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PLANAR SLOW-WAVE CIRCUIT

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FIG. 1.

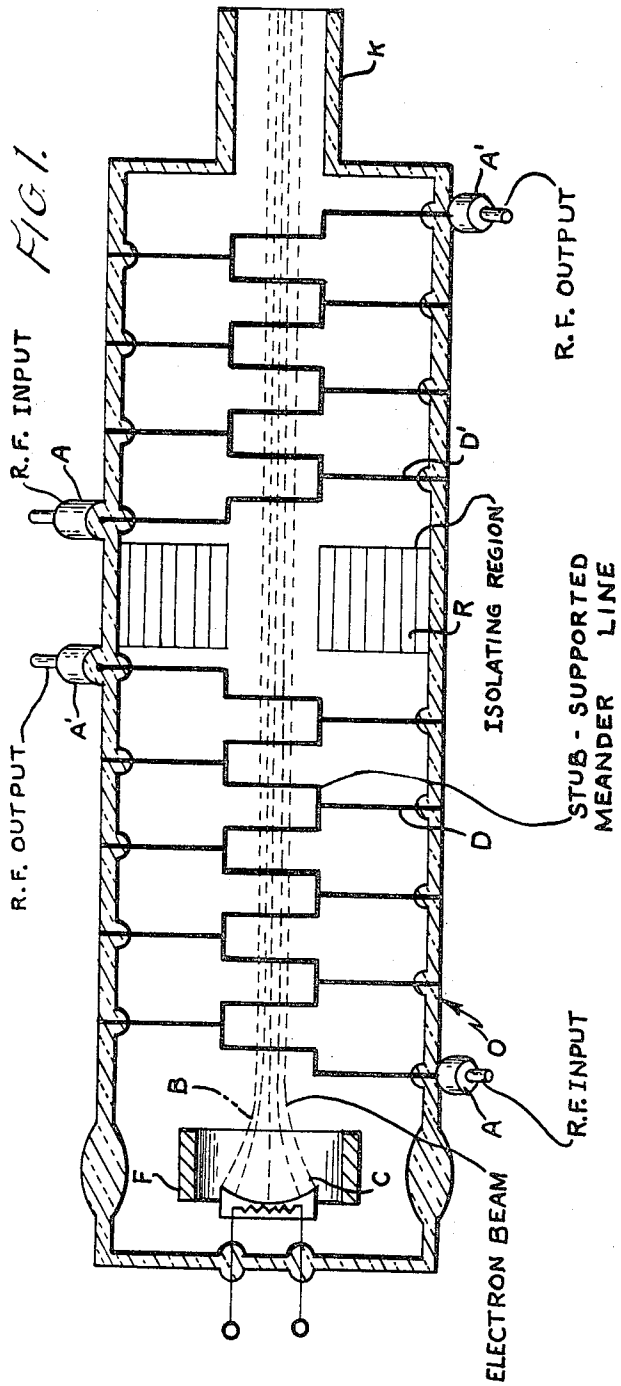
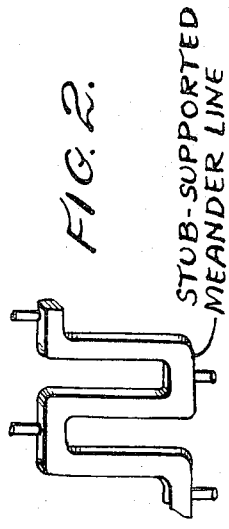


FIG. 2.



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PLANAR SLOW-WAVE CIRCUIT

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ABSTRACT OF THE DISCLOSURE

A traveling wave tube with a source of electrons at one end and first and second slow transmission lines axially separated by an isolation region. Electrons are focused and pass along the entire length of the transmission lines to a collector. Radio frequency inputs are provided for each of the slow transmission lines at the end nearest the electron beam source with output means located at the opposite end.

This invention relates to the class of devices which depend upon an interchange of energy between a stream of electrons and a radio frequency field to provide amplification and/or oscillations, and more particularly, to propagating circuit means for use as a traveling wave tube or as a klystron with resonant cavities.

In the conventional traveling wave tube the most common slow-wave transmission line or circuit for producing radio frequency fields in the interaction region is a helix. However, such a circuit operating at millimeter wave lengths is extremely difficult to make, and the attendant loss of accuracy results in such a small power dissipating capability as to be unusable for producing or amplifying any large amount of power. Another type of prior art, slow-wave propagating circuit employed is a stub-supported ring bar circuit. However, in such a circuit the field outside the rings is wasted as far as interaction is concerned, and particularly, for a high velocity circuit there is a considerable waste of energy outside the rings. That is to say, in the region of the stubs there is a considerable field which is not used for interaction in the normal cylindrical bar circuit.

Accordingly, a principal object of this invention is to provide a high frequency, slow-wave planar circuit in a traveling wave tube which overcomes the aforesaid limitations.

It is a further object of this invention to provide an electro magnetic wave slowing structure in a traveling wave tube wherein the width of the beam can be made whatever width where there is an appreciable amount of an electric field.

It is still a further object of this invention to provide a flattened stub-supported circuit line as the electro magnetic wave slowing structure.

Still another object of this invention is to provide an electro magnetic wave slowing structure easily adapted to provide an electron velocity selection device.

In accordance with the present invention the basic wave slowing structure comprises a flattened (meander) line comprised of flattened metal bars with flattened supporting stubs. Such a flattened line can either be used alone as a propagating circuit or a pair of them can be used with a beam passing between them. In the case of one flattened line being used as a circuit, a flattened beam can be passed on either or both sides of the circuit. There is no requirement on meander line structure except to produce the right velocity; its dimensions can be chosen in any convenient way.

