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L. D. BALDWIN
MICROWAVE TUNER

2,925,568

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2 Sheets-Sheet 1

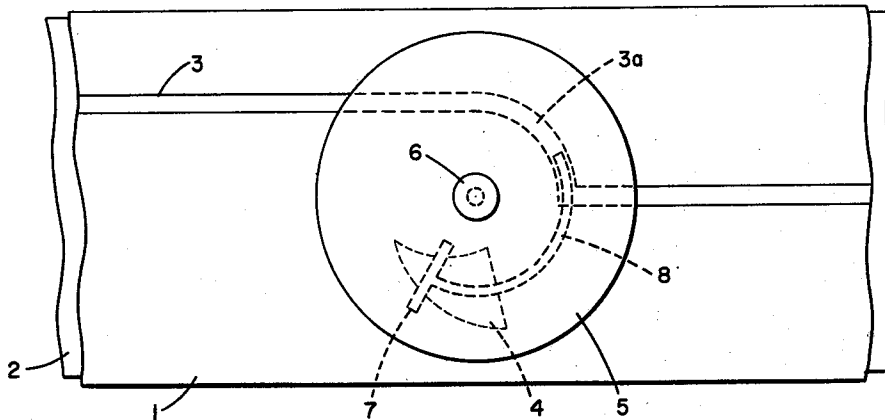


Fig. 1

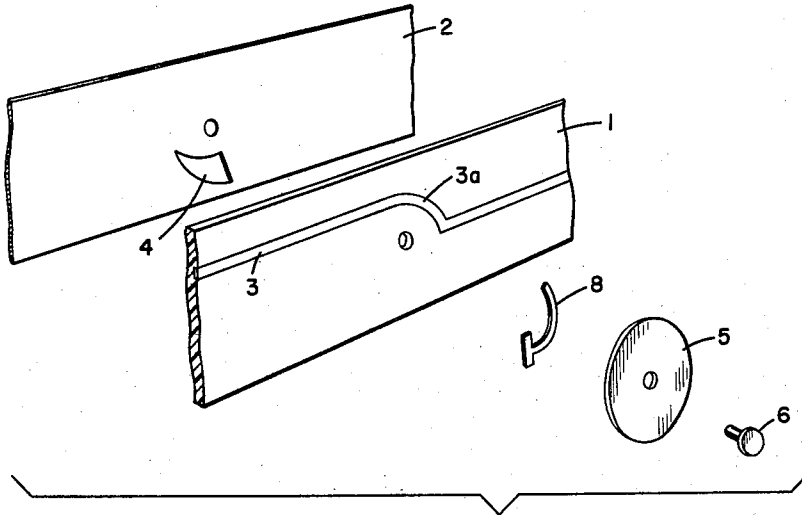


Fig. 2

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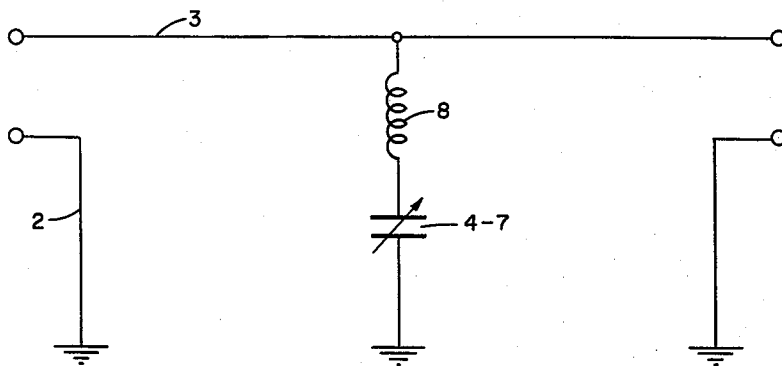


