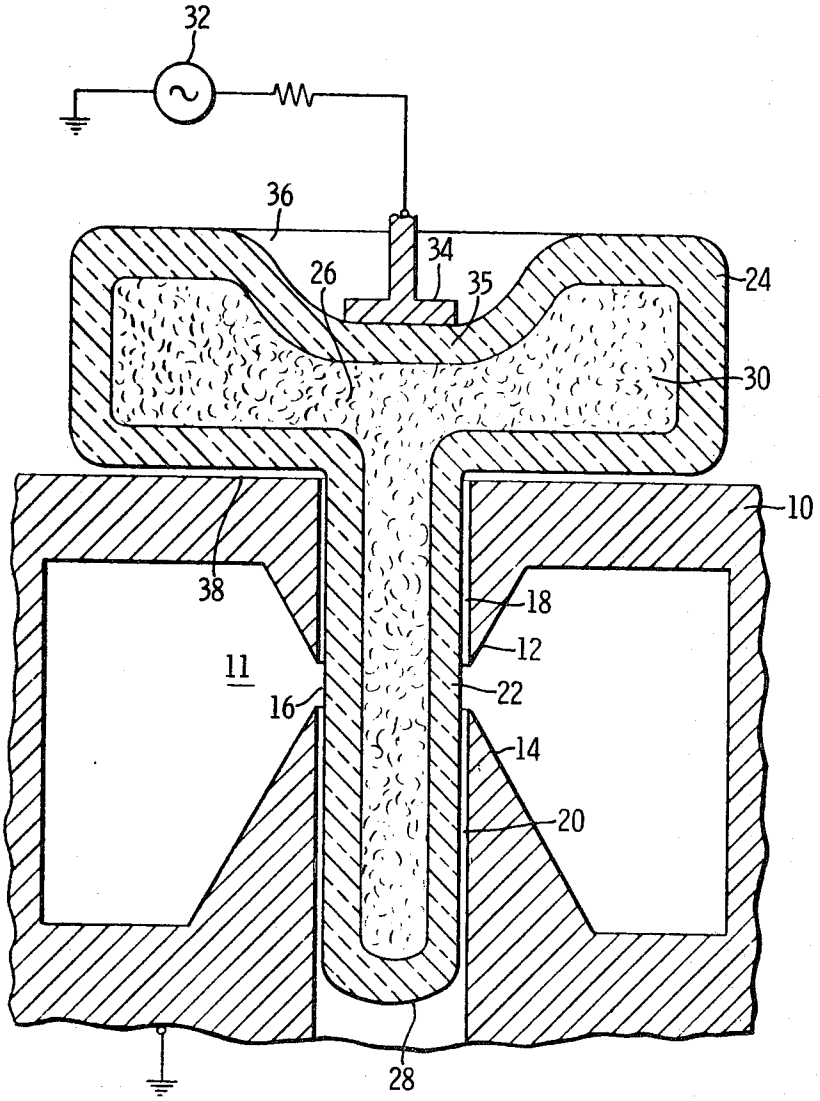
Oct. 13, 1970 H. GOLDIE ETAL 3,534,298

RF ENERGY PRIMED T-R SWITCH

Filed May 15, 1969



United States Patent Office

3,534,298

Patented Oct. 13, 1970

3,534,298

RF ENERGY PRIMED T-R SWITCH

Harry Goldie, Randallstown, Md., and Gerald I. Klein, Westbury, N.Y., assignors to Westinghouse Electric Corporation, Pittsburgh, Pa., a corporation of Pennsylvania

Filed May 15, 1969, Ser. No. 824,763
Int. Cl. H01p 1/14; H01j 19/80
U.S. Cl. 333—13 5 Claims

ABSTRACT OF THE DISCLOSURE

A T-R switch is provided with a halogen gas filled capillary tube traversing the discharge gap in a waveguide. In order to increase the reliability of the gas discharge, the gas is "primed" with electrons from a glow discharge excited by AC energy from an oscillator. This AC energy is capacitively coupled into the gas through external capacitive leads or plates abutting the outside surface of the gas container. Because these leads are external, they are not attacked by the chemically active halogen gas.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates, in general, to discharge devices and, more particularly, to gaseous discharge ultra high frequency or microwave switching devices more commonly known as transmit-receive or T-R switches.

