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MAGNETRON AMPLIFIER

2,683,256

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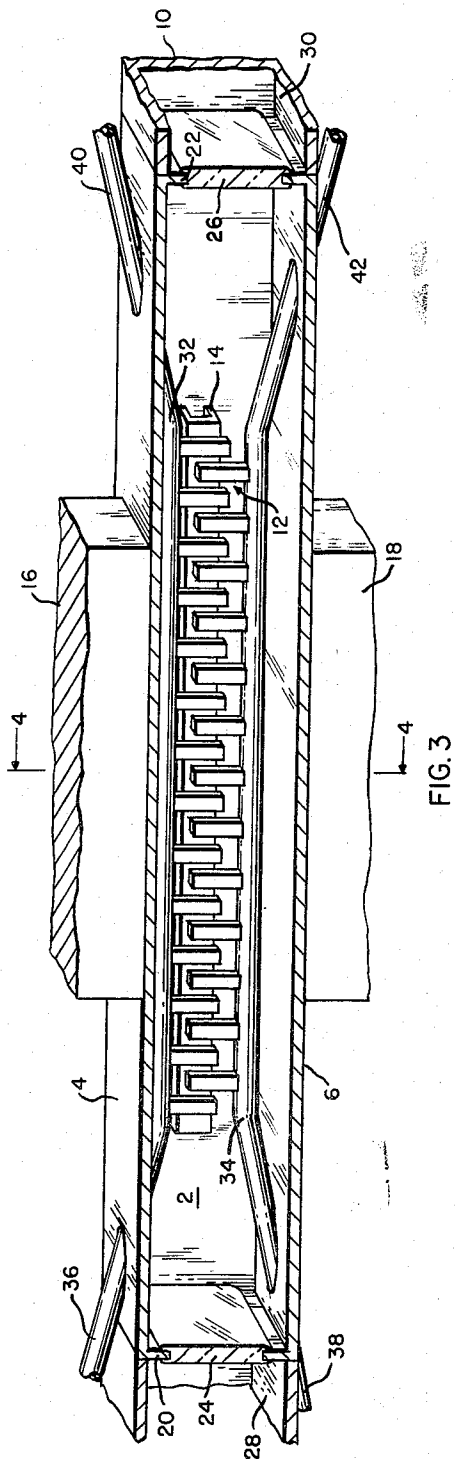


FIG. 3

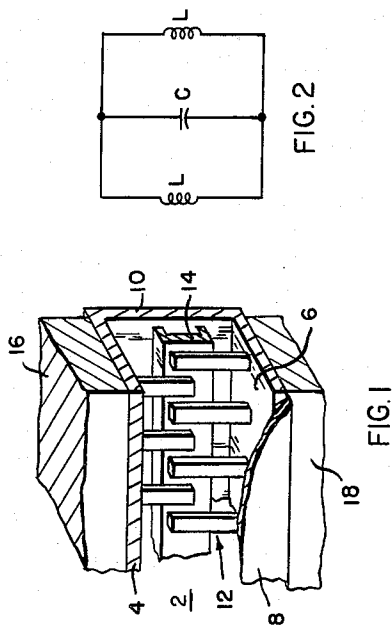


FIG. 1

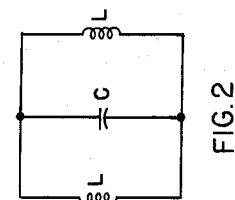


FIG. 2

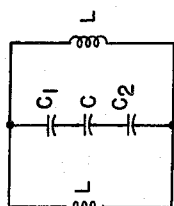


FIG. 5

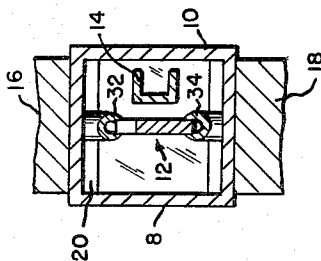


FIG. 4

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2,683,256

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6 Claims. (Cl. 333-95)

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 sec. 266)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without payment of any royalty thereon.

The invention relates to an improvement in wide-band microwave amplifiers and more particularly to waveguide structures adapted for use in wide-band microwave amplifiers of the magnetron type.

