# United States Patent

**Low et al.**

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[54] **ACTIVE MICROWAVE IRISES AND WINDOWS**

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[52] **U.S. Cl.** ....... **333/98 R,** 333/98 P, 333/98 S, 333/7, 333/81 R

[51] **Int. Cl.** ....... **H01p 1/08,** H01p 1/10, H01p 1/22

[58] **Field of Search** ....... 333/98 P, 98 S, 7, 2, 13, 81 B; 332/54; 338/216

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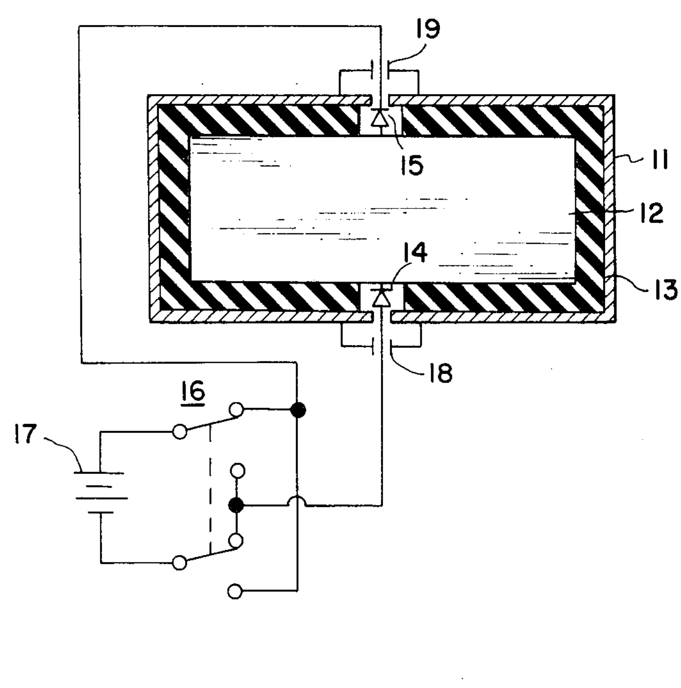
[57] **ABSTRACT**

A waveguide thin film window or an iris fabricated from either a thin film or a conventional plate and mounted transverse to the flow of energy in a waveguide and electrically insulated from the waveguide. Diode switching means are provided for selectively disconnecting and connecting the window or iris to the walls of the waveguide.

**6 Claims, 2 Drawing Figures**



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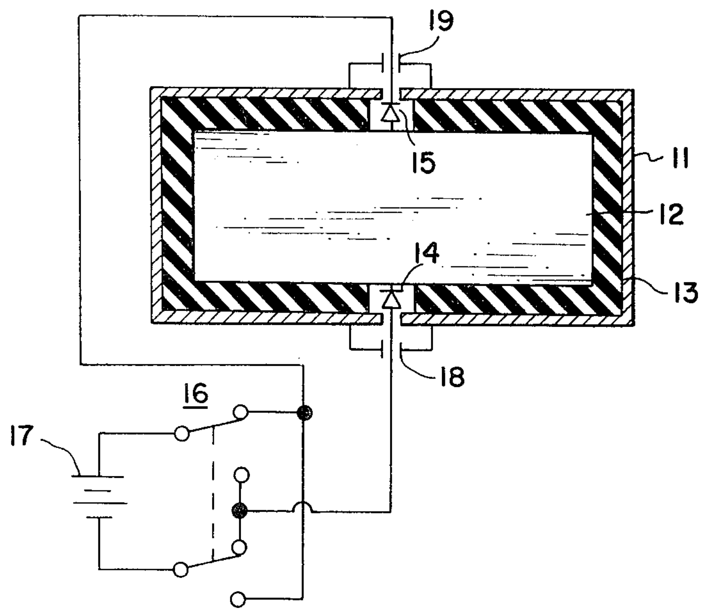


FIG. 1

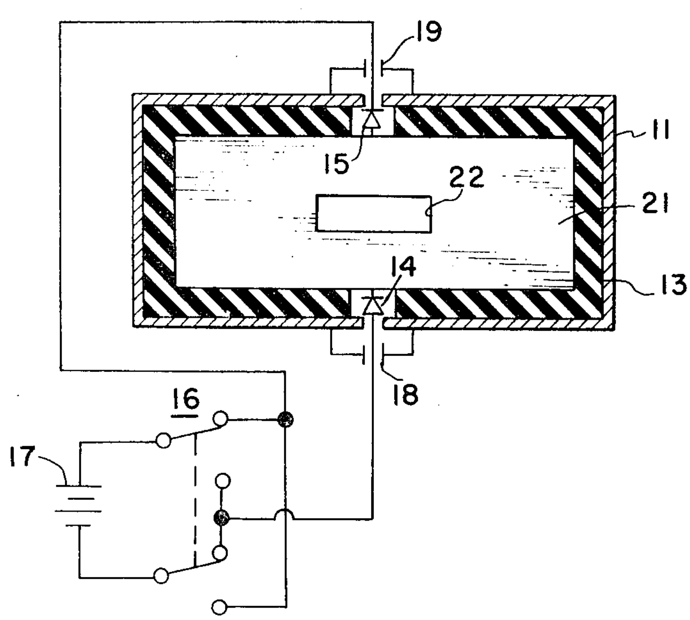


FIG. 2

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## ACTIVE MICROWAVE IRISES AND WINDOWS

### ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of section 305 of the National Aeronautics Space Act of 1958, public law 85-568 (72 stat 435, 42 USC 2457).