Fig. 3

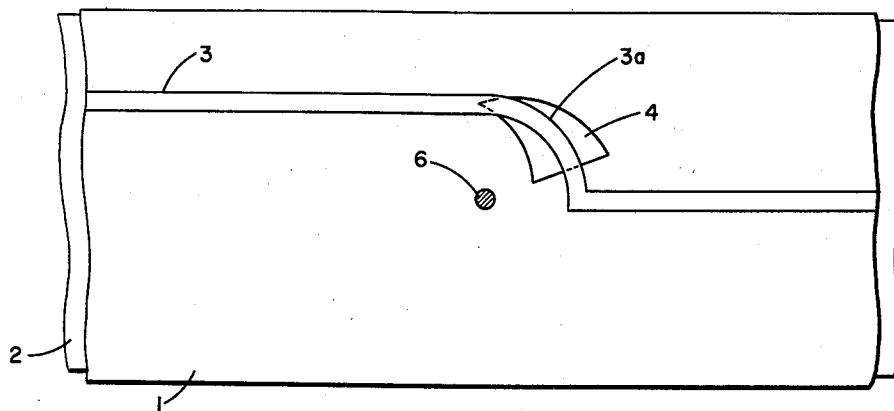


Fig. 4

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1

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MICROWAVE TUNER

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1 Claim. (Cl. 333—82)

This invention relates to variable tuners, and is particularly directed to variable capacitors adapted to the microwave ranges of frequency.

The conventional variable condenser having a rotating shaft carrying one set of plates interleaved with a set of stationary plates is impractical in circuits where the wave length of the currents to be handled approaches the dimensions of the plates and their leads. Such structures are relatively complex and have always been a high-cost component in systems manufacture. The effects of variable capacity have been obtained heretofore in wave guides, coaxial cables, tuned wire transmission lines or other conductors with distributed constants, by the use of the standing wave phenomena as by adjustment of line length, stub length, or probe position. It is often desirable, however, that shunt capacities be variable without disturbing the distributed constants of the line. Conventional condensers cannot be used because of their size and their cost, as well as because of their large dimensions with respect to the wave length to be handled.

The object of this invention is to provide an improved variable condenser for use in microwave circuits, particular attention being given to economical manufacture and desirable electrical properties in the microwave range.

The objects of this invention are attained in a printed-circuit-type transmission line having a line or strip conductor adhered to one side of an insulating sheet, the other side of which is covered with a ground plate, characterized in that a window is cut through either the insulating sheet or ground plate, and a movable flat metal electrode slidable across the window with a stub line connected to the electrode and in slidable contact with said line so that the capacity between said strip conductor and ground plate is varied. The construction is simple and economical in manufacture, is reliable in operation, and does not disturb the distributed inductance or capacity of the strip line conductor.

Other objects and features of this invention will become apparent to those skilled in the art as the following description proceeds, and the features of novelty which characterize the invention will be pointed out with particularity in the claim annexed to and forming a part of this specification. The accompanying drawing, showing specific embodiments of the invention, comprises:

Fig. 1 is a plan view of one microwave condenser of this invention,

Fig. 2 is a perspective partly sectioned view of the structure of Fig. 1,

Fig. 3 is an approximate circuit equivalent of the condenser of Fig. 1, and

Fig. 4 is a plan view of an alternative structure embodying this invention.

In Fig. 1 is shown the sheet 1 of insulating material. The material of sheet 1 is of high quality, low loss, high dielectric insulation commercially obtainable for use in fields of microwave frequency. Such materials may, for example, be of polystyrene or polyethylene or commercially obtainable "Teflon."

2

To the under or back side of the insulating sheet is affixed as by gluing a thin sheet or foil 2 of copper, or other good electrical conductive material. To the top or front side of the sheet is laid the line conductor 3, which, like the sheet 2, is preferably of foil thickness and firmly adhered to the insulating sheet so that the spacing between sheet 2 and conductor 3 is substantially uniform throughout the length of the line conductor. The fields produced by high frequency currents flowing in the conductor are largely limited to the space occupied by the insulation between or near to the space under the conductor, in which case there is little loss by radiation.

The line conductor 3 may be applied to the face of sheet 1 by "printing" powdered metal ink or paint on the sheet and backing. Alternatively, the front side of sheet 1 may be covered overall with a metal sheet similar to sheet 2, the entire area covered with commercial photoresist and exposed through a negative image of the desired line conductor contour. By a metal etching solution, the unexposed portion of the sheet can be removed.

If the cross sectional dimensions of the line conductor 3 are not materially changed, the characteristic impedance of the line conductor remains fairly uniform. It has been found that curves or bends may be made in the conductor without changing its electrical characteristics.

