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ELECTRICALLY VARIABLE WAVE GUIDE RESONANT IRIS

Original Filed Jan. 30, 1952

FIG. 1

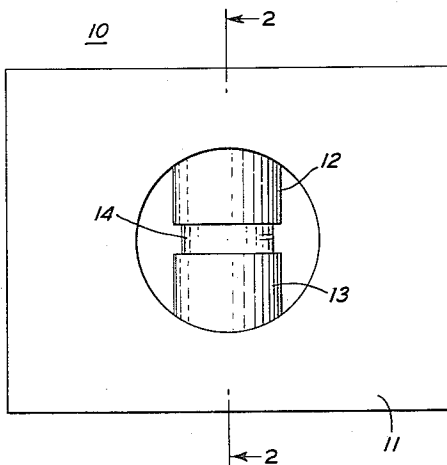


FIG. 2

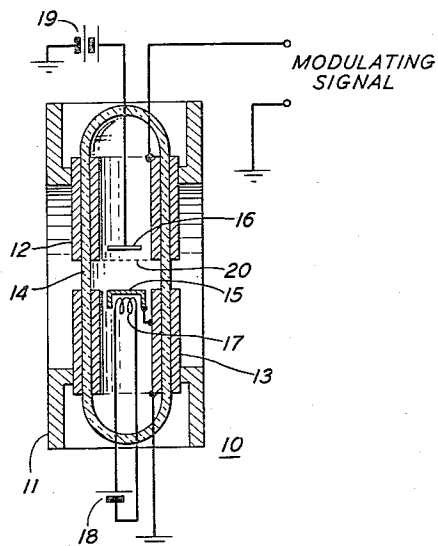
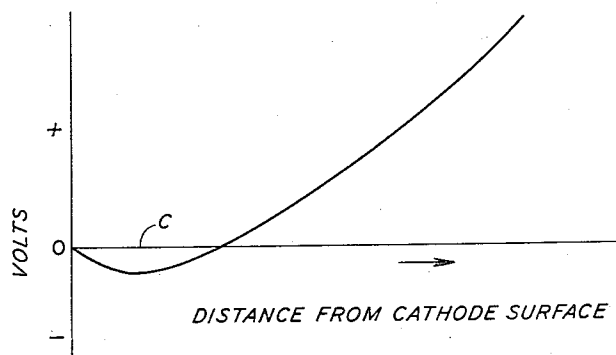


FIG. 3



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ELECTRICALLY VARIABLE WAVE GUIDE
RESONANT IRIS

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Original application January 30, 1952, Serial No. 268,979.
Divided and this application April 29, 1953, Serial No. 351,946

2 Claims. (Cl. 333—81)

This invention relates to variable reactors and more particularly to electrically variable reactors. This application is a division of copending application Serial No. 268,979, filed January 30, 1952. The latter application matured into Patent 2,784,377 granted March 5, 1957.

An object of this invention is to provide improved means for varying the resonant frequency of a tuned circuit.

One of the most obvious and convenient ways of varying frequency in accordance with a modulating signal is by varying the reactance of an element in a resonating circuit which determines the frequency. While this method is attractive because of its simplicity, conventional ways of varying a reactance are seriously limited in their usefulness by the undesirably low rate at which the reactance may be changed. Until recently, however, other factors obscured this limitation and it was not so glaringly conspicuous as it has become with the development of super high frequency circuits having band widths of the order of several octaves. In order at least partially to utilize these great band widths, it is desirable to have available a variable reactor whose reactance can be varied rapidly, of the order of tens of megacycles per second, over a wide range. The present invention, in one of its more important aspects, is designed to provide a simple and inexpensive reactor of this kind which is capable of use in a variety of tuned circuits.

In accordance with the present invention, the "hot-capacitance" effect, that is, the change in capacitance for a change in signal amplitude, in a space discharge tube is utilized to change the resonant frequency of a microwave resonant element. The specific embodiment illustrated herein is a wave guide resonant iris filter which may be used, for example, as a frequency determining element in the oscillator system disclosed in the above-mentioned copending application. This filter consists essentially of a conducting plate apertured by an opening into which there extends from opposing sides thereof two conducting posts or stubs axially aligned with each other and separated by a small gap between their ends approximately at the center of the opening. Positioned within these stubs are electron beam forming and projecting electrodes aligned so that an electron stream flows parallel to the axis of the stubs across the gap between them. As the electron current is changed by a modulating signal applied to a control electrode, the capacitance across the gap correspondingly changes and this causes an increase or decrease in the resonant frequency of the filter.

A more complete understanding of this invention, however, together with a better appreciation of its advantages, will best be gained from a study of the following description given in connection with the drawings in which:

Fig. 1 is a front view of a resonant iris arranged for use as a filter in a rectangular wave guide;

Fig. 2 is a side section view of the same iris taken as indicated by line 2-2 in Fig. 1; and

Fig. 3 is a plot of potential versus distance from the cathode in a typical electron current tube.

