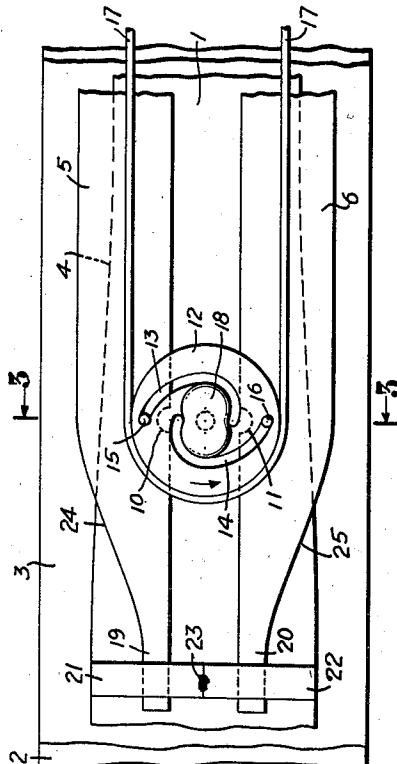


Fig. 2



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2 Sheets-Sheet 2

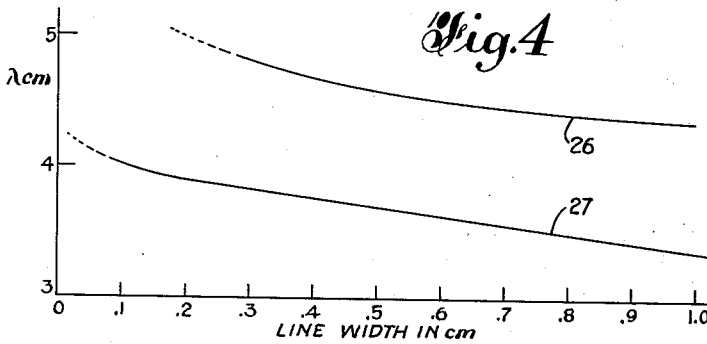


Fig. 5

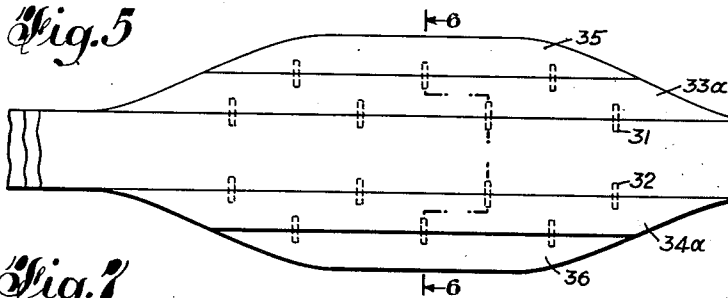


Fig. 6

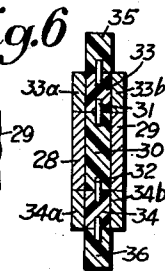


Fig. 7

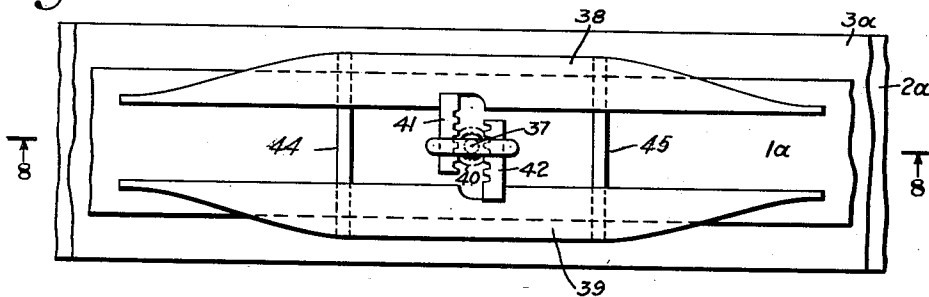


Fig. 8

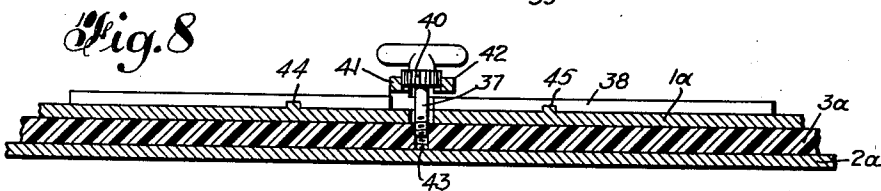


Fig. 9

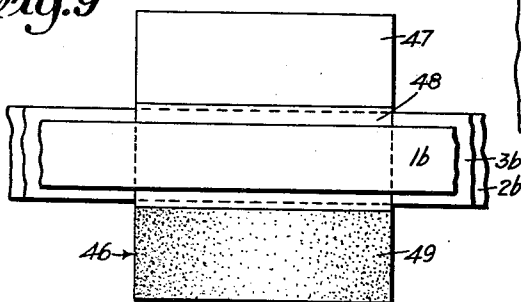
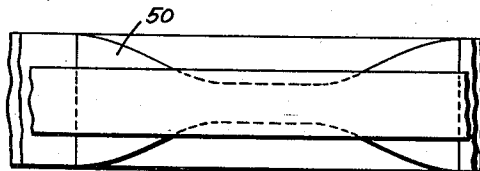


Fig. 10



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2,833,995

MICROWAVE TRANSMISSION LINE

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Application May 8, 1952, Serial No. 286,765

9 Claims. (Cl. 333—97)

This invention relates to microwave transmission lines and more particularly to a means for adjusting the wavelength characteristic of a section of such line.

In the compending applications of D. D. Grieg and H. F. Engelmann, Serial Nos. 227,896 now abandoned, and 234,503 now Patent No. 2,721,312, filed May 23, 1951, and June 30, 1951, respectively, and M. Arditi and P. Parzen, Serial No. 276,764, filed May 8, 1952, now Patent No. 2,774,046, a type of microwave transmission line is disclosed comprising, in one of its simplest forms, two conductors printed or otherwise disposed in substantially parallel relation on opposite sides of a strip or layer of dielectric material a small fraction of a quarter wavelength thick. The two conductors may be of the same width or one may be made wider than the other. The dielectric between the two conductors may be of substantially the same width as the narrowest of the two conductors or wider according to the relationships desired.

An object of this invention is to provide a section of transmission line of the parallel conductor type which is capable of adjustment in width whereby changes in line wavelength may be made.

Another object of this invention is to make a device for use in transmission lines which is capable of line wavelength adjustment.

