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ELECTRONICALLY CONTROLLED MICROWAVE ATTENUATOR

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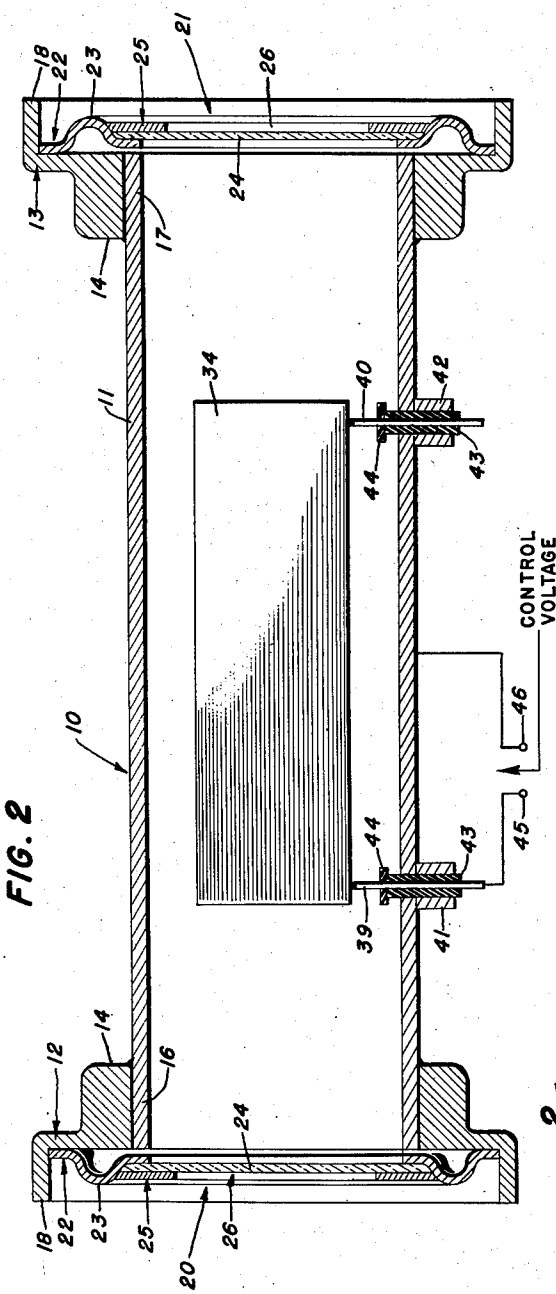


FIG. 2

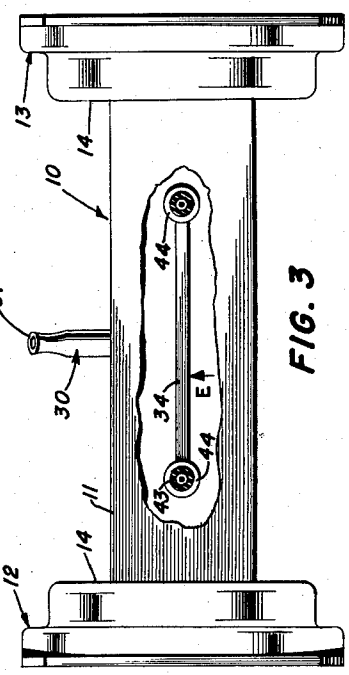


FIG. 3

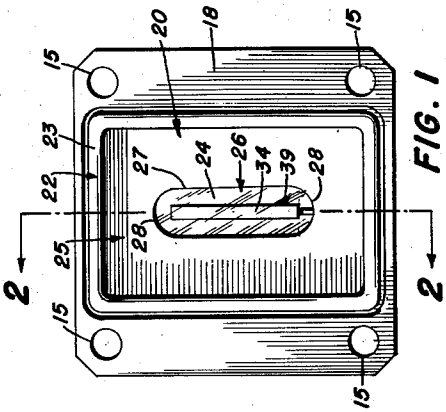


FIG. 1

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ELECTRONICALLY CONTROLLED MICROWAVE ATTENUATOR

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1 Claim. (Cl. 333—81)

This invention relates to ultra high frequency control systems and more particularly to means for attenuating and controlling electromagnetic waves propagated within a hollow-pipe type of waveguide system.

It is desirable in a waveguide system that means be provided for limiting or varying the energy of a propagated wave, both for the purpose of amplitude modulation and for the purpose of maintaining a constant energy output by regulation of a variable energy input. While in low frequency circuitry a lumped line impedance having variable characteristics will suffice for this purpose, control in a waveguide system is most effectively accomplished through a distributed impedance. In fact, it is desirable that the distributed impedance be co-extensive with the cross sectional area of the waveguide for greatest effectiveness in controlling the energy propagated therethrough. To achieve a maximum range of control, however, the attenuating effect of such an impedance element must be readily removable.

As is well known, a waveguide system must be substantially free from impedance mis-matching to avoid creation of reflected waves and attendant lowering of efficiency. Accordingly, a further desideratum of an impedance control device in a waveguide is that its design should not require dimensional discontinuities within the waveguide.

