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DEVICE FOR ELECTRONICALLY CONTROLLING THE PROPAGATION OF RADIO FREQUENCY POWER

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Fig. 1.

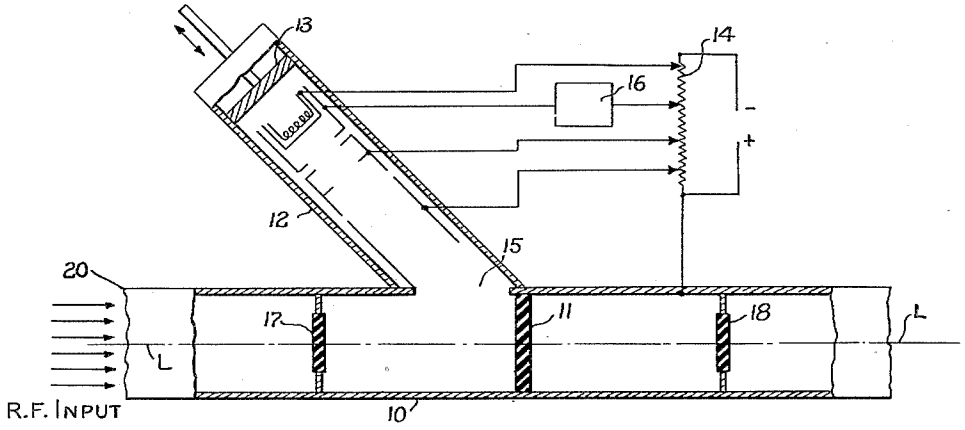
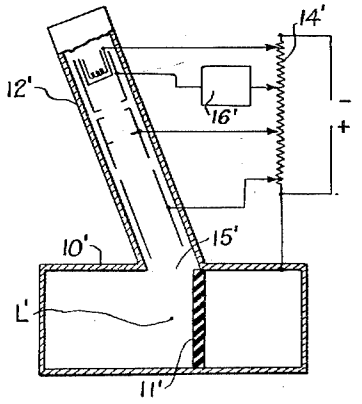


Fig. 2.



INVENTOR.
BENJAMIN KAZAN

BY
Harry M. Saragovitz
Attorney

United States Patent Office

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DEVICE FOR ELECTRONICALLY CONTROLLING THE PROPAGATION OF RADIO FREQUENCY POWER

Benjamin Kazan, Princeton, N. J., assignor to the United States of America as represented by the Secretary of the Army

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5 Claims. (Cl. 315—4)

(Granted under Title 35, U. S. Code (1952), sec. 266)

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

This invention relates to an improved system for switching, attenuating, reflecting, modulating or phase shifting radio frequency power.

Heretofore, the electronic variation of radio frequency power in wave guide systems has been accomplished to a large degree by means of gas discharge devices. The present invention is intended to accomplish the same result, but instead of a gas filled space or chamber a high vacuum may be employed.

An object of this invention is to provide an improved system for variably attenuating radio frequency energy in a wave guide.

A further object of the invention is to provide an improved system for variably absorbing, reflecting or switching electromagnetic wave energy.

Still another object of the invention is to provide an all electronic system for modulating energy propagated within a wave guide or similar structure.

An additional object of the invention is to provide a variable phase shifter.

These objects are accomplished by providing an insulating (dielectric) or semi-conducting vane or window member in a conduit for propagating electromagnetic energy and by bombarding the said member with a beam of high voltage (high velocity) electrons. It has been discovered that the electrons impinging upon the insulating or semi-conducting member induce a state of conductivity in the member and thus provide a variably conductive wave guide element. The conductivity of this element and consequently, the energy propagated in the wave guide may be modulated by modulating the electron beam.

Other and further objects of the invention will be found in the following description of the invention taken in conjunction with the accompanying drawing, in which Fig. 1 is a longitudinal section of a first embodiment of the invention, and Fig. 2 is a transverse section of a second embodiment of the invention.

Referring to Fig. 1, 10 represents a rectangular wave guide having the radio frequency energy introduced at 20. An insulating or semi-conducting plate or window 11 is mounted transversely within said wave guide. An electron gun structure generally indicated by the numeral 12 is arranged to communicate with the interior of wave guide 10 through an aperture 15 in a broad wall of the wave guide. The electron gun structure 12 may include the conventional cathode, grids, accelerating electrodes, and focusing electrodes, each of which is connected to a D.-C. potential divider 14 in a well known manner. Electron gun 12 is angulated with respect to the wave guide 10 in order that the beam of electrons projected by the gun may illuminate the surface of the window 11. The walls of the wave guide 10 may serve as the collector

electrode for secondary electrons emitted from the window 11 and for primary electrons which are not absorbed by the window.

The junction of electron gun 12 and wave guide 10 should be designed to introduce as little discontinuity in the wave guide structure as is practical. Aperture 15 may comprise a narrow longitudinal slot centered on a broad wall of the wave guide 10 and cut parallel to the axis of the wave guide, or if more uniform illumination is desired, a larger aperture may be employed, and a plunger 13 may be provided to tune out the discontinuity presented by the aperture. The plunger may be adjusted to reflect a very low impedance at the aperture.

The gun structure 12 may be designed by conventional techniques to provide any type of electron beam desired. In addition, conventional deflecting electrodes may be provided to allow scanning of the surface of the window 11. A variable control element 16, which may comprise a mechanical switch, a video amplifier, an oscillator, or other modulator, is inserted in the control grid circuit of the gun 12 to allow variation of the electron beam.