One of the features of this invention is the provision of a section of a parallel conductor line with pieces of conductors overlying in parallel relation one of the line conductors together with means for adjusting the position of such pieces laterally with respect to the line conductor. By this arrangement the effective width of the line conductor can be adjusted at will. By making the line conductor smaller where the overlapping pieces are located, the line conductor can actually be made narrower by adjusting the conductor pieces within the outline of the line conductor.

Another feature of the invention includes changing the effective width of the dielectric strip and in some instances the widths of both the dielectric and conductors whereby changes in line wavelength are obtained. Still other features include selective substitution of the line dielectric, and the use of a conductive screw either by itself or in conjunction with line width adjustable conducting pieces for producing change in line wavelength.

The above-mentioned and other objects and features of this invention will become more apparent by reference to the following description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a plan view of a section of microwave transmission line with means for adjusting the effective width thereof in accordance with the principles of this invention, the section of line being shown in its narrowest adjusted width;

Fig. 2 is a plan view of the left-hand side of the line shown in Fig. 1 with the effective line width adjusted to its maximum value;

Fig. 3 is a cross-sectional view taken substantially along line 3—3 of Fig. 2;

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Fig. 4 is a graph showing changes in line wavelength in accordance with the different widths of the line conductor;

Fig. 5 is a plan view of a modified form of transmission line incorporating the principles of this invention;

Fig. 6 is a cross-sectional view taken along line 6—6 of Fig. 5;

Fig. 7 is a plan view of a modified form of the invention;

Fig. 8 is a longitudinal cross-section along line 8—8 of Fig. 7;

Fig. 9 is a plan view of still another embodiment; and

Fig. 10 is a plan view of a dielectric-card usable in the form of Fig. 9.

