March 28, 1967 M. GILLER 3,311,852

HIGH FREQUENCY EXTERNALLY PULSED SWITCH TUBE

Filed Nov. 12, 1964 2 Sheets-Sheet 1

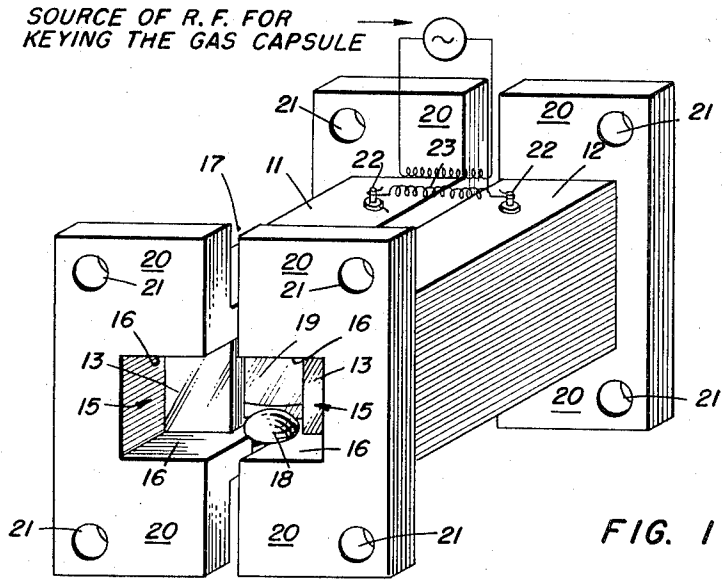


FIG. 1

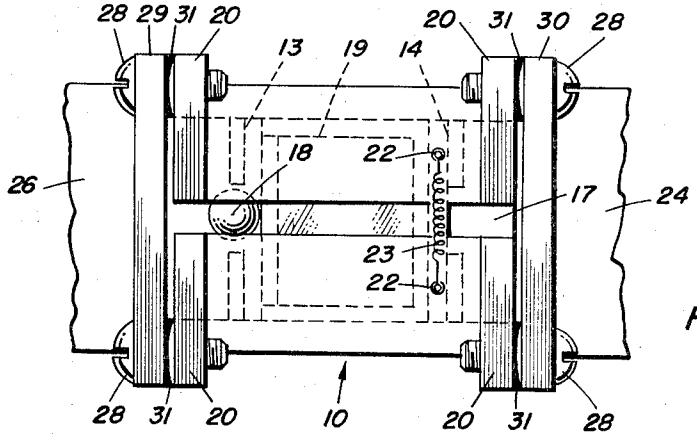


FIG. 3

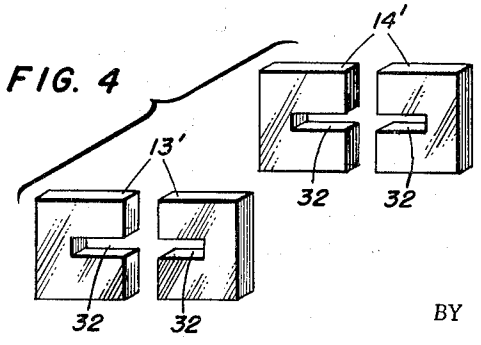


FIG. 4

INVENTOR
MORRIS GILLER

BY Claude Funkhouser
ATTORNEY

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HIGH FREQUENCY EXTERNALLY PULSED SWITCH TUBE

Filed Nov. 12, 1964 2 Sheets-Sheet 2