### BACKGROUND OF THE INVENTION

The invention relates generally to waveguides and more specifically concerns waveguide windows and irises.

This invention is applicable to both thin film and conventional irises. "Thin film" as used in this specification and claims include all film thicknesses for which (a) the electrical conductivity of the film is less than the bulk conductivity of the same material, and (b) the thickness of the film is negligible when compared to the waveguide wavelength of the microwave signal. To be more specific, in the case of all metal and semimetal films, a thin film includes all film thicknesses of less than 1,000 angstrom units even though the thickness can be several thousand angstrom units and still meet the definition. Low conductivity semiconductors, on the other hand, could require a thickness on the order of wavelength and therefore cannot be considered as films. High conductivity semiconductors may be on the order of tens of thousands of angstroms in thickness and satisfactorily meet the requirement of being a thin film.

Conventional irises are usually electrically connected to the walls of the waveguide. However, if these irises are electrically disconnected from the walls of the waveguide the transmission and reflection characteristics of the irises materially change. Consequently, if means are provided for selectively disconnecting and connecting the irises to the walls of the waveguide the irises have many applications. It is therefore the primary purpose of this invention to provide means for selectively disconnecting and connecting conventional and thin film irises and windows to the walls of a waveguide.

### SUMMARY OF THE INVENTION

The invention consists of a conventional or a thin film iris or window in a waveguide with the iris or window electrically insulated from the walls of the waveguide by means of an insulating material. Diodes are connected between the bottom of the iris or window and the bottom wall of the waveguide and between the top of the iris or window and the top wall of the wave guide through the insulating material. Means are provided for selectively forward and reverse biasing these diodes to connect and disconnect the iris or window from the walls of the waveguide, thereby providing means for changing the transmission and reflection characteristics of the iris or window.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic drawing of the embodiment of the invention using a thin film iris without an aperture; and

FIG. 2 is a schematic drawing of the embodiment of the invention using either a thin film iris with an aperture or a conventional iris.

### DETAILED DESCRIPTION OF THE INVENTION

Turning now to the embodiments of the invention selected for illustration, the number **11** in FIG. **1** designates a waveguide having a top, a bottom and two sidewalls. Located inside the waveguide and transverse to the flow of energy through the waveguide is a thin film iris **12** that is electrically insulated from the walls of the waveguide by an insulating material **13**. A diode **14** has its cathode connected to the bottom of thin film **12** and its anode connected through the bottom of waveguide **11** and a feedthrough capacitor **18** to a switch **16**. A diode **15** has its anode connected to the top of thin film **12** and its cathode connected through the top of waveguide **11** and a feedthrough capacitor **19** to switch **16**. Switch **16** is also connected across a battery **17**. Feedthrough capacitor **18** is connected to the bottom of waveguide **11** and feedthrough capacitor **19** is connected to the top of waveguide **11**. When switch **16** is in the position shown, diodes **14** and **15** are reverse-biased and thin film **12** is thereby electrically disconnected from the top and bottom walls of waveguide **11**. When switch **16** is in its other position, diodes **14** and **15** are forward-biased and microwave energy flows from the thin film **12** through diodes **14** and **15**, and the feedthrough capacitors **18** and **19** to the walls of the waveguide.

With switch **16** in the position shown, the two diodes are reverse-biased and thin film **12** is entirely insulated from the walls of waveguide **11** which results in a maximum power transmission through thin film **12**. With switch **16** in its other position the two diodes are forward-biased connecting the bottom and top of thin film **12** to waveguide **11** which greatly reduces the power transmission through the thin film. By electrically adjusting the forward bias current the power transmission through the film may be controlled. For the principle $TE_{10}$ mode in rectangular waveguides there are essentially no currents between the two sides of the film and the sidewalls of the waveguide. Therefore, these two sides of the film can be left disconnected from the waveguide with no noticable change in power transmission.

The embodiment of the invention disclosed in FIG. **1** has several uses. It can be used as a switch modulator by controlling switch **16**. With switch **16** in the position shown the diodes are reverse-biased and there is an increased transmission through the thin film. With the switch **16** in its other position the diodes are forward-biased which decreases the transmission through the film. Thus by controlling the conductivity of the diodes by means of switch **16** the invention can be used as a microwave power transmission switch or modulator.

