July 2, 1957 W. CAITHNESS 2,798,186

ELECTRON DISCHARGE DEVICE FOR MICROSTRIP TRANSMISSION SYSTEMS

Filed April 19, 1955 4 Sheets-Sheet 1

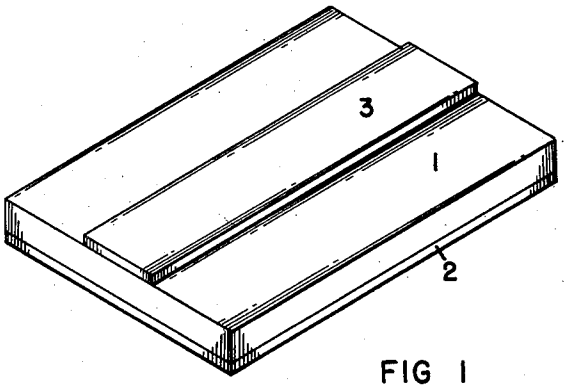
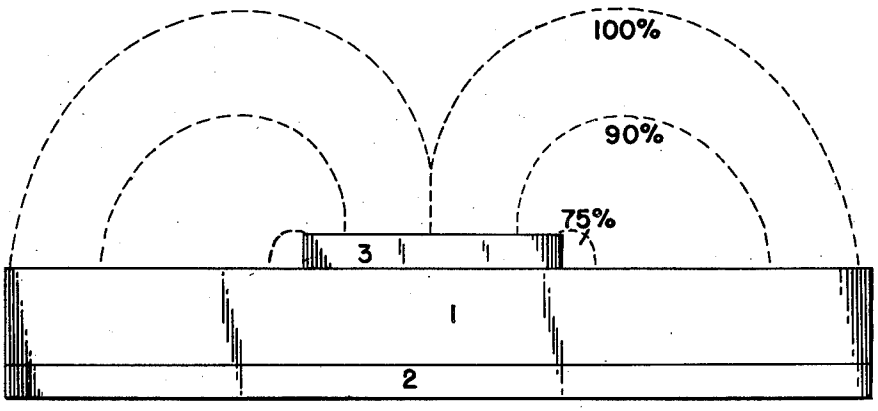


FIG 1



DISTRIBUTION OF POWER FLOW

FIG 2

INVENTOR.

WILLIAM CAITHNESS

BY Edgar O. Rost

ATTORNEY

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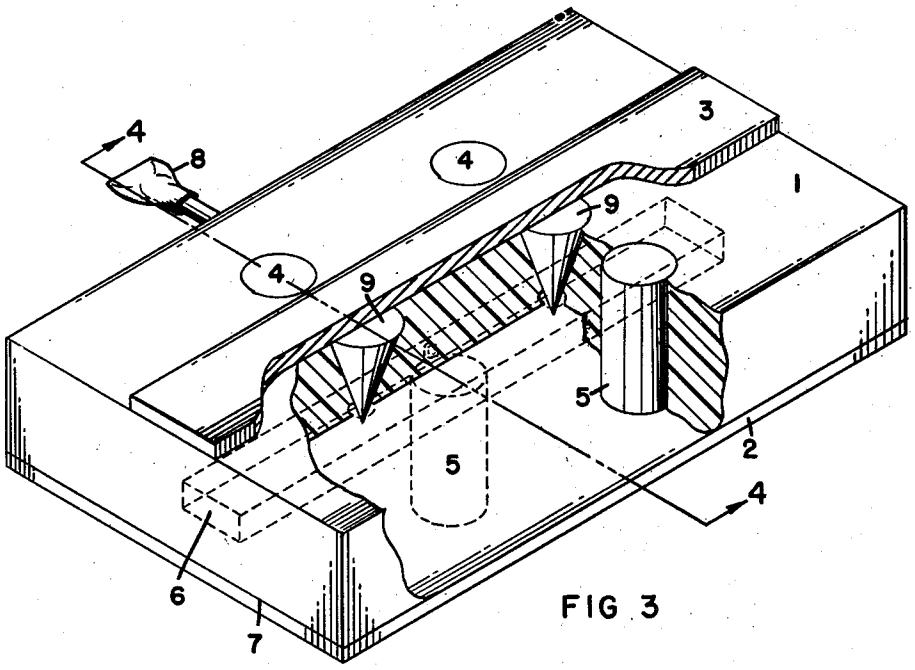