Referring to Figs. 1, 2, and 3 of the drawing, the microwave transmission line shown is of the printed circuit type comprising a first or "line" conductor 1 and a second or "base" conductor 2 with a layer 3 of dielectric material therebetween. The conductive material may be applied and/or shaped or etched on a layer of dielectric material, such as polystyrene, polyethylene, "Teflon," fiberglass, quartz or other suitable material of high dielectric quality, in the form of strips, conductive paint or ink, or the conductive material may be chemically deposited, sprayed through a stencil, or dusted onto selected prepared surfaces of the dielectric, or by any other of the known printed circuit techniques. The spacing of the two conductors is preferably selected a small fraction in the order of about $\frac{1}{10}$ to about $\frac{1}{2}$ of a quarter wavelength of the microwave propagated therealong.

The conductor 1 is preferably narrowed gradually as indicated at 4 for a desired length either 1 or 2 line wavelengths long. A pair of conductive strips 5 and 6 are disposed in overlapping relationship with respect to the conductor 1. The combined widths of the two strips 5 and 6 are preferably equal to the narrowest width of the line conductor 1 although not necessarily so. Centrally disposed at spaced points with respect to the line conductor 1 are two posts 7 and 8 preferably of dielectric material which may be the same as the dielectric 3. The posts 7 and 8, however, may be of conductive material secured to the conductor 2 at one end providing the posts are free of contact with the conductor 1 and the conductor pieces 5 and 6. This may be accomplished by providing enlarged openings 9 in the conductor 1 through which the posts extend. Likewise, the pieces 5 and 6 may be provided with cut-outs as indicated at 10 and 11 to avoid contact with the post should the latter be of conductive material. The position of such a post in the line is found to have small effect upon the line compared with the change in conductor width provided by adjustment of conductor pieces 5 and 6.

Pivotal mounted on these posts 7 and 8 are cams 12 and 12a, which contain a pair of cam slots or surfaces 13 and 14. The slots 13 and 14 receive pins 15 and 16 carried by conductor pieces 5 and 6, respectively. Encircling the cams 12 and 12a is an endless cord 17. When either cam is manipulated by manually turning knob 18, both cams are rotated through means of the endless cord 17. This rotation of the cams 12 and 12a causes movement of the conductor pieces 5 and 6 outwardly or inwardly laterally of the conductor 1 depending upon the direction of rotation of the cams. In the position shown in Fig. 1, the cams are shown at one extremity of their move in a direction such as to draw the conductor pieces 5 and 6 inwardly with respect to the outline of the line conductor 1. In Fig. 2 the conductor pieces 5 and 6 are shown in their outward position when the cams are moved to the opposite end of their movement. It will be observed that the pins 15 and 16 are at one end of the cam slots 13 and 14 in Fig. 1 and the opposite ends of the same slot in Fig. 2.

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In order to maintain the conductor pieces 5 and 6 in good conductive contact with the line conductor 1, the ends 19 and 20 are received beneath a strap 21, 22. This strap may be formed of lateral extensions of the conductor 1 bent back across the ends of the conductor pieces 5 and 6 and soldered together as indicated at 23. The strap 21, 22 may be otherwise formed and in fact may constitute a plate of suitable material, either conductive or dielectric, as may be desired, carried by either the conductor 1 or the dielectric 3. Regardless of the structural arrangement of the strap 21, 22, the purpose thereof is to hold the ends 19 and 20 flat against the conductor 1 so as to insure conductive contact, and yet to provide sufficient resilience to allow lateral movement of the pieces 5 and 6.

As hereinbefore described, the edges of the conductor 1 are gradually tapered inwardly to the narrowest cross section desired for the conductor 1. The end portions of the conductor pieces 5 and 6 are likewise curved gradually as indicated at 24 and 25 so as to avoid any abrupt discontinuity between the edge of the conductor 1 and the edges of the two pieces 5 and 6. This gradual transition holds substantially throughout the extent of adjustment.