The embodiment of the invention in FIG. **1** can also be used as a power splitter which operates on the principle of partial transmission through the thin film and partial reflection from the thin film. The power transmission and power reflection of the thin film are both functions of the product of the film conductivity and the film thickness. Hence by controlling the product of the film conductivity and the film thickness, any desired ratio of power transmission to power reflection can be obtained. Further, if desired, the transmission can be switched from a low value to a high value by disconnecting the film from the waveguide walls. With the embodiment of the invention in FIG. **1** located at a tee in the waveguide such that part of the microwave energy is reflected by the thin film and part of it is transmitted through the thin film then the device can be used as a power splitter. That is, the transmitted part of the energy will travel down one branch of the waveguide from the tee and the reflected part of the energy will travel down the other branch of the waveg$ide. By the use of switch **16** the amounts of transmission and reflection can be varied.

The embodiment of the invention in FIG. **1** can further be employed to couple a microwave cavity to a microwave system in which case it is a cavity coupler. The thin film iris offers the advantage that no coupling iris is required as in the case of conventional cavity coupling systems.

In each of these three devices, the thin film iris offers a compact, low-cost device which may be produced with a large degree of flexibility. In the case when microwave diodes are employed to control the effects of the film, the advantages are not only small size and low cost, but the desirability of electric control as contrasted to magnetic control currently used by existing devices of a similar nature. Electric control offers small size and weight in the control of circuitry and fast response as compared to magnetic control systems.

The thin film in a microwave system is a passive transmission-reflection type coupling element which can be made into an active coupling element as described in FIG. **1**. Also, because of the ability of the thin film to support an electric field, it can be placed in the sidewalls or top or bottom walls of the waveguide to couple energy from one waveguide into another waveguide system. The principle of operation of this example and the ones above is based upon the voltage drop that appears across the film because of a microwave current in the film. The electric field produced by this voltage drop radiates energy into the coupled system as well as back into the original waveguide system. This second component of radiated energy appears as reflection from the film. Although the efficiency of this method of coupling is not very high, it does offer promise for use in directional couplers used in microwave instrumentation circuits.

The other embodiment of the invention disclosed in FIG. 2 differs from the embodiment disclosed in FIG. 1 only in that an aperture is employed to increase the amount of power transmitted over that which can be handled by the thin film iris. The film or conventional plate **21** with an aperture **22** is mounted exactly the same as the thin film iris **12** in FIG. 1. The exact shape and symmetry of the aperture is selected to provide the impedance and power transmission desired when the iris is connected to the walls of the waveguide. Whenever the iris **21** is disconnected from the walls of the waveguide, the power transmission through the iris increases from 10 to 100 times and the impedance presented by the iris is materially altered. The ability to switch the transmission properties of the iris can be used to develop several devices such as modulators, phase shifters and slot radiators. If the diode bias current is controlled by a modulating signal, the iris can serve as a transmitting type modulator. Step phase shifters that are electrically switched in accordance with this invention should have a faster response than the present magnetically switched phase devices that employ ferrites. Diode switching of thin films placed over the slots of a multislot radiation guide would permit electronic control of the radiated intensity and the radiated field pattern.

It is to be understood that the forms of the invention herewith shown and described are to be taken as preferred embodiments. Various changes may be made in the shape, size and arrangement of parts. For example, equivalent elements may be substituted for those illustrated and described herein, parts may be reversed, and certain features of the invention may be utilized independently of the use of other features, all without departing from the spirit or scope of the invention as defined in the subjoined claims. Transistors or other electronic devices could be used in place of the diodes for switching. More than one switching device at the bottom and top of the waveguide could be used. Other electronic switching devices could be used in place of switch **16** and means other than the feedthrough capacitors could be used to apply the biasing voltages to the diodes without departing from the invention.

What is claimed is:

1. An active microwave waveguide iris comprising:
   a microwave iris located inside a waveguide transverse to the flow of energy in the waveguide;
   means for attaching said iris to the wall of said waveguide and for electrically insulating the iris from the walls of the waveguide;
   first switching means connected between said iris and one side of said waveguide through said insulating means for disconnecting and connecting said iris to said one side of said waveguide;
   second switching means connecting between said iris and a second side of said waveguide through said insulating means for disconnecting the connecting said iris to said second side of said waveguide; and
   means for controlling said first and second switching means to selectively disconnect and connect said iris to said one and second sides of said waveguide.

2. An active microwave waveguide iris according to claim 1 wherein said iris is a thin film without an aperture.

3. An active microwave waveguide iris according to claim 1 wherein said iris is a thin film with an aperture.

4. An active microwave waveguide iris according to claim 1 wherein said iris is a conventional conducting plate with an aperture.

5. An active microwave waveguide iris according to claim 1 wherein said first and second switching means are diodes.

6. An active microwave waveguide iris according to claim 5 wherein said control means include means for selectively applying a controlled reverse bias and a controlled forward bias to said diodes.

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