FIG 3

INVENTOR.
WILLIAM CAITHNESS
BY Edgar O. Lost
ATTORNEY

July 2, 1957 W. CAITHNESS 2,798,186

ELECTRON DISCHARGE DEVICE FOR MICROSTRIP TRANSMISSION SYSTEMS

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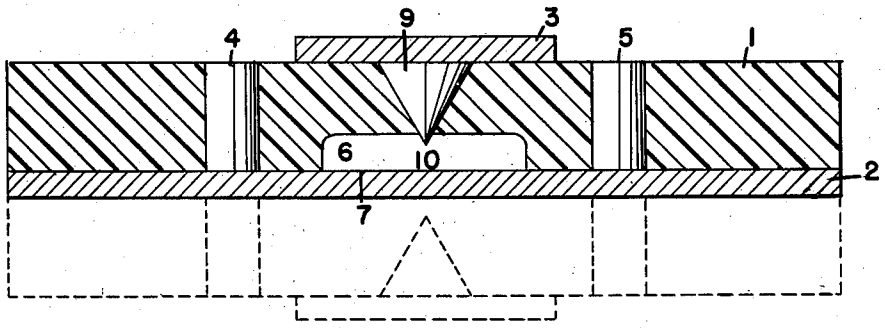


FIG 4

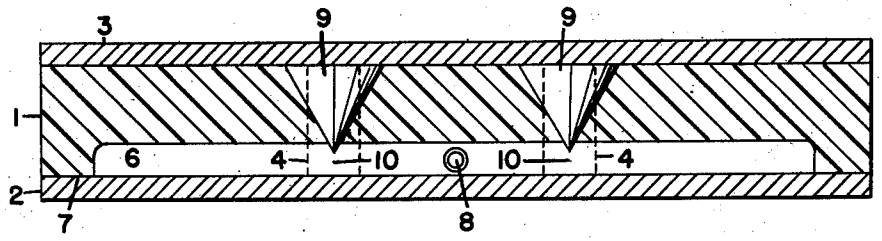


FIG 5

INVENTOR.
WILLIAM CAITHNESS
BY Edgar O. Post
ATTORNEY

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ELECTRON DISCHARGE DEVICE FOR MICROSTRIP TRANSMISSION SYSTEMS

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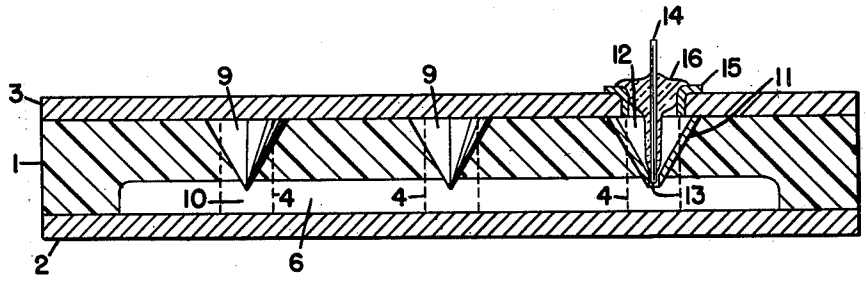


