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BRANCHED COAXIAL WAVEGUIDE STRUCTURE UTILIZING FINE RESISTIVE WIRE COUPLING

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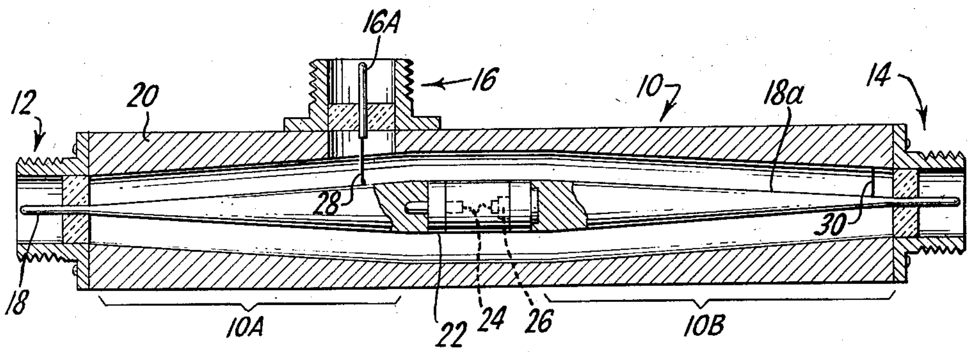

INVENTOR.
LLOYD A. ADDLEMAN
BY
J. Albert Hultquist
ATTORNEY.

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BRANCHED COAXIAL WAVEGUIDE STRUCTURE UTILIZING FINE RESISTIVE WIRE COUPLING

Lloyd A. Addleman, Los Altos, Calif., assignor, by mesne assignments, to Sylvania Electric Products Inc., Wilmington, Del., a corporation of Delaware

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8 Claims. (Cl. 250—20)

The present invention relates to waveguide systems, and more particularly it relates to connections to electrical translators in waveguides.

An object of the invention is the broadbanding of a waveguide structure having a connection for low frequency signals, or direct current. A more specific object is the avoidance of resonance effects caused by low-frequency connections to crystal detectors or rectifiers and other translating devices in waveguide systems. In a particular important aspect, an object of the invention lies in the provision of a novel broadband microwave heterodyne detector.

Broadbanding as an important feature of the invention has been emphasized, but novel waveguide systems incorporating features of the invention will be found to have other valuable properties. Thus, while not necessarily intended for broadband use, this very characteristic minimizes the number of adjustments required of such systems, even in narrow-band applications, and makes the adjustments relatively non-critical. This, in turn, makes for ease of manufacture and correspondingly low cost.

Accordingly, a general object of the invention resides in the novel construction of waveguides having connections for low frequency and direct current energy, and in particular, in the structure of novel waveguides incorporating electrical translating devices such as crystal diodes and thermionic diodes, triodes and the like.

In the illustrated disclosure that follows in detail, it will be seen that two connections for low frequency signals are made in a waveguide, where it is desired to minimize reflections and mismatch due to structural discontinuity represented by the connections. The illustrative waveguide is shown as coaxial, and multiple high frequencies are fed into the coaxial guide in opposite directions. However, mixed arrangements of rectangular, cylindrical, coaxial and other forms of waveguides are within the broad contemplation of the invention, where multiple high frequency paths are to be provided. The illustrative embodiment of the invention will be seen to include a main waveguide, in coaxial form, in which there is a connection for low frequency currents in the form of a high-resistance filament. This functions as a choke, and does so in exemplary fashion. Suitably, fine gauge resistance wire is used, chosen to have an impedance which is equal to or exceeds the characteristic impedance of the main waveguide. Being of high R.F. impedance and of fine gauge, it differs from simple wire probes, which, because of their high conductivity and comparative large cross-section, create troublesome reactive components in the system. In an example, a waveguide converter employing such a filament has given sufficiently flat output for receiver operation over a band from 1 to 12 kilomegacycles per second. The filamentary resistor used is so fine as to be barely visible to the normal unaided eye when viewed from an end of the waveguide section. Nevertheless, it does not produce serious loss or attenuation in the heterodyne output circuit.

