May 29, 1956 L. J. VARNERIN, JR 2,748,351

MICROWAVE WINDOWS AND GASEOUS DEVICES

Filed Dec. 19, 1950

Fig. 1a

PRIOR ART

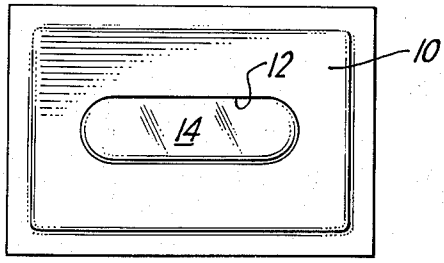


Fig. 1b

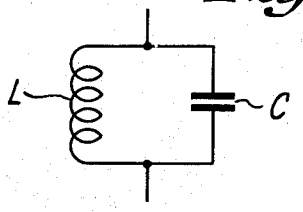


Fig. 2a

IMPROVED WINDOW

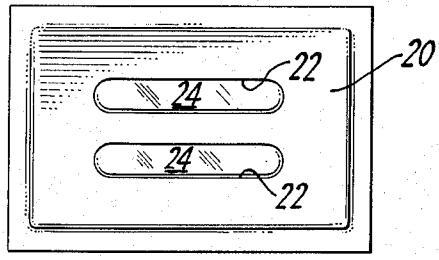


Fig. 2b

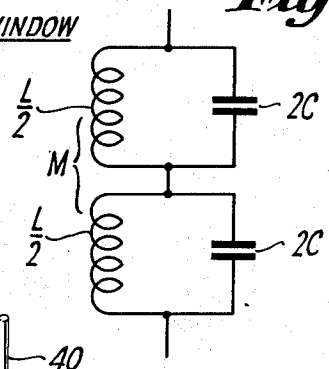
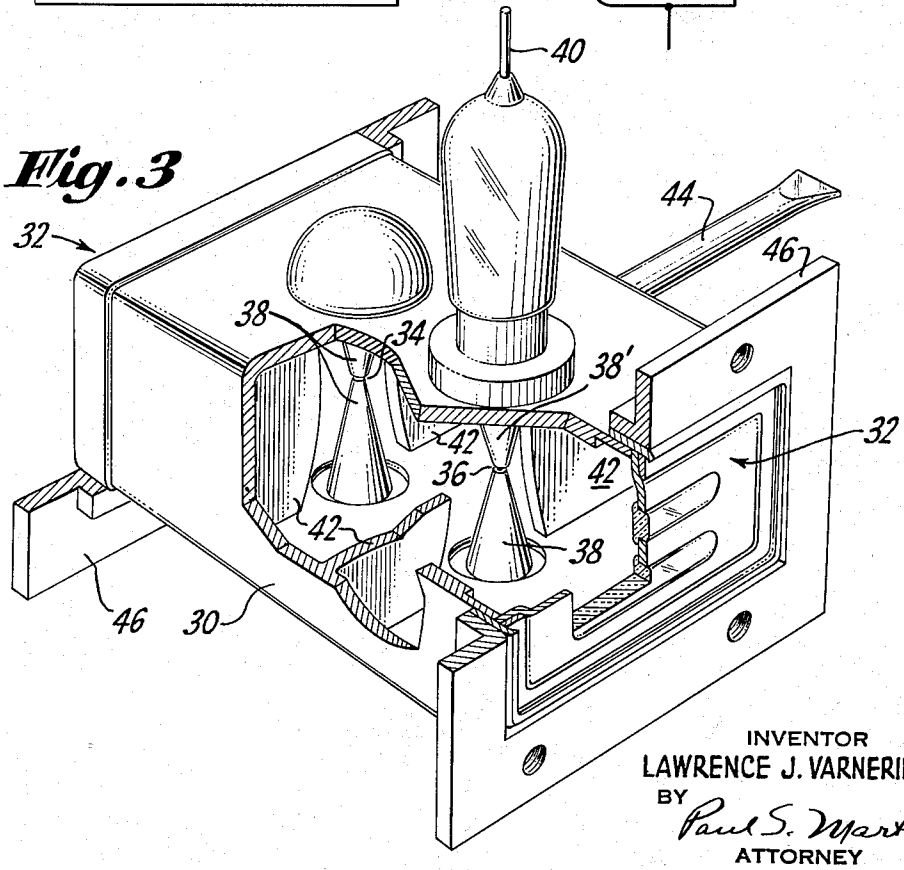


Fig. 3



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MICROWAVE WINDOWS AND GASEOUS DEVICES

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12 Claims. (Cl. 333—13)

The present invention relates to microwave energy transmission in wave-guides, and to wave-guide devices employing "windows" and to windows as separate elements.