FIG 6

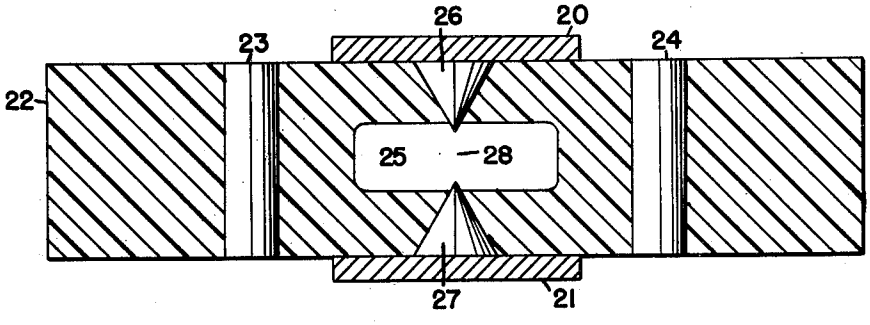


FIG 7

INVENTOR.
WILLIAM CAITHNESS
BY Edgar O. Lost
ATTORNEY

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2,798,186

ELECTRON DISCHARGE DEVICE FOR MICROSTRIP TRANSMISSION SYSTEMS

William Caithness, Reading, Mass., assignor to Bomac Laboratories Inc., Beverly, Mass., a corporation of Massachusetts

Application April 19, 1955, Serial No. 502,278

7 Claims. (Cl. 315—39)

The present invention relates to microwave components for conductor-ground-plane transmission systems and in particular to a novel transmit-receive (TR) tube for such systems.

The function of the transmit-receive tube in switching microwave energy within the metallic enclosed type waveguide has been described in detail in the prior art and literature. An embodiment of such tubes is shown in U. S. Patent No. 2,680,207 issued June 1, 1954, to Harold C. Booth.

The development of the conductor-ground-plane, or as it is commonly referred to, microstrip transmission system has been described in the Proceedings of the I. R. E., December 1952, vol. 40, No. 2, at pages 1644–1663 inclusive.

A primary object of the present invention is to provide a novel high frequency gaseous discharge transmit-receive device for such a system.

One embodiment of a microstrip transmission line comprises a block of a dielectric material joined between a narrow ribbon conductor and a base member or ground plane of a similar conductive metal. According to the teachings of my invention, I provide a resonant iris structure within a section of microstrip line and a conical electrode structure is provided on the undersurface of the ribbon conductor. A reservoir for an inert gas filling is defined by a recessed channel in the dielectric block surface adjacent to the base member. The tip of the conical electrode structure extends into the reservoir and is spaced from the base member to define a discharge gap. When the voltage potential across the gap reaches the breakdown potential of the gas, a gaseous discharge will result to thereby short circuit the transmission line.

The invention will now be described in the following specification with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view of a section of a conventional microstrip transmission line;

Fig. 2 is an end view with dotted lines indicating approximate power distribution in transmission lines illustrated in Fig. 1;

Fig. 3 is a perspective view of the embodiment of the present invention with a portion of the envelope removed to disclose interior structure;

Fig. 4 is a cross-sectional view of the embodiment along the line 4—4 in Fig. 3;

Fig. 5 is a longitudinal cross-section view of the illustrative embodiment;

Fig. 6 is an alternative embodiment with ignitor electrode structure; and

Fig. 7 is a cross-sectional view of still another embodiment of the invention.

Referring now to Fig. 1, there is shown an illustrative embodiment of a section of microstrip transmission line of the metal-clad dielectric type with the dielectric material 1 sandwiched between two high-conductivity metals such as copper, silver and the like with the wide base member 2 serving as the ground plane and the narrow

ribbon-like conductor 3 serving as the transmission-line configuration. Various dielectric materials may be employed that have low dielectric losses and good temperature characteristics; for example, Teflon, any of the polystyrene and laminated phenolic plastics, glass or ceramics.

The theoretical calculations of transmission characteristics will not be discussed since they have been disclosed in detail in the aforementioned Proceedings of the I. R. E.