A continuous control of ultra high frequency signals propagated within a waveguide has heretofore been achieved with a confined ionizable gas in the waveguide by the application of an ionizing voltage to a pair of electrodes extending into the gas. Such electrodes have had a complex and expensive design tending to introduce substantial discontinuities in the dielectric path of the microwave signal. Consequently, a difficulty has been experienced in achieving an impedance matching over an appreciable range of frequencies of the transmitted signal. Resort has been taken to the insertion of a gaseous discharge tube within the waveguide in an effort to confine therein a low pressure gas together with electrodes for ionizing the gas. This construction has not resulted in even a substantial approach to the ultimate achievable range of attenuation, presumably because the gaseous discharge tube cannot be conveniently designed to have an interior dimension coextensive with the interior dimensions of the waveguide section in which such tube is reposed.

Accordingly, it is the object of this invention to provide an effective, yet simple control of ultra high frequency energy propagated within a confined dielectric medium.

It is a further object of this invention to provide an improved control for ultra high frequency energy by means for ionizing a gas through which the energy is propagated.

It is yet a further object of this invention to provide such a control wherein a single electrode is employed within a waveguide section capable of confining the ionizable gas.

Still another object of this invention is to provide a waveguide section with resonant windows at either end to confine an ionizable gas within the section and to match the impedance of the section to impedances of sections coupled thereto, while the gas is ionized to varied degrees by means of an interior electrode.

As an exemplification of this invention, there is provided a waveguide section sealed by a resonant window at either end to enclose an inert, ionizable gas which surrounds an emissive cold cathode spaced within the walls of the waveguide section. In relation to a waveguide of rectangular cross section with standard coupling flanges at either end, it is contemplated that the cathode should take the form of a planar strip supported centrally in relation to the flanges and the walls of the waveguide and normal to the electric field of the ultra high frequency signal. Control of energy propagated through this section is achieved by imposing a voltage upon the cathode negative in relation to the walls of the waveguide section and variable over a range including the ionization potential of the gas. It will thus appear that the present invention may be embodied in a standard waveguide section simply modified to incorporate the resonant sealing windows at either end and an emissive planar cathode intermediate such ends.

Further objects and advantages of the present invention will become apparent from a consideration of a preferred embodiment of the invention which is herein described and which is represented upon the drawings, wherein:

Figure 1 is a front elevational view, displaying a cathode as seen through a resonant window;

Figure 2 is a cross sectional view taken along the line II—II in Figure 1; and

Figure 3 is the bottom view of the device constructed in accordance with the invention with a portion broken away to display the cathode.

Throughout the figures, like numerals are used to designate like parts or portions. There is thus shown a space resonant cavity or chamber **10** which may comprise a section **11** of a standard waveguide of the hollow-pipe type. This waveguide section may have any suitable hollow configuration but, in the embodiment illustrated, has a conventional rectangular cross section. It is requisite that the waveguide section have electrically conductive walls defining an energy directing cavity which may be sealed off to confine an ionizable gas therein.

To this end, the rectangular waveguide section **11** is fitted at either end with coupling flanges **12** and **13**. Each of these flanges has a collar portion **14** fitted snugly about the respective endwise portions **16** and **17** of the waveguide section and sealed thereto by soldering or other means. As seen in Figure 1, the collar portions **14** are provided with holes **15** at their four corners to receive coupling bolts for securement to mating flanges of adjacent waveguide sections (not shown). Radially outward of each collar portion **14** is an axially extending flange **18** defining an endwise opening cavity in which window assemblies **20** and **21** may be received.

Window assemblies **20** and **21** may each comprise a frame **22** having a raised bead **23** thereabout, a window **24** nested within the bead **23** and against the frame **22**, and apertured mask **25**. The window **24** may be composed of any dielectric material relatively transparent to ultra high frequency radiation, yet having sufficient structural strength to withstand atmospheric pressure. As an example, the window **24** may be composed of mica or glass in sheet form, so as to pass ultra high frequency without substantial attenuation or reflection.

The mask **25**, which fits within and is secured to the

bead 23, provides a resonant aperture or iris 26, exposing the window 24 for microwave transmission. In the illustrated embodiment, the aperture 26 is shown to be a centrally positioned slot with straight side edges 27 and circular top and bottom edges 28. An optimum design of the resonant aperture 26 may be determined by principles well known in the art to provide a matching with the characteristic impedance of the waveguide sections or other elements to which either end of the waveguide section 11 may be coupled. The frame 22 supporting the resonant aperture may be lodged snugly within the axial flanges 18 and 19, so that an air tight seal will be perfected at either end of the waveguide section 11 whenever its flanges are coupled to mating flanges of other waveguide sections (not shown). Alternatively, the window assemblies 20 and 21 may be secured and sealed to the coupling flanges 12 and 13 by welding or the like.

When such a seal has been perfected, tubulation 30 may be first connected to an evacuation pump until a vacuum is produced within the cavity, and then it may be connected to a supply of inert ionizable gas or vapor at low pressure. The gas or vapor may suitable be composed of neon, argon, zenon, mercury vapor, or a mixture. When the cavity 10 contains only a low pressure ionizable gas or vapor, the tubulation 30 may be closed off at its end 31.