Description of the prior art

Frequently T-R switches in radar systems have employed a small quantity of a readily ionized gas such as krypton, water vapor, or argon contained in an enclosed resonant aperture section of the waveguide. The gas was continuously maintained in a weakly ionized or excited condition by a DC "keepalive" or primer voltage applied across the gas within the enclosed section. Pulses of incident RF energy from the radar transmitter caused a more complete breakdown of the weakly ionized or "armed" gas and established a low impedance path traversing the waveguide. This change in impedance detuned the resonant aperture and prevented the incident pulses from passing through the resonant aperture. In contrast, the target pulses picked up by the radar antenna were of insufficient energy to cause a more complete ionization and operate the T-R switch. These low energy pulses passed through the resonant aperture unattenuated.

Typically, the keepalive voltage electrode extended into the capsule and was in direct contact with the gas. Possible chemical reactions between the electrode metal and the ionized gas were a consideration in these prior art electrode discharges.

Another feature of prior art T-R switches was to employ an electronegative gas which rapidly "cleaned-up" the primer electrons. The halogen gases, chlorine in particular, are highly electronegative and provided excellent recovery times, as is shown in U.S. 3,208,012 entitled "Hollow Waveguide Discharge Switching Device Having a Capillary Tube Extending Through the Electrodes" by G. I. Klein.

Heretofore, halogen gas has not been employed in a T-R switch in conjunction with a keepalive voltage because the metallic surface of the keepalive electrode reacted chemically with the highly active halogen ions. The resulting rapid sputtering of the electrodes altered the pressure and contents of the gas, thus shortening the life of the T-R switch. Without the primer electrons provided by the primer or keepalive voltage, it is difficult to obtain

a constant reliable, first pulse breakdown of the discharge gas and the sensitive radar receiving circuits are not fully protected from the high energy transmitter pulses. Also, without priming, the leakage energy through the resonant aperture during discharge is not a low constant. Occasional high level leakage energy escaping through the resonant aperture is harmful to the receiving circuits.

SUMMARY OF THE INVENTION

Accordingly, it is a general object of this invention to provide an improved electron discharge device.

Another object of this invention is to provide a more reliable waveguide switching device having a relatively fast recovery time.

Another object of this invention is to provide a waveguide switching device which is electron primed by AC energy.

Another object of this invention is to provide a waveguide switching device in which chemical reactions are avoided between the discharge gas and the AC primer lead.

Another object of this invention is to provide a waveguide switching device in which direct contact between the discharge gas and the metallic surface of the primer lead is avoided.

Another object of this invention is to provide a truly electrodeless discharge in a waveguide switching device.

Another object of this invention is to provide first pulse breakdown of the discharge halogen gas in a pulsed waveguide switching device.

Another object of this invention is to provide a pulsed waveguide switching device employing a halogen gas and having a steady value of leakage energy during discharge.

Briefly, the present invention accomplishes these and other objects by providing a waveguide switching device having an insulative container of a readily ionized, electronegative gas traversing the discharge gap. The gas is primed with electrons by an AC energy source or oscillator. The incident pulses of RF energy from the transmitter ionize or breakdown the already primed gas establishing a low impedance path across the discharge gap. The presence of the priming electrons produced by the AC primer or igniter oscillator assist in initiating the main discharge. The source of AC igniter energy is capacitively coupled into the confined gas through capacitive plates or leads. The leads are external to the gas container or mechanically insulated from the gas. Fast recovery halogen gases may be employed because the leads are not in direct contact with the gas. Locating the igniter lead on the outside of the gas container and not in direct contact with the discharge gas avoids chemical reaction between the metallic lead and the highly reactive ionized gas. A steady supply of priming electrons provided by the igniter will yield a reliable first pulse breakdown of the discharge gas and will establish a constant low leakage energy for the switch.