Referring now more particularly to the drawings, the

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wave guide iris 10 shown by way of illustration in Fig. 1 consists of a resonant circuit formed by the circular opening through conductive rectangular plate 11 into which reactive posts 12 and 13 extend. The axis common to these posts is preferably, though not necessarily, perpendicular to the axis of the opening in plate 11. Envelope 14, which is preferably glass or quartz, is sealed to both posts so that it forms a gas tight enclosure surrounding the electron path between them. The dimensions of the above elements and the size of the opening in plate 11 relative thereto may easily be determined by formulas well known in the art once the operating frequency and the band width of filter 10 have been chosen.

Fig. 2 shows an electron cathode 15 and an anode or collector electrode 16 aligned within posts 12 and 13 so that an electron stream may flow in the gap between them and parallel to their common axis. Filament 17 in conjunction with battery 18 is arranged to heat electron emissive grounded cathode 15 sufficiently to produce a copious supply of electrons. Some of these electrons may then be attracted to the anode 16 by the electric field generated between the anode and the cathode by battery 19. Grid 20 is preferably connected across the end of post 12 so that the modulating signal applied to it may readily control the current flowing in the gap between posts. If desired it may be omitted entirely and replaced by collector 16 but in this event the modulating signal source must be able to conduct all of the current flowing from the cathode. Glass envelope 14, in addition to providing an evacuated enclosure, insulates grid 20 and cathode 15 from each other and from plate 11. However, since the frequency of operation of the iris may be of the order of a thousand times the maximum modulating signal frequency, the capacitances between the grid electrode and plate 11 and between the cathode electrode and plate 11 provide a low impedance current path in spite of envelope 14 and accordingly its effect upon the filter characteristics is negligible.

Fig. 3 shows, by way of explanation of the operation of iris 10, a plot of electric potential versus distance from the cathode surface in the region near the cathode surface of a typical electron tube.

The cathode surface is grounded and the origin of the plot coincides with this surface. Assuming that the cathode is able to supply many more electrons than are reaching the collector electrode, that is, that the tube is space charge limited, and that the electrons are emitted from the cathode with a finite average velocity, there must, in order to satisfy these assumptions, be some point at which the average electron velocity falls to zero. The locus of these points, designated C in Fig. 3, of zero velocity is located some distance from the cathode surface and appears to the collector electrode as the actual electron emitting surface. The distance that this locus, or virtual cathode, is spaced from the cathode depends upon tube current and accordingly since electrode capacitance depends on electrode spacing, tube capacitance is a function of current therein.

The electrode dimensions and operating potentials of the space discharge tube positioned within envelope 14 of filter 10 are chosen so that a virtual cathode exists in the gap between posts 12 and 13. The capacitance between them and the corresponding resonant frequency of the iris may then be varied by a modulating signal applied to current control grid 20.

The foregoing description is intended to be in illustration of the general nature and objects of this invention and not as a complete exposition of all possible embodiments thereof. It should be understood in particular that these general principles may be applied to variously shaped structures. Changes or modifications in the embodiment illustrated herein will occur to those skilled in the art and

may be made without departing from the spirit or scope of this invention.

What is claimed is:

1. A variable resonant element comprising a conductive plate member apertured to form a circular, tunable iris, first and second hollow conductive posts extending radially toward one another in a direction generally parallel to the plane of said plate member from opposite sides of the iris circumference, and partially across, said aperture and forming a capacitance reactance gap therebetween, electron discharge means extending within the hollow of the two posts including a cathode electrode adjacent the end of one of said posts and a control electrode adjacent the end of the other post, said electrodes spaced apart a distance substantially equal to the spacing between the posts, means for forming a virtual cathode between said electrodes whereby the virtual cathode and the control electrode serve as capacitive plates bounding the gap between the posts, and means for varying the spacing between said virtual cathode and said control electrode in accordance with a modulating signal.

2. A resonant iris filter comprising a plate having a circular aperture therein tunable to microwave frequencies, a pair of collinear hollow conducting posts projecting from the circumference of said aperture to form a gap adjacent the center thereof and providing capacitive reactance thereat, electronic means for varying said capacitance

comprising an electron discharge tube positioned in said hollow posts, said tube having a cathode, grid and anode electrodes, wherein the grid is located in the space of the gap and the spacing between cathode and grid is substantially equal to that of the posts, means for establishing an electronic space charge and forming a virtual cathode in the gap between the posts, and means for varying the position of said virtual cathode in the gap to vary the said capacitive reactance between the posts electronically and thereby the tuning of said iris filter, comprising a modulating signal of relatively low frequency applied to said grid.

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