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The broadband performance that results is evidently widely applicable. For example, it may be utilized in connecting operating power supplies to the electrodes of a grid controlled thermionic tube contained within a waveguide system or any suitable form of cavity resonator. In such a device the filamentary resistor can extend across a region where a difference of high frequency potential is developed in operation without producing troublesome reactive effects, while at the same time furnishing a conductive path for the operating power. In the specific case of a disc-seal triode oscillator having a coaxial resonator, an electrode that is connected to an inner conductor of the resonator may have energizing potential applied by way of a radially extending filamentary resistor. However, the principles of this broad aspect of the invention are well illustrated, and further advantages are realized, in its application to a crystal mixer, as will be seen. Varied modifications and further applications will be evident to those skilled in the art from this disclosure.

The illustrative embodiment of this invention is shown in the single accompanying drawing which is a simplified longitudinal cross-section thereof.

The drawing shows a microwave heterodyne detector. In this drawing a main coaxial waveguide **10** is shown with one input connector **12** for one signal source, such as an antenna, and another input connector **14** for another signal source, such as a source of local oscillations. An output or branch coaxial connector **16** is shown, constituting a short initial portion of a longer coaxial line to a heterodyne circuit. The input waveguide system to the antenna, the local oscillator and the heterodyne output circuit are omitted from the drawing as unnecessary to the full understanding of the invention.

The diameter of the center conductor **18**, **18*a*** and the diameter of the passage in the outer conductor **20** have reverse tapers **10A** and **10B** from the small sizes at the connectors **12** and **14** toward the center. This is for maintaining the characteristic impedance of the line unchanged along its length, while at the same time providing a diameter of the center conductor **18**, **18*a*** at the junction between its two parts large enough at the middle to receive a standard microwave crystal rectifier **22**. Typically, this is a silicon crystal of the 1N23 series, with the base flange removed to eliminate the discontinuity and the unnecessarily large dimension that would be otherwise involved. Crystal **22** has a whisker or resilient pointed wire **24** in rectifying contact with a crystal **26**, disposed as shown. The crystal is arranged with the base nearest the local oscillator coupling **14** and the whisker nearest the antenna coupling **12**.

Signals from end connectors **12** and **14**, coupled to the crystal in the arrangement shown, are heterodyned. The beat-frequency is derived at coaxial line connector **16**. Connection is made from the center conductor **18** at the whisker end of crystal detector **22** to the center conductor **16A** of coaxial line element **16** via filamentary wire

28. A similar connection via filamentary wire **30** is made from conductor **18a** contacting the base end **26** of crystal **22** to the outside conductor of coaxial element **16**. These wires are of fine gauge, high resistance wire, so that each impedance equals or exceeds the characteristic impedance of line **10**. Number 36 A.W.G. wire of a high resistance alloy such as "Advance" resistance wire is suitable, and it is physically connected to the coaxial line elements mentioned. The wire **30** may be omitted if the external circuit connected at coupling **14** affords a return circuit for the heterodyne signal of the detector or rectifier **22**.

The coaxial waveguide **10** operates with a radial electric field pattern, one extremity of this electric field being at the outer conductor **20** and the other at inner conductor **18**. The radial filamentary choke **28** extends through a region where a difference of instantaneous radio frequency potential is developed. Being prominently resistive and high in total impedance, the radial filamentary resistor **28** introduces a minimum amount of discontinuity and reflection in line **10**. By like token, filamentary resistor **30** is of negligible reactive effect. Notably, the filamentary resistor **28** or **30** acts as a series element of a circuit that passes frequencies below the waveguide frequencies and direct current, but has negligible interaction with the high frequency field enclosed by the waveguide **10**.

The drawing is somewhat diagrammatic, in that it omits the physical sub-sections built up into the single coaxial line structure **10**. This normally will include convenient separations for practical assembly, and for easy replacement of crystal detector **22**; and appropriate added insulating supports may be incorporated. Also, the tapers shown are not essential, for stepped size-changers may be suitable in some systems, and in some designs there may be no need for size changing. These details and further specific modifications are unnecessary to the proper appreciation of the invention, and the details thereof have been omitted in the interests of a concise disclosure.

The waveguide system shown achieves broad-band operation and a minimum value of VSWR over the band of operation without resort to a series of critical and complicated tuning stubs, capacitive shunts and couplings, etc. A highly successful, practical crystal detector utilizing the novel waveguide apparatus is also realized.

Varied applications, and various modifications in matters of detail, will occur to those skilled in the art, and accordingly the spirit of the invention should be taken into account in considering its scope.