It will suffice for the purposes of this disclosure to refer to the approximate power-flow distribution pattern for such a transmission system, as shown in Fig. 2. To first provide the resonant iris condition so necessary for a satisfactory transmit-receive tube, a pair of inductive members 4 and 5 which may be of circular configuration are positioned in the zone of high field intensity, preferably in the 90% zone for mechanical considerations. The inductive iris posts 4 and 5, as shown in Figs. 2–4, are positioned wholly within the dielectric material 1 and contact ground plane 2.

A gas reservoir 6 containing a suitable ionizable atmosphere is defined in the dielectric block 1 by means of a recessed channel closed at both ends extending along the longitudinal axis of the microstrip section along the side adjacent to the ground plane 2. By hermetically sealing the dielectric block to the ground plane by means of suitable low loss cements or brazing techniques, a vacuum tight joint may be provided along the joining edge 7. It will be noted in Fig. 5 that the reservoir 6 does not extend throughout the length of the microstrip section and is in effect surrounded on one side by the ground plane 2 and on remaining sides by the dielectric material 1. Exhausting of reservoir 6 and filling with an ionizable atmosphere such as argon, hydrogen or similar inert gases is accomplished by means of an exhaust tubulation 8 extending through dielectric block 1.

The electrode structure comprises a conical electrode 9 of a conductive metal attached to the underside of ribbon conductor 3 by conventional soldering techniques. The inner tip of electrode 9 extends into the reservoir 6 and is spaced a short distance from the ground plane 2 to provide a discharge gap 10. Various attenuative methods of mounting electrode 9 may be selected such as drilling an aperture in the ribbon conductor and positioning the wide section of the electrode within the aperture.

While a single electrode may be satisfactory in certain applications, a plurality of similar electrodes may be provided with accompanying iris posts 4 and 5 at intervals of approximately a quarter of a wavelength as shown in the embodiment in Figs. 3 and 5.

An alternative embodiment of the invention is shown in Fig. 6 and incorporates the addition of a third electrode 11 having a hollow conical section 12 and an open-end tip 13. A wire electrode 14 extends into this hollow section to a point a short distance from open-tip 13 and is positioned on the ribbon conductor 3 by means of an eyelet 15 with an insulator 16 of a ceramic or glass material. By connecting electrode 14 to a direct current voltage supply, a source of electrons will be present in the area of the discharge gap to facilitate the initiation of the gaseous discharge.

Referring again to Fig. 4, one of the characteristics of the microstrip transmission system will be explained briefly to facilitate an understanding of still another modification of the invention.

The so-called "image effect" has been observed and calculated for parallel-wire systems in the cited publication as well as in U. S. Patent No. 2,159,648 issued May 23, 1939, to Andrew Alford. It has been found that a conductor supported by an infinite ground plane is the equivalent of a parallel-wire with the ground plane pro-

viding an "image" when a field is present. This so-called "image" is indicated by dotted lines in Fig. 4.

Another alternative embodiment of the invention shown in Fig. 7 will result in such instances where the ground plane is removed and a transmission line comprising two narrow conductors is employed. In this embodiment two parallel ribbon conductors **20** and **21** are supported on opposite sides of a dielectric block **22** of approximately twice the thickness of the material employed in Fig. 1. Plural inductive posts **23** and **24** extend through said block in a similar position to that shown in Fig. 4. A rectangular cavity **25** extends along the longitudinal axis of the dielectric block and is located at an intermediate point between the ribbon conductors to provide a reservoir for a gas atmosphere. Conical electrodes **26** and **27** with opposed spaced convergent ends providing a discharge gap **28** are electrically connected to each ribbon conductor and are contained wholly within the dielectric material. The tips of said electrodes extend into the gas reservoir **25** which may be filled with similar gas atmospheres by means of an exhaust tabulation. If desired, auxiliary ignitor electrode structure may be positioned within one of the conical electrodes by providing a hollow passageway therein.