In Fig. 4 a graph of the line wavelength for different line widths is shown for two different materials. The curve 26 was determined by means of a printed microwave transmission line using polystyrene as the dielectric 3. Curve 27 was determined from a transmission line section using fiberglass as the dielectric 3. The frequency employed for these tests was 4700 mc./s. A change in width of the line conductor 1 from 6 mm. to 3 mm. in the case of the fiberglass specimen increased the line wavelength from 36.3 mm. to 38.3 mm. The same change in conductor width for the specimen utilizing polystyrene dielectric was from 45 mm. to 48 mm.

The changing of the width of the dielectric material while leaving the conductors the same width also produces a change in the line wavelength. By extending the width of the dielectric strip from a width equal to the width of two conductors of the same width by 27 mm. in opposite directions, a line wavelength was varied from 35.2 mm. to 36.8 mm. In Fig. 5 a transmission line is shown wherein the conductors 28 and 29 are of substantially the same width separated by a similar width of dielectric material 30. The side edges of the dielectric strip 30 may have small recesses 31 and 32 whereby additional strips of dielectric material 33 and 34 may be applied by means of dielectric pins receivable in the recesses 31 and 32. However, any suitable means may be provided to secure these additional strips, one simple method being to use a bonding lacquer. Two or more of such additional dielectric strips may be added as indicated by the additional strips 35 and 36. In this way the line wavelength may be increased as desired. The additional strips 33-36 would of course be provided with tapered end portions so as to present a gradual transition from the width of the strip 30 to the combined width therewith of the additional strips of dielectric. If desired these additional strips of dielectric may also carry strips of conductors as indicated at 33a, 33b and 34a, 34b. These additional conductor strips may be on one side only of the additional dielectric strips or on both sides as may be desired.

Figs. 7 and 8 show a further embodiment of the invention wherein a double line wavelength effect is obtained simultaneously. One effect is obtained by a conductive screw 37 and the other is obtained by a pair of conductive pieces 38 and 39 similar to those shown in Figs. 1 to 3. The screw 37 is provided with gear teeth 40 which mesh with racks 41 and 42 carried by the pieces 38 and 39, respectively. The screw 37 is threadably received in a hole 43 and when turned therein it activates racks 41 and 42 to move the pieces 38 and 39 laterally to effect a change in the effective width of the line con-

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ductor 1a. The introduction of screw 37 into the space between conductors 1a and 2a also effects a small change in the width characteristic of the line conductor. For example, a conductive screw of 0.05 in diameter inserted substantially entirely across the space between conductors corresponds to an increase of approximately 0.008 in the line wavelengths.

The threads of the screw 37 may be such as to cause screw movement into the line when pieces 38 and 39 are moved apart, or vice versa, the screw may move out of the line when pieces 38 and 39 are moved apart. In the first instance the two effects are additive and in the second instance the effect of the screw would be subtractive with respect to the effect of pieces 38 and 39. Ribs 44 and 45 are provided on conductor 1a to guide the pieces 38 and 39.

In Fig. 9 we show still another embodiment wherein the widening effect or line wavelength is varied by selectively changing the dielectric in the line. A section of the dielectric 3b is replaced by a card 46 made up of a plurality of strips 47, 48 and 49 of materials having different dielectric constants. By selectively placing the card between conductors 1b and 2b a variation in line wavelength may be obtained in accordance with the particular dielectric constant of the strip introduced in alignment with the dielectric 3a. Air dielectric may be had by removing the card but then the abrupt change between dielectric 3b and air produces an impedance mismatch unless the spacing between conductors is reduced. Where a card section is of foam dielectric having a distribution of air spaces therethrough, as indicated by section 49, the same impedance matching problem is present. We overcome this, however, by making that section of the card denser at the ends of the strip thereby presenting a gradual transition between dielectric 3a and the less dense foam in the center portion of the section 49. As a further variation the card 45 may be replaced by a card of a particular dielectric and if desired the card may be specially shaped to produce a gradual transition as indicated by the card 50 of Fig. 10. The change in dielectric width to a dimension less than the width of the line conductor 1b introduces air as part of the effective dielectric.