In my copending application, Serial No. 170,875, filed June 28, 1950, there is described a linear interdigital magnetron type structure adapted to be used as a travelling-wave tube amplifier. This structure includes an interdigital or interlaced transmission line disposed in a vertical plane between the top and bottom walls of an evacuated waveguide, and an electron emitting surface disposed between one end wall of said wave guide and the transmission line. The interdigital magnetron type structure is particularly suited for employment as a microwave amplifier over a wide band of frequencies inasmuch as interdigital transmission lines are relatively non-dispersive, that is, the phase velocity does not vary rapidly with frequency. However, because of the capacitance of the centrally positioned interleaved teeth, a transverse resonance occurs in the tooth-loaded waveguide section at a frequency lower than the normal cut-off frequency of the evacuated waveguide. The top and bottom walls of the waveguide and the interdigital teeth form a high Q circuit resonant at this lower frequency. Since this resonance is not loaded, that is, there is no electromagnetic wave propagation, it is the first resonance excited by the electron cloud and usually occurs at a relatively low voltage. This transverse resonant frequency is generally lower than the propagated frequency which is to be amplified and it is therefore present as a parasitic oscillation at all higher frequencies within the band-pass of the amplifier. Since such parasitic oscillation represents a loss of microwave energy and is difficult to eliminate, the usefulness as an amplifier of the linear interdigital magnetron type structure illustrated in my aforesaid copending application is limited.

It is therefore an object of the present invention to provide an improved linear interdigital transmission line for overcoming the aforesaid

one object of the present invention to provide for supporting the interleaved members which are separate from the waveguide walls so that no

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short conduction current path exists between the waveguide walls and the interleaved teeth.

It is a further object of the present invention to provide means for reducing the capacitance loading effect of the interleaved tooth structure whereby the frequency of transverse resonance is beyond the range of the propagated frequencies to be amplified.

In accordance with the present invention there is provided a transmission line for use in a magnetron amplifier comprising an evacuated rectangular wave guide having a pair of spaced hollow tubular members therein. These tubular members are spaced from the top and bottom surfaces of the wave guide and are adapted to support the interdigital transmission line which is the frequency propagating medium. The tubular members decrease the effective capacitance across the tooth-loaded section in such a manner so that the transverse resonance frequency thereof is increased beyond the propagating frequency range of the transmission line.

For a better understanding of the present invention, together with further objects thereof, reference is had to the following description taken in connection with the accompanying drawings in which like reference numerals indicate similar parts:

Fig. 1 is a partial perspective view of the linear interdigital magnetron amplifier embodied in my copending application;

Fig. 2 illustrates the equivalent electrical circuit in the transverse plane of the structure shown in Fig. 1;

Fig. 3 is a perspective view of a central transverse section, in a vertical plane, of a linear interdigital magnetron amplifier tube embodying my invention;

Fig. 4 is a section taken on line 4-4 of Fig. 3; and

Fig. 5 illustrates the equivalent electrical circuit of the structure shown in Fig. 4.

Fig. 1 shows the amplifier section incorporated in the linear interdigital magnetron type of travelling-wave tube amplifier disclosed in my aforesaid copending application. Although reference may be made to this application for a description of the linear interdigital magnetron amplifier, a brief discussion of the structure is presented at this point to better understand the present invention. In Fig. 1, there is shown a hollow wave guide 2 of uniform rectangular cross section having top and bottom surfaces 4 and 6 and side walls 8 and 10. A uniform interdigital transmission line 12, which extends longitudinally

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from one end of the amplifier section to the other end thereof, is linearly disposed in a central vertical plane between top and bottom surfaces 4 and 6. A linear thermionic cathode 14 is centrally positioned within waveguide amplifier section 2 between side wall 10 and interdigital transmission line 12. Cathode 14 may be coextensive with the longitudinal dimension of amplifier section 2 and may be supported in position by means well known in the art.

Transmission line 12 may be maintained at a positive potential with respect to cathode 14 by any suitable means (not shown). A magnetic field having flux lines which extend between top and bottom surfaces 4 and 6 and are concentrated in the interaction space between cathode 14 and interdigital transmission line 12 is provided in conventional manner by pole pieces 16 and 18. Since the interleaved teeth of transmission line 12 extend from the top and bottom surfaces of the wave guide, it is apparent that a short circuit current path exists between the teeth and the waveguide walls to form a resonant structure schematically illustrated in Fig. 2. From Fig. 2, it can be readily seen that the transverse resonant frequency may be calculated from the equation

$$f_r = \frac{1}{2\pi\sqrt{\frac{L}{2}C}}$$

where f_r is the transverse resonant frequency and C is the capacitance of the interleaving teeth.

Figs. 3-5 illustrate the improvement of the amplifier section of Fig. 1 in accordance with the present invention. Referring now to Figs. 3 and 4, there is shown an amplifier section comprising an evacuated waveguide structure 2 of uniform rectangular cross section having top and bottom surfaces 4 and 6 and side walls 8 and 10. End walls 20 and 22 of wave guide 2 are terminated by conventional thin, broad-band, resonant coupling windows 24 and 26, respectively. Input and output circuits to waveguide structure 2 are provided respectively by wave guides 28 and 30 which are of conventional design and have a uniform rectangular cross section. It is to be assumed that the dimensions of the input and output guides 28 and 30 are so chosen that propagation is to be limited to a single mode, preferably the $TE_{0,1}$ mode. It is well known that the pass-band of such rectangular wave guides is fairly wide, the cutoff wavelength for any particular mode being a function of the inside dimensions of the wave guide.