BRIEF DESCRIPTION OF THE DRAWINGS

Further objects and advantages of the present invention will become apparent from the following detailed description taken in conjunction with the drawing, which is an enlarged sectional view of the present T-R switch including a partial sectional view of a waveguide, section looking in the direction of the longitudinal axis.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the figure, a hollow waveguide **10** is shown with resonant aperture **11** for directing or transmitting the incident of energy pulses to the switching device. Spaced upper and lower conductor cones or posts **12** and **14** protrude into the resonant aperture **11**. They

form microwave discharge gap **16**. The upper and lower cones are provided with aligned bores or apertures **18** and **20** respectively. An insulating capillary tube or elongated gas container **22** is inserted through the aligned bores **18** and **20**, and traverses the discharge gap **16**. A reservoir capsule or container **24** is formed at the upper end of the capillary tube **22** and is in fluid communication with the tube **22** through the open upper end **26** of the tube. In the embodiment shown, the reservoir **24** is outside of the waveguide **10**. The lower end of the tube **22** is closed by end member **28**.

A quantity of electronegative gas **30** is provided within the traversing container **22** and connected reservoir container **24**. At least one of the halogen gases, chlorine in particular, is preferred. The gas **30** may contain a discharge stabilizing ingredient such as oxygen. The desired gas pressure is a function of the frequency of operation, and in the embodiment shown may vary from 2 to 50 torr. The gas **30** when ionized forms a low impedance path between conducting cones **12** and **14** across the discharge gap **16** and effectually detunes the resonant aperture **11**.

The gas **30** is primed with electrons by AC igniter energy from an oscillator **32**. The igniter energy is capacitively coupled into the gas **30** through capacitive plate or lead **34** which in the embodiment shown abuts the outside upper surface of the reservoir container **24** in a depressed region **36** located directly above the open end **26** of the traversing capillary tube **22**. In order to avoid contact with the gas **30**, the plate **34** must be external to the region enclosed by the containers **22** and **24**. It may be external to the container itself as shown, or the plate **34** may be embedded within the container material. The other side of the capacitive coupling is formed by portion **38** of the waveguide **10** appropriately spaced from plate **34** and including the area proximate the upper bore **18** immediately below the reservoir chamber **24**.

The AC igniter energy establishes a priming discharge between the spaced coupling capacitor plates **34** and **38** proximate the open end **26** of traversing tube **22**. Primer electrons from this discharge diffuse into the traversing tube **22** into the region of the discharge gap **16**. The primer electrons present in the discharge gap **16** when subjected to the energy of the incident RF pulse initiate the main breakdown of the gas **30** and cause a low impedance discharge path across the cones **12** and **14**. The depressed region **36** in the reservoir **24** reduces the diffusion distance of the primer electrons and increases the electron concentration in the discharge gap **16**. This electron concentration is also dependent upon the magnitude of the AC igniter voltage.

In operation, pulses of incident RF energy from the radar transmitter in conjunction with the primer electrons in the discharge gap **16** establish the main discharge or breakdown operation which detunes the resonant aperture **11**. The energy from the transmitter is higher than a predetermined energy level required to operate the switch. These higher energy pulses are substantially attenuated by the low impedance discharge and resultant detuning of the resonant aperture **11**. During normal operation, the low energy target pulses pass through the switch substantially unattenuated.