While we have described above the principles of our invention in connection with specific apparatus, it is to be clearly understood that this description is made by way of example only and not as a limitation to the scope of our invention as set forth in the objects thereof and in the accompanying claims.

We claim:

1. A transmission line comprising first and second ribbon-like conductors, means disposing said conductors in spaced substantially parallel relation, and means for adjusting the line wavelength of a section of said line including a piece of conductor having an elongated flat surface disposed in longitudinal overlying parallel contact relation to said first conductor and means for adjusting the position of said piece of conductor laterally to extend beyond said first conductor and confront said second conductor to thereby widen the conductor characteristics of said first conductor relative to said second conductor.

2. A transmission line according to claim 1, wherein said piece of conductor has tapered end portions to insure a gradual transition with respect to said first conductor when said piece of conductor extends beyond the edge of said first conductor.

3. A transmission line comprising first and second ribbon-like conductors, means disposing said conductors in spaced substantially parallel relation, and means for adjusting the line wavelength of a section of said line including a pair of conductor pieces each having an elongated flat surface disposed in longitudinal overlying parallel juxtaposed relation to said first conductor and means for adjusting the positions of said pieces laterally to extend beyond said first conductor and confront said

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second conductor to thereby widen the conductor characteristics of said first conductor relative to said second conductor.

4. A transmission line according to claim 3, wherein the means for adjusting the position of said pieces of conductor comprises a cam carried by the transmission line, means carried by each of said conductor pieces for engagement with said cam and means for turning the cam to effect movement of said conductor pieces.

5. A transmission line according to claim 4, further including means for maintaining said conductor pieces in conductive contact with said first conductor.

6. A transmission line comprising first and second ribbon-like conductors, said second conductor being wider than said first conductor, a strip of dielectric material separating said conductors in spaced substantially parallel relation a small fraction of a wavelength apart, and means for adjusting the width of said first conductor including a pair of conductor strips disposed in overlying contact relationship with respect to said first conductor and means for adjusting the positions of said pieces laterally to vary the overall width of said first conductor.

7. A transmission line comprising first and second ribbon-like conductors, said second conductor being wider than said first conductor, a strip of dielectric material separating said conductors in spaced substantially parallel relation a small fraction of a wavelength apart, and means for adjusting the width of said first conductor, said first conductor comprising a section tapered from its normal width to a given narrow width and the means for adjusting the width of said first conductor includes a strip of conductor overlying said first conductor and means to adjust the position of said conductor strip laterally of said first conductor to project outwardly beyond the edge of said first conductor, the end portions of said conductor strip being tapered to provide a gradual transition with the edge of said first conductor.

8. A transmission line comprising first and second ribbon-like conductors, means disposing said conductors in spaced substantially parallel relation, means for adjusting the line wavelength of a section of said line including a piece of conductor having an elongated flat

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surface disposed in longitudinal overlying parallel contact relation to said first conductor, means for adjusting the position of said piece of conductor laterally to extend beyond said first conductor and confront said second conductor to thereby widen the conductor characteristics of said first conductor relative to said second conductor, said adjusting means including a conductive screw threadably adjustable through one of said conductors relative to the other.

9. A transmission line comprising first and second ribbon-like conductors, means disposing said conductors in spaced substantially parallel relation a small fraction of a quarter wavelength apart, means for adjusting the line wavelength of a section of said line including a pair of conductor pieces having elongated flat surfaces in longitudinal overlapping contact relation to said first conductor, means for adjusting the position of said conductor pieces laterally to extend beyond said first conductor and confront said second conductor to thereby widen the conductor characteristics of said first conductor, said adjusting means including means guiding said conductor pieces for said lateral movement, a rack carried by each said piece and a conductive screw threadably received through said first conductor for adjustment relative said second conductor and gear teeth carried by said screw to activate said racks.

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