An interdigital transmission line 12 is supported in a central vertical plane between top and bottom surfaces 4 and 6 by means of spaced tubular members 32 and 34 longitudinally positioned within wave guide 2. For the preferred $TE_{0,1}$ mode of propagation, said vertical plane may be considered to be at the high voltage region of evacuated amplifier wave guide 2. As shown, upper tubular member 32 is spaced from top wall surface 4 and lower tubular member 34 is spaced from bottom wall surface 6. The teeth comprising interdigital transmission line 12 may be welded, or affixed to the tubular members in any other suitable manner. One set of teeth extends downwardly from upper tubular member 32 and the other set of teeth extends upwardly from lower tubular member 34. The ends of tubular members 32 and 34 may be flared outwardly as at 36, 38, 40 and 42 to provide an impedance match between the tooth-loaded section of wave guide

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2 and the uniform sections thereof. The flared portions of tubular members 32 and 34 may extend through top and bottom surfaces 4 and 6 and may be brazed thereto to provide an hermetically sealed structure. By this arrangement interdigital transmission line 12 may readily be supported in position by means of tubular members 32 and 34 within waveguide structure 2. If desired, other suitable means may be used to support the spaced tubular members within wave guide 2.

It is to be understood, of course, that transmission line supporting members 32 and 34 may be of any suitable cross section and, in addition, may be hollow to permit liquid cooling of the interdigital teeth forming the transmission line. A cathode 14 and magnetic pole pieces 16 and 18 may be provided as in Fig. 1.

Fig. 5 shows the equivalent electrical circuit of the waveguide amplifier structure of Fig. 4. It can readily be seen that there is no longer a direct short circuit path between the transmission line teeth and the wave guide walls. Instead, there is a capacitance C_1 and C_2 which represent the capacitance between tubular members 32 and 34 respectively and the walls of the wave guide in series with teeth capacitance C . Obviously, the transverse resonant frequency of the tooth-loaded section is now at a much higher value than that for the structure shown in Fig. 1 since the overall capacitance has been decreased. By this arrangement, the transverse resonance at guide cut-off is moved higher in frequency rather than being at the lowest frequency supported in the guide, thus eliminating the parasitic resonance which may occur at a relatively low voltage.

While there has been described what is at present considered to be the preferred embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is therefore aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a microwave system, an evacuated rectangular wave guide, a pair of spaced tubular members longitudinally positioned within said wave guide, said tubular members being spaced from the top and bottom surfaces of said wave guide, means for supporting said tubular members in position within said wave guide, and an interdigital tooth structure rigidly mounted between said tubular members and affixed thereto.

2. A transmission line for use in a magnetron amplifier comprising an evacuated rectangular wave guide having a pair of spaced tubular members longitudinally positioned therein, said tubular members being spaced from the top and bottom surfaces of said wave guide, an interdigital tooth structure rigidly mounted in a vertical plane between said tubular members and thereto, and means for supporting said members in position within said wave guide.

3. A transmission line for use in an amplifier comprising an evacuated rectangular wave guide having a pair of spaced tubular members longitudinally positioned therein, said tubular members being spaced from the bottom surface of said wave guide, an interdigital tooth structure rigidly mounted in a vertical plane between said tubular members and affixed thereto, the ends of said tubular members being flared outwardly as at 36, 38, 40 and 42 to provide an impedance match between the tooth-loaded section of wave guide

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bers being flared outwardly and extending through said top and bottom surfaces for supporting said tubular members in position within said waveguide.

4. The transmission line set forth in claim 3 wherein said tubular members are hollow.

5. A transmission line for propagating electromagnetic waves comprising an evacuated wave guide, an interdigital tooth structure within said wave guide, and means for supporting said tooth structure between the top and bottom surfaces of said wave guide, said means comprising a pair of tubular members spaced from the top and bottom surfaces of said wave guide.

6. A transmission line for propagating electromagnetic waves comprising an evacuated wave guide having a pair of spaced tubular members longitudinally positioned therein, said tubular

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members being spaced from the top and bottom surfaces of said wave guide to provide a capacitance therebetween, an interdigital tooth structure rigidly mounted in a vertical plane between said tubular members and affixed thereto, said capacitance being combined in series with the capacitance of said tooth structure whereby the transverse resonance frequency of said transmission line is increased beyond a predetermined propagating frequency range of said transmission line.

References Cited in the file of this patent

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Number	Name	Date
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