The invention will be described in connection with a transmit-receive (TR) tube, but in its broader aspects, of course, it will be recognized as having other applications.

In TR tubes as in other devices, it frequently becomes necessary to interpose a barrier across a section of wave-guide so as to confine a region of the wave-guide at one gas pressure separate from adjoining wave-guide portions at different gas pressures. It has been the common practice in this art to provide a barrier in the form of a resonant "window" having a metal frame provided with an aperture so that the microwave energy can be transmitted, and to seal the aperture with glass or the like so as to prevent the flow of gas past the window.

When such a window is used in a TR tube or the like, it is subjected to heating attributable to dielectric loss of the microwave energy in the glass, and recombination of electrons and ions on the surface of the glass.

TR tubes conventionally have a glass fill which becomes ionized in the course of its operation. As the power transmitted is increased, a tendency arises for the glass to melt or crack. Substitution of ceramics for the glass permits higher heat dissipation but requires processes that are difficult and expensive. The present invention has for an object the provision of a new form of window, a prominent advantage which is its capacity to operate at high power levels without requiring special fabrication techniques or materials. The novel window and devices employing this window will be recognized to have other advantages, such that their use will be found desirable even where the high levels of power may not be involved.

In the illustrative form of the present invention described below, the window is constituted not of a frame with a single closure, but of multiple apertures and separate closures. The aggregate effect of the multiple apertures is such as to satisfy the main transmission requirement of the single-aperture window. In a practical example, a window having a long and fairly wide glass closure is replaced by a window having two slits of roughly the same length but each of half width of the aperture in the original window.

The justification of this will be understood from the illustrative embodiment discussed below in connection with the accompanying drawings. Figure 1*a* is the front elevation of a window in accordance with the prior art, and Figure 1*b* is the approximate lumped constant circuit representation thereof. Figure 2*a* is the front elevation of a window embodying aspects of the present invention and Figure 2*b* is the approximate lumped constant representation thereof.

Figure 3 is a perspective view of an illustrative TR tube incorporating the window of Figure 2*a*, parts of the device in Figure 3 being broken away and shown in section for clarity.

The window in Figure 1*a* includes a frame portion **10**

of metal having an opening **12** provided for transmission of microwave energy. For the purpose of maintaining a gas pressure differential on opposite sides of the window, opening **12** is hermetically sealed by a center cover or closure **14** advantageously of glass or like vitreous material. Where the frame **10** is of Kovar or other alloy having like thermal expansion characteristics, closure **14** is of hard glass. The glass and the metal should have matched thermal expansion characteristics.

Opening **12** is represented in Figure 1*b* in the form of a parallel resonant circuit having an inductor L and a capacitor C familiar in resonant circuits of low frequency applications. The representation is for the purpose of supporting a theoretical explanation of the invention and is not intended to be rigorous.

In Figure 2*a* there is shown a window having the frame **20** of metal and two openings **22** each of which has edge portions embodying elements of inductance L and capacitance C as shown in Figure 2*b*. Openings **22** are hermetically closed to maintain a gas pressure differential at opposite sides of the windows by suitable energy-permeable covers or closures **24** of glass or the like. The openings **22** in this example are of half the width of opening **12**, but the length of opening **22** is approximately the same as that of opening **12**. Openings **22** are equally spaced from the center-line across the window, parallel to its long dimension. Each of the openings **22** has a relatively greater capacitance as represented by **2C** in Figure 2*b*, and each aperture **22** has a relatively lower inductance as represented by

$$\frac{L}{2}$$

in Figure 2*b*. These are approximations, and are affected by various factors such, for example as mutual coupling between the slits represented by M in Figure 2*b*.