The above-mentioned and other features and objects of this invention and the manner in obtaining them will become more apparent, and the invention itself will be best understood by reference to the following description, taken in connection with the accompanying drawing, wherein:

FIGURE 1 shows a schematic version of the instant stub-supported meander line embodied in an electrical tube; and

FIGURE 2 shows an isometric view of the stub-supported meander line partly in section.

The figure can serve as the description of the instant device used as a traveling wave tube or as a klystron with resonant cavities, each cavity using a stub-supported meander line. In the diagram, C shows the cathode from which the electron beam originates; F is the focusing ring for focusing the electrodes; B shows the electron sheet beam which passes from the cathode through the entire structure to the collector marked K. It is to be understood that any other structure for producing an electron sheet beam may be employed. D and D′ are the stub-supported meander lines and are shown above the beam. If this is a double-deck meander line, there will be another similar structure underneath the beam but it would not appear in the diagram. The device would work with one or two such lines, i.e. single or double deck.

As shown here, there are two such separated meander lines, D and D′ separated by the region called R. Each meander line as shown has an input antenna marked A and an output antenna marked A shown as a coaxial line. D′ is the meander line in the second section. If used as a traveling wave tube, then power would be injected into first meander line, D, would pass along the circuit, interact with the electron beam and then A of the first meander line would go to a termination and the region marked R would then act as an isolating region between the input and output traveling wave section. The beam would carry the excitation from the first to the second. This is what is normally known as a severed tube and A′ of the first meander line would merely be a way of terminating it and the power is wasted. The beam then goes on to the second meander line, excites a signal which grows, and power comes out of A′ of the second meander line. This is a traveling wave tube with all of the A and A′ terminals as shown terminated in a characteristic impedance of a corresponding transmission line. If used as an extended interaction klystron where each of the two sections is resonant, then in the first meander line A′ would be terminated by a short circuit, power would be fed into A to excite the resonant structure, and then the excited beam would go on to the second section and excite a signal there. Power could be taken out through A′ of the second circuit and A of the second circuit would be merely terminated with a short. In this case, both of the two separate meander lines would be made resonant and they would act as resonant cavities. This obviously can be extended to more sections than shown here and other variations more or less obvious. For example, instead of the supporting stubs turned inward to give a crankshaft-like appearance as shown in the figure, the meander line could be a zig-zag line with supporting stubs extending from either edge of the line.

The spacing of the two structures, D and D′, is governed only by a consideration of obtaining maximum interaction with the electron beam. The spacings of the meander line are merely to get the correct phase velocity. Herein lies an important feature of this invention in that it is not important in the instant configuration that the diameter of the beam, if a cylindrical beam is used, be smaller than the dimensions of the planar structure; whereas, such dimensions would be critical when using the conventional cylindrical ring bar circuit. This is because in the instant embodiment there is a field extending out in the stub region and it makes no difference whether

the beam interacts with the field due to the stubs, particularly for high velocity circuits.

Since the field on the stubs presumably varies as a sine the interaction region can extend for a considerable distance beyond the edges of the meander line itself and still have a field which has not decreased appreciably from the field along the central line. Therefore, the instant structure enables use of a relatively wide beam. With respect to the thickness of the beam, there is the usual exponential drop-off of the field with increasing distance from the planar circuit.

In contrast, in the cylindrical structure there are problems with resonances if the diameter of the rings becomes too large. This limitation is very often in conflict with the size of the beam that can be used at the high velocity.

The instant planar slow-wave circuit lends to be used in a cross-field amplifier. In this case there is a flat beam between the two planar propagating circuits. Of the two possible modes, symmetric and anti-symmetric, only the symmetric mode is used. If only a single propagating meander line with a beam on either side of it was used, focusing would still be possible with the use of an electric field perpendicular to the propagating circuit of such sign that it would give an outward force on the electron beams on either side with the magnetic focusing producing an inward force, the two forces balancing so as to maintain the beam at the right distance from the circuit. Also, it is possible to use planar modifications of the above focusing scheme by using an outward electric field from the slow-wave circuit which would tend to deflect the two electron beams away from the circuit and a periodic electric field produced by rods on either side of the propagating circuit itself to provide an inward focusing force. The balance between these two fields maintain the beams at the proper distance from the slow-wave circuit.

The instant propagating circuit also easily lends itself to the use of depressed collectors. With an electron beam on either side of the flat circuit and an electric field perpendicular to the flat circuit (which tends to keep the beam away from the circuit), then it is apparent that once the two beams pass into the collector, a plate in the center of the collector provides an electric field on both of the two beams which would tend to deflect them if other focusing forms were removed. Namely, if the magnetic fields are discontinued (or periodic electric fields as the case may be) then the electric normal field deflects the two beams away from the mid-plane. It is well-known that under the action of such a deflecting field the amount of deflection varies inversely as the velocity of the electrons, and, therefore, the result is a velocity selection device which deflects the low energy electrons by a greater amount than the high energy electrons. Thus, a series of electrodes can be used to collect electrons at different energies.

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

I claim:

1. A traveling wave tube comprising: an evacuated housing; means for producing a flat sheet like beam of electrons, at one end of the housing; means for collecting the beam of electrons at the other end of the housing; first and second slow-wave transmission lines located between the electron producing means and the electron collecting means, and having a flattened, crankshaft-shaped planar conductor with a plurality of stublike supporting members, said stublike members being regularly spaced and affixed to the evacuated housing; an isolation region axially separating the first and second slow-wave transmission lines; magnetic focusing means exerting an inward force on said beam of electrons and an electric focusing means exerting an outward force on said electrons whereby the electron beam passes along the entire length of each of said transmission lines and in close proximity thereto; radio frequency input means for each of said slow wave transmission lines at the end of said lines nearest to said electron beam producing means, and radio frequency output means at the opposite end of each of said slow-wave transmission lines.

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