What I claim is:

1. A waveguide system including a first coaxial waveguide for high frequency signals and a second coaxial waveguide for electrical energy considerably below the first waveguide frequencies, each of said waveguides having an inner conductor and an outer space-bounding conductor, the second waveguide having its outer conductor joined to a side opening in the outer conductor of the first waveguide, and a substantially straight fine gauge wire having a high and substantially constant impedance to the higher frequency of said signals extending between the inner conductors of said waveguides.

2. A coaxial waveguide system including a first coaxial waveguide, a second coaxial waveguide connected to the first waveguide as a branch thereof, each of said waveguides having an inner conductor and an outer conductor, and a straight, fine gauge high resistance wire choke extending substantially radially from the center conductor of the first waveguide to the end of the center conductor of the second waveguide, said wire having an impedance to high frequency energy at least as high as characteristic impedance of the first waveguide.

3. A waveguide system including a crystal rectifier, a pair of coaxial waveguides each having an inner conductor and an outer conductor, one of said waveguides having said crystal rectifier interposed in the inner conductor thereof as a series element, the other of said waveguides having a connection to said one waveguide as a branch thereof adjacent said crystal rectifier, said connection including a fine gauge high resistance wire extending endwise from the inner conductor of said other waveguide and extending substantially perpendicularly to the inner conductor of said one waveguide.

4. A waveguide system including a crystal rectifier, a pair of coaxial waveguides each having an inner conductor and an outer conductor, one of said waveguides having said crystal rectifier interposed in the inner conductor thereof as a series element, the other of said waveguides having a connection to said one waveguide as a branch thereof adjacent said crystal rectifier, said connection including a fine gauge substantially straight wire extending endwise from the inner conductor of said other waveguide and extending substantially perpendicularly to the inner conductor of said one waveguide, said wire having a high resistance and an impedance at least as large as the characteristic impedance of said one waveguide.

5. A waveguide converter including first and second coaxial waveguides each having an inner conductor and an outer conductor, a crystal rectifier interposed as a series element in the inner conductor of the first waveguide, the ends of said first waveguide having couplings for the signals to be heterodyned, the second coaxial waveguide being connected as a branch of the first waveguide, said crystal having a substantially straight fine gauge high resistance wire connected from its terminals to the center conductor of said second coaxial waveguide and to the outer conductor of the first waveguide, respectively.

6. Broadband high frequency mixer apparatus including a main section of coaxial line having inner and outer conductors, a crystal rectifier serially connected in the inner conductor of said main coaxial line, a branch coaxial line having inner and outer conductors connected to said main coaxial line in the vicinity of said crystal rectifier, and a connection for coupling low frequency signals between said crystal rectifier and said branch coaxial line consisting solely of a fine gauge high resistance wire connected to the inner conductor of said branch coaxial line and extending radially across the space between the inner and outer conductors of said main coaxial line and connected to the inner conductor of said main coaxial line.

7. A broadband high frequency waveguide converter including first and second coaxial waveguides each having an inner conductor and an outer conductor, a crystal rectifier interposed as a series element in the inner conductor of said first waveguide, the ends of said first waveguide having couplings for high frequency signals to be heterodyned, said second waveguide being connected as a branch of said first waveguide from a point in the vicinity of said crystal rectifier, and a connection for coupling direct current and low frequency signals between said crystal rectifier and said second waveguide consisting solely of a fine gauge, high resistance wire connected to the inner conductor of said second wave guide and extending radially across the space between the inner and outer conductors of said first waveguide and connected to the inner conductor of said first waveguide.

8. A broadband high frequency waveguide converter including first and second coaxial waveguides each having an inner conductor and an outer conductor, a crystal rectifier interposed as a series element in the inner conductor of said first waveguide, the ends of said first waveguide having couplings for high frequency signals to be heterodyned, said second waveguide being connected as a branch of said first waveguide from a point in the vicinity of said crystal rectifier, and a connection non-reactive to high frequency signals propagated in said first waveguide for coupling low frequency and direct current signals between said crystal rectifier and said branch coaxial line consisting solely of a fine gauge, high resistance wire con-

nected to the inner conductor of said second waveguide and extending radially across the space between the inner and outer conductors of said first waveguide and connected to the inner conductor of said first waveguide.

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