Electrically, the window of Figure 2*a* can be expected to transmit the same center frequency energy of a microwave band of frequencies to be transmitted. There may be some slight difference in respect to insertion loss. The dielectric loss in the glass will be very little changed. The voltage gradient across the double slits, as these narrow openings **22** may be termed, may be taken to be very nearly the same as in single-opening window. Due to the greater length of glass-to-metal connection there may be a slight increase in the dielectric loss in the glass, but this may be considered negligeable.

As before, the heat that this double slit window can dissipate is proportional to the temperature gradient in the glass and inversely proportional to the heat-conduction distance in the glass. For the same peak glass temperature as in the single opening window, the temperature gradient can become twice as large. The length of the glass-metal boundary is very nearly twice as great. If the metal were a perfect heat conductor, the double slit window could dissipate very nearly four times as much heat. Even if the glass-sealing alloy should not have excellent heat conduction properties compared to other metals, nevertheless its conduction is so far superior to that of the glass that the departure of the alloy from perfection as a heat conductor is only a second order effect. The reduction of the length of the heat conduction path in the glass from its center to the metal enables almost proportionate increase in heat dissipation.

It is possible to use the principles concerning heat conduction to construct a single narrow slit to give greater heat dissipation. In so doing, however, the window Q is necessarily increased. The double slit arrangement does not have this increased Q and thus it becomes possible to construct a window having superior heat dissipation properties by using plural apertures, without,

however, narrowing the operating band of frequencies of the device incorporating the window.

A window such as that in Figure 2*a* is incorporated in a TR tube in Figure 3. That TR tube is of the type described in applications Serial No. 35,905, filed June 29, 1948 by Ezio Thomas Casellini, now Patent No. 2,611,109 dated September 16, 1952, and Serial No. 125,055 filed November 2, 1949 by Paul Gates. This TR tube includes a length of rectangular wave-guide **30** having a window closing each of its ends, each window being indicated generally by the arrows and numerals **32**. This window is of the double slit construction as in Figure 2*a*. The TR tube includes a pair of discharge gaps **34** and **36** constituted of conical electrodes **38**. One of these **38'** is hollow-ended, contains an electrode **40**, electrodes **38** and **40** (separated by glass insulation) constituting a keep-alive which in operation maintains a small volume of weakly ionized gas in its immediate vicinity for minimizing the "firing" time of the device when exposed to a sudden burst of high level energy. The gas contained within the device is to become highly ionized so as to effect short circuiting and prevent transmission of the high level energy. The device is commonly filled with a mixture of water vapor and argon in equal proportions at a total pressure of approximately 10 millimeters of mercury.

Electrodes **38** are located between conducting plates **42** which have edges that, with the upper and lower walls of wave-guide **30** and electrodes **38**, constitute resonant irises so as to build up a large voltage gradient across gaps **34** and **36**, without however, bypassing low-level signals. Finally, exhaust and fill tubulation **44** and flange **46** are provided in the conventional manner.

In operation, the device represents a wave-guide having a broad pass-band while its gas is not ionized significantly, the total effect of the windows **32** and the resonant irises described giving the device a broad-band characteristic. The fact that the double slit window includes double resonant arrangements which are coupled together tends to improve the broad-band performance of the two slit windows as compared to the single-opening window. When a high burst of energy reaches the device, the gas fill becomes intensely ionized, especially in the immediate vicinity of the window near the source of the high level energy. This ionization produced by heavy microwave currents, causes heating of the glass, and this glass is also heated by numerous other factors some of which are mentioned above. The double-slit window construction effectively dissipates this heat, both because there is greater length of metal in contact with the glass (a metal being a far better conductor for heat dissipation) and because the width of the glass is greatly diminished so as to reduce the length of heat conduction path in the glass. Double-slit windows at both ends of the TR tube facilitates tube design, in respect to operation while deionized.