This invention further contemplates that within the cavity 10 will be placed a cold cathode 34 of the electron emissive type. As the purpose of this emissive cathode 34 is to ionize the inert gas in a generally uniform manner throughout the region of the cavity 10, the electrode is given a central position in relation to the surrounding conductive walls of the cavity and to the endwise portions 16 and 17 of the section. For this reason also, the cathode preferably has a substantial axial dimension in relation to the axial dimension of the cavity or section, where the axis is considered to extend in the direction of wave propagation.

Because the cathode is comprised of a relatively conductive material which would tend to disturb the transmission of an ultra high frequency signal, it has been conceived that the cathode should take a position in the dielectric medium where the electric field gradient of the signal is substantially zero. Since, by conventional type of excitation, the electric field E of an ultra high frequency signal passing through the rectangular waveguide system 11 will extend from side to side within the cavity, or normal to the axial plane in which the section of Figure 2 is taken, the cathode 34 is placed in this same axial plane centrally disposed between the side walls of the waveguide section 11. In the preferred embodiment of the invention, therefore, there is employed a planar or strip-like cathode 34 which is approximately equidistant from all of the surrounding walls of the cavity in which it is placed and is disposed within those walls so as to be normal to the electric field E of the ultra high frequency energy confined by the walls. At either end of the cathode 34, pins 39 and 40 are affixed to provide a means of support. These pins 39 and 40 composed of electrically conductive material are led out through sealed ports 41 and 42, respectively, in the bottom wall of the waveguide section, and are insulated from the bottom wall and the ports by means of bushings 43 and disks 44 composed of insulating material. A control voltage from whatever source desired my be applied across leads 45 and 46 connecting, respectively, to the cathode 34 through the pin 41 and to the metallic walls of cavity 10.

A zone of ionization will be created by application of a control voltage at 45—46, which will substantially pervade and extend throughout the entire region of the cavity 10. The ionization thus created will be substantially uniform by reason of the central positioning of the emissive cathode 34. As a consequence, a high degree of control of ultra high frequency of energy propagated within the cavity may be achieved.

In use, the waveguide section 11, is coupled between other waveguide elements which generally will be waveguide sections of similar configuration. The coupling of the sealed waveguide section 11 may be accomplished by bolting together the coupling flanges 12 and 13 with mating flanges of adjacent waveguide sections. Ultra high frequency is then introduced within the waveguide system and enters and departs from the sealed waveguide section through the resonant windows 24. Assuming first that no control voltage is imposed upon the leads 45—46, the ultra high frequency energy will pass through the section 11 without an appreciable attenuation, just as if the section were of standard design and devoid of control features. This results from the employment of resonant windows 24, the use of a standard waveguide 11 to form a cavity, and the positioning of the cathode 34 normal to the electric field. When a negative voltage is applied to the cathode 34 sufficient to cause emission of electrons, the inert gas filling the cavity is ionized by the collison energy of the electrons moving toward the more positively charged walls of the cavity. In accordance with the well-known theory of gaseous discharge devices, the degree of ionization within the cavity may be rapidly varied in proportion to a variable voltage applied to the cathode. The degree of attenuation of the propagated ultra high frequency energy is a direct function of the dielectric constant of the propagated medium and is, therefore, a function of the difference between the dielectric constant of the medium when not ionized and a quantity which is directly proportional to the number of charged particles within a unit volume and the square of the unit charge of each particle and which is inversely proportional to the mass of each charge and a function of the signal frequency. Thus, the attenuation of the ultra high frequency signal may be accomplished by a varying degree of ionization.

Utility of this device in modulating a guided ultra high frequency wave by an alteration of the dielectric constant will be apparent to those skilled in this art. Briefly, however, this device may be used for amplitude, phase, or frequency modulation of the propagated wave, or for regulating the energy thereof. Because the waveguide section employed in this embodiment of this invention is basically of a standard design, it may be manufactured in accordance with prevailing practice, with the further steps of assembling the simple cathode structure interiorly of the section, affixing the sealing window assembly at either end of the section, and filling the section with a suitable gas. Upon these considerations it will be apparent that there is provided a relatively inexpensive, utilitarian device serving a variety of purposes when employed in conjunction with a waveguide system.

The particular embodiment of this invention, which has here been shown and described in detail, is intended merely to exemplify the principles and practice of this invention. Accordingly, as it will be obvious to those skilled in the art that changes and modifications may be made therein without a substantial departure, it is intended in the appended claim to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

In a waveguide system within which electromagnetic waves may be propagated, a sealed waveguide section enclosing a quantity of ionizable gas, said waveguide section having conductive interior walls defining a rectangular cavity, a strip-like electron emissive electrode supported within said section in an equidistantly spaced and electrically insulated relation to the walls thereof, said electrode lying in a plane parallel to opposite interior walls of said section and extending lengthwise in relation thereto, and means for applying a potential between said walls

and said electrode, thereby to ionize said gas uniformly by reason of said equidistantly spaced relationship.

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