In Fig. 1 is shown, according to this invention, means for variably changing the capacity between one point in the line and the ground plate 2. The flat metal electrode 7 slides on the side of the insulating sheet opposite the metal sheet and in contact with the line 3, the apparent electric capacity of the sheets to the movable electrode being asymmetrical in a limited area so that the capacity coupling of the line to the metal sheet may be varied by sliding the electrode across said area. Conveniently, an irregularly shaped window 4 is cut in either sheet, a cut-out in the metal sheet, or plate 2, being shown in Fig. 1. The movable insulating plate 5 overlies window 4 and a portion of line conductor 3. Plate 5 in the example shown is a disk pivoted on pin 6 at the center of the disk, which pin extends through sheets 1 and 2. To the under side of disk 5 is applied a foil-like electrode 7, electrically connected to the stub conductor 8.

According to an important feature of this invention, the electrode 7 is so disposed on disk 5 as to be carried across window 4. Also, stub conductor 8 is so laid out on the under face of disk 5 as to remain in sliding contact with line conductor 3 while electrode 7 traverses the window 4. Preferably line conductor 3 is laid out in an arcuate path, 3a, around the pivot hole 6 and on the same radius as stub conductor 8 on the disk. As conductor 8 moves in sliding contact with 3a, the effective electrical length of conductor 3 remains unchanged. The length of stub conductor 8, however, does change, and the inductive reactance thereof increases somewhat with increased length, particularly at the shorter wave lengths. Of course, where the length of stub conductor 8 approaches the wave length of the operating frequency, tuning effects will be experienced.

In Fig. 3 is shown the approximate circuit equivalent of the condenser of Fig. 1, where line 3 is above radio frequency ground potential and where intermediate its ends, the condenser 4—7 is shunted to ground. At the higher frequencies, stub conductor 8 appears as an inductance in series with the capacity of the condenser.

The shape of the window 4 will be determined by the displacement vs. capacity variable desired. If a linear variation of capacity is desired, the window may be triangular in shape, and where the triangle is laid out on the arc of a circle as suggested in the specific embodiment of Fig. 1, the sides of the triangle would be curved as shown. The dimensions of the window will, of course,

be computed from the range of capacities desired and from the dielectric constant of the insulating material in sheet 1. Exponential variations in capacity are easily attained by appropriately shaping the edges of the window 4. While rotational movement has been suggested by the disk 5, it will appear to those skilled in the art that rectilinear movement may be provided by moving the carrier, corresponding to disk 5, in guideways. The advantage of the circular movement lies in the fact that the disk may be rotated by the pin 6 extending through the ground plate 2 to the outer end of which may be keyed a conventional tuning knob.

Should it be desired to operate the tuning condenser of this invention at frequencies at which the length of stub conductor 8 becomes an appreciable fraction of the wave length of the operating frequency, the effects of the variable length stub may be obviated as shown in Fig. 4. By placing the window under the curved portion of the line, 3a, so that the electrode 7 slides in contact with the line as the electrode traverses the window, the stub conductor may be eliminated.

While the window 4 has been disclosed as being in the ground plate, variations in capacity may be produced by cutting the window in the insulating sheet 1. Where the dielectric constant of the sheet is high compared to the dielectric constant of the media in the window (air in this case), the variations of capacity can be made as large as desired.

While a specific embodiment of this invention has been shown and described, other modifications will readily occur to those skilled in the art. It is not, therefore, desired that this invention be limited to the specific arrangement shown and described, and it is intended in the appended claim to cover all modifications within the spirit and scope of this invention.

What is claimed is:

In a microwave transmission system, a printed-circuit-type transmission line having a sheet of insulation with a metal plate and a line conductor on opposite sides thereof, said line conductor extending across said sheet and having a circularly curved portion intermediate the ends of the line conductor, a disc on said sheet pivoted at the center of curvature of said line conductor, a circularly curved conductor carried on one face of said disc, the radii of curvature of the conductors on said sheet and disc being equal so that the conductor on said disc registers with and overlies said curved portion of the conductor on said sheet and so that the conductor on said disc can be adjustably extended as a tunable stub beyond said curved portion of said line conductor, and the sheet and plate having a dielectric discontinuity within the area traversed by the extended portion of said tunable stub so that the capacity of the plate to the movable stub changes and the inductive reactance of the stub is varied as the disc is revolved.

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