This process of subdivision of the single window and its glass closure into two or more slits has been shown not to deprive the window of its wave-transmission properties, and will be found to have varied applications. The invention can obviously be practiced without necessarily duplicating the design or materials described in connection with the illustrative embodiment. The invention is also advantageously applied to anti-transmit-receive (ATR) tubes so as to include a gas-filled quarter-wave length of wave-guide, closed at one end by a metal wall and covered at the other end by the novel multiple-aperture window and to like gaseous wave-guide devices. It is therefore, appropriate that the appended claims be accorded that broad interpretation that is consistent with the spirit and scope of the invention.

I claim:

1. A microwave transmission control unit including a length of wave-guide and a window sealed across an end thereof, said window including a metal frame portion and plural openings therein, all of said openings having parameters selected to provide window resonance at a predetermined operating frequency and being sealed by glass closures and said openings having a free transmission path therebetween at each of the opposite sides of the windows.

2. A microwave transmission control unit including a length of rectangular wave-guide and a window sealed across the end thereof, said window including a metal frame portion and parallel slits therein, said slits having parameters selected to provide window resonance at a predetermined operating frequency and being sealed by glass closures, said slits having free transmission paths at opposite sides of the windows.

3. A broad-band microwave transmission control unit including a length of wave-guide having a window sealed across an end thereof, said window including a metal frame portion and plural openings therein, said openings being sealed by glass closures and all of said openings being coupled to each other by a free transmission path at each of the opposite sides of the window and being resonant to the center frequency of the transmission band of the control unit.

4. A microwave transmission control unit including a gas-filled length of wave-guide and a hermetically sealed multiple-apertured window across an end thereof, said window apertures having parameters selected to provide window resonance at a predetermined operating frequency and having multiple glass closures separately surrounded by metal and having a free path therebetween at the respective sides thereof.

5. A TR tube including a gas-filled length of wave-guide, juxtaposed electrodes constituting a discharge-initiating gap, and a window sealed across each end of said wave-guide, each window including a metal frame having multiple juxtaposed parallel slits with parameters selected to provide window resonance at a predetermined operating frequency and glass covers sealed across said slits.

6. A microwave transmission control device including a gas-filled rectangular wave guide, and a window sealed across an end of said wave guide, one of the transverse dimensions of said wave-guide being greater than the other, and said window having like glass covers sealed across slits in a metal frame, the slits having parameters selected to provide window resonance at a predetermined operating frequency and being parallel to each other and to said greater dimension and having a free coupling path at each of the opposite sides of the window.

7. A microwave window including a frame of metal having plural openings with parameters selected to provide window resonance at a predetermined operating frequency, and glass covers sealed across all of said openings and having a free coupling path between the openings at the respective sides of the covers.

8. A microwave window including a frame of metal having plural duplicate openings freely coupled to each other at the opposite sides of the frame and with parameters selected to provide window resonance at a predetermined operating frequency, and glass covers sealed across said openings.

9. A microwave window including a long and relatively narrow rectangular metal frame, having parallel slits symmetrically disposed on opposite sides of the center line parallel to the length of the frame, said slits having parameters selected to provide window resonance at a predetermined operating frequency, and glass covers sealed across said slits and having a free coupling path at the respective opposite faces of the covers.

10. A gaseous discharge tube including a sealed gas-filled length of waveguide containing juxtaposed electrodes constituting a gap for initiating an ionized discharge, and a window sealed across an end of said wave-

guide embodying a metal frame having multiple parallel slits with parameters selected to provide window resonance at a predetermined operating frequency and glass covers across said slits and sealed thereto hermetically against gas leakage, said device having a gas passage between said electrodes and said window exposing said window to the ionized discharge initiated at said gap.

11. A microwave window including a frame of metal having a plurality of apertures sealed by dielectric material, said apertures having parameters selected with relation to the dielectric constant of said material and having relative positions to provide window resonance at the center frequency of the predetermined band of frequencies to be translated by said window.

12. A broad-band microwave transmission control unit including a length of waveguide having a window sealed across an end thereof, said window including a conductive frame portion and plural narrow apertures therein, said apertures being sealed by material permeable to microwave energy, the apertures being spaced in parallel relation and resonant to the center frequency of the transmission band of the control unit, the total perimeter/area ratio of said apertures being substantially in excess of the perimeter/area ratio of a single relatively wide resonant aperture tuned to said center frequency and having a Q comparable to the overall Q of the plural narrow apertures.

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