Referring again to the figure, it will be noted that in the embodiment shown, the upper con **12** is shorter than the lower cone **14**. The purpose of the asymmetry in the cone dimensions is to asymmetrically position the discharge gap **16** closer to the priming discharge established between the spaced capacitor plates **34** and **38**. The result of the asymmetrical positioning is to reduce the diffusion distance of the priming electrons, as was described in connection with the depressed region **36** of the reservoir **24**. The upper cone **12** may be completely eliminated in order to minimize the diffusion distance and increase the concentration of priming electrons proximate the

discharge gap **16**. The length of the upper cone **12** in the embodiment shown is 0.019 inch and the lower cone **14** is 0.495 inch. These dimensions provide a "Q" of about five for the resonant aperture **11**.

The AC oscillator frequency in this specific embodiment is 13 megahertz; but may be selected from a wide range of frequencies. Preferably, the oscillator frequency should not be a submultiple of the radar transmission frequency which in this embodiment is 30 megahertz. The voltage of the AC igniter energy in this embodiment is 1400 RMS volts and will cause the T-R switch to operate at the predetermined threshold power of approximately 0.7 watt. The igniter voltage may be varied over a range of from about 1000 to about 2000 volts RMS to establish a threshold power of from about 0.8 watt to about 0.5 watt, respectively.

The oscillator energy may be applied continuously to the gas, or it may be periodically interrupted at the transmitter pulse repetition rate and applied only when incident RF pulses approach the T-R switch. Under interrupter operations, a higher AC priming voltage may be applied across the gas and the resulting attenuation of the incident RF pulses is greater.

While the present invention has been described with a degree of particularity for the purpose of illustration, it is ot be understood that all modifications, alterations, or substitutions within the spirit and scope of the present invention are herein meant to be included. For example, while the switching device has been illustrated in an upright position, it is to be understood that the switch is operable in any position. A hollow waveguide was shown in the embodiment illustrated, however, any suitable transmission device may be employed.

Hence it is readily apparent that the present invention will provide an improved, waveguide switching device. The halogen discharge gas effects a fast recovery time. The AC igniter energy provides an increased reliability and insures first pulse breakdown by generating the required concentration of electrons in the discharge gap. Chemical reactions with the highly reactive halogens are avoided by locating the igniter lead or plate on the outside of the gas container. The elimination of direct contact with the gas provides a truly electrodeless discharge.

We claim as our invention:

1. A wave transmission switching device responsive to incident radio frequency energy above a predetermined power level for substantially preventing the incident energy from passing therethrough, but permitting incident radio frequency energy of less than the predetermined power level to pass therethrough substantially unattenuated, the switching device comprising:
   - a section of wave transmission means for directing the incident radio frequency energy to said switching device;
   - a pair of conductor means protruding transversely of said transmission means and dimensioned to form a discharge gap across said wave transmission means;
   - an insulating container extending across said discharge gap;
   - means for providing a readily ionizable gas proximate the discharge gap; and
   - capacitive lead means external to and insulated from said gas in said container for applying an AC igniter voltage to the gas to weakly ionize the gas and provide electrons proximate the discharge gap, which electrons in conjunction with the incident radio frequency energy above the predetermined power level cause substantial ionization in the gas proximate the discharge gap which substantially prevents the passage of the incident radio frequency energy, the concentration of electrons and the configuration of the conducting means predetermining the power level of incident radio frequency energy to which the switching device is responsive.

2. The wave transmission switching device as specified

in claim 1, wherein the conductor means is asymmetrically dimensioned to position the discharge gap asymmetrically with respect to the axis of said section and proximate to said igniter voltage applying means.

3. The wave transmission switching device as specified in claim 1, wherein a reservoir containing means for containing additional gas is provided in fluid communication with said insulating container.

4. The wave transmission switching device as specified in claim 1, wherein there is a reservoir in fluid communication with said container positioned outside of said section.

5. The wave transmission switching device as specified in claim 1, wherein the readily ionized gas is electronegative.

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HERMAN KARL SAALBACH, Primary Examiner
M. NUSSBAUM, Assistant Examiner

U.S. Cl. X.R.

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