It will be evident that the invention disclosed may be modified or altered by increasing the number of resonant elements, providing ignitor electrode structure or plural discharge electrode structure. Numerous waveguide components have been developed for microstrip transmission, such as attenuators, couplers, hybrids, bends, terminations, crystal holders, matching stubs and transitions to coaxial or waveguide lines. It is, therefore, possible to design a complete microwave system at a saving in weight and cost. The addition of the transmit-receive switch will further enhance the state of the art in wide-band transmission employing the microstrip techniques.

What is claimed is:

1. An electron discharge device comprising a section of a conductor-ground-plane transmission line having a dielectric member joined between a narrow metallic conductor and a flat metallic base member, said dielectric member having a centrally located recessed cavity in the surface adjacent to said base member, a pair of transversely aligned inductive metallic iris members vertically disposed within said dielectric member in electrical contact with said base member, and conical electrode structure extending downwardly from the undersurface of said narrow conductor into said recessed cavity with the inner end thereof spaced from said base member to define a discharge gap.

2. An electron discharge device comprising a section of a conductor-ground-plane transmission line having a block of a dielectric material joined between a narrow metallic ribbon conductor and a flat metallic base member, said dielectric block having a centrally located recessed channel closed at both ends in the surface adjacent to said base member to define therewith a gas reservoir, a plurality of inductive metallic iris members extending in transverse alignment along the longitudinal axis of said dielectric block at spaced intervals of approximately a quarter-wavelength with the ends thereof contacting said base member, a plurality of spaced conical electrodes positioned at an intermediate point between said iris members, said electrodes extending downwardly from the undersurface of said narrow ribbon conductor into said reservoir with the inner ends thereof spaced from said base

member to define a discharge gap, and a filling of an ionizable atmosphere within said reservoir.

3. An electron discharge device according to claim 2, further defined by at least one of said conical electrodes being hollow and a wire electrode insulatingly supported at one end by said narrow ribbon conductor extending into said hollow electrode with its inner end in close proximity to said discharge gap.

4. An electron discharge device comprising a section of a conductor-ground-plane transmission line having a block of a dielectric material joined between parallel opposed narrow ribbon conductors, said dielectric block having a centrally positioned internal cavity, a plurality of inductive iris members vertically disposed within said dielectric block at an intermediate point between the lateral edges of said narrow conductors and the edge of said dielectric block, plural opposed conical electrode structure extending in axial alignment from the undersurface of said ribbon conductors into said internal cavity with spaced convergent ends defining a discharge gap, and a filling of an ionizable atmosphere within said internal cavity.

5. An electron discharge as defined in claim 4, further defined by at least one of said conical electrodes being hollow and a wire electrode extending into said hollow electrode with its inner end in close proximity to said discharge gap and the outer end insulated from the narrow conductor.

6. A transmit-receive tube for a microstrip transmission system comprising a rectangular block of a dielectric material having joined thereto on opposed wide walls a narrow strip of a highly conductive metal and a sheet of a similar metal having the same overall dimensions as the dielectric block, said dielectric block having defined in the surface adjacent to the metallic sheet a recessed cavity to define with said sheet an enclosure for the storage of an ionizable gas filling, a plurality of inductive iris posts vertically positioned throughout their length within said dielectric block at an intermediate point between the lateral edges of said narrow strip and the edge of said dielectric block, said posts being in electrical contact with said metallic sheet, spaced discharge electrodes extending from the undersurface of said narrow strip into said recessed cavity with the inner ends thereof spaced from said metallic sheet to define a discharge gap.

7. A transmit-receive tube for a microstrip transmission system comprising a narrow strip of a highly conductive metal separated from a sheet of a similar metal by a block of a dielectric material, a recessed cavity defined in the surface of said dielectric block adjacent to said metallic sheet, plural metal rods positioned on each side of said narrow strip and extending vertically within said dielectric block to contact said metallic sheet, plural conical electrodes extending downwardly from the undersurface of said narrow strip into said recessed cavity to define with said metallic sheet a discharge gap, and an inert gas contained within said recessed cavity.

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