When the window 11 is bombarded with high voltage primary electrons, for example, 10,000 volts, a state of induced conductivity will exist on the window which will be many times greater than the conductivity of the unbombarded material. In general, the induced conductivity arises on the surface layer of the material, since the bombarding electrons do not penetrate very far, for example, one micron at 10,000 volts. Electromagnetic wave energy which is propagated in the guide 10 along the axis "L" will be reflected or attenuated to a degree dependent upon the conductivity of the window 11. Control element 16 may be utilized to vary this conductivity in any desired manner.

Additional windows 17 and 18 are provided to ensure a high vacuum in the vicinity of the electron gun structure. It is evident that window 18 may be omitted, if desired. However, it may be convenient to utilize windows 17 and 18 to form a resonant cavity. In this case the windows 17 and 18 may comprise metal diaphragms with dielectric centers. The spacing of the diaphragms may be adjusted to produce a standing wave having a voltage maximum at the window 11. In this manner variations in conductivity of the window 11 will have a greater effect upon radio frequency waves propagated within the wave guide 10. The diaphragms may also be utilized to counteract the discontinuity caused by aperture 15 or to cancel energy reflected from window 11 back into the radio frequency source.

It will be clear to anyone skilled in the art that various modifications of the device in Fig. 1 may be constructed without departing from the principle of the invention. For example, the window 11 may be bombarded by electron beams from opposite sides of the window. Instead of employing the walls of the wave guide 10 as a collector for the electrons, additional electrodes may be inserted within the wave guide, provided that they do not interfere with the propagation of the radio frequency energy. Several of the units may be employed in cascade or in tandem relationship, and thus, two units may provide successive attenuation or reflection in a single wave guide, or alternate attenuation or reflection in a pair of wave guides. The window 11 may be laminated and may consist of a first material, such as an insulator, and another material, such as a semi-conductor which is coated on the insulator in a thin layer. Among the well known insulators or semi-conductors which may be employed are mica, glass, aluminum oxide, arsenic oxide, antimony sulphide, selenium, silica, and magnesium fluoride.

The wave conduit and the electron gun may have any configuration and need not be rectangular or round. In fact, the invention is not restricted to wave guides but may be employed to vary the transmission characteristics of a coaxial line or the resonant characteristics of a cavity resonator. Furthermore, the variable conductivity element may be employed in a stub or spur line which is coupled to the main transmission line. For example, a closed ended stub wave guide one-half of a guide wave length long may be attached as a branch guide perpendicular to a broad wall of a main rectangular wave guide. The variable conductivity window may be placed a quarter wave length from the closed end of the stub, so that causing the window to become conductive will vary the short circuit normally reflected at the junction of the main and stub wave guides. It should be noted that the construction in Fig. 1 is merely illustrative of the principle of the invention, which should not be unduly limited to this embodiment.

Another embodiment of the invention is shown in Fig. 2. Elements corresponding with those in Fig. 1 are designated by corresponding primed reference numerals; however, Fig. 2 illustrates a transverse section, while Fig. 1 illustrates a longitudinal section. The window **11** has been replaced by a longitudinal vane element **11'**, which may be centered or located off center of the wave guide **10'**. The vane **11'** may assume any desired configuration, and any of the conventional matching means such as end-notching or tapering may be employed. Electron gun **12'** may conveniently communicate with the wave guide **10'** through a central longitudinal aperture **15'**, in the embodiment shown. As in Fig. 1, matching means and vacuum sealing devices may be employed. Various modifications are obvious, as indicated previously.

Radio frequency energy propagated in wave guide **10'** with the electric vector substantially parallel to the major surface of the vane **11'** will be attenuated to a degree dependent upon the conductivity induced by the electron bombardment.

Although it has not been set forth above, it is evident to anyone skilled in the art that the invention illustrated in Figs. 1 and 2 will serve as a variable phase shifter without modification.

What I claim as my invention is:

1. A radio frequency component comprising a hollow pipe wave guide section, a dielectric element in said section, means for introducing electromagnetic waves into said section with the electric field parallel to a substantial dimension of said dielectric element, and means bombarding said dielectric element with a beam of high voltage electrons for varying the conductivity of said dielectric element to variably attenuate said electromagnetic waves.

2. The component described in claim 1 wherein said wave guide section is evacuated, said dielectric element is a transverse window in said section, said electromagnetic waves are propagated through said window, and said means producing a beam of high voltage electrons includes means for modulating said beam.

3. A variable attenuator comprising a hollow pipe wave guide section, means for projecting a beam of high voltage electrons into said wave guide section, a plate element in said wave guide section and in the path of said electrons, said plate element having a conductivity which varies in response to bombardment to said electrons, means for introducing electromagnetic energy into said wave guide section with the electric field parallel to a substantial dimension of said plate element, means for maintaining a high vacuum in said wave guide section in the vicinity of said plate element, and means for varying the number of electrons in said beam.

4. The attenuator described in claim 3 wherein said plate element is a transverse dielectric window in said wave guide section, said means for projecting a beam of high voltage electrons comprises an electron gun positioned at an acute angle with respect to said section and coupled to said section through an aperture in the wall thereto, and said component further includes means for effectively eliminating the discontinuity of said aperture.

5. The component described in claim 3 wherein said plate element is a longitudinal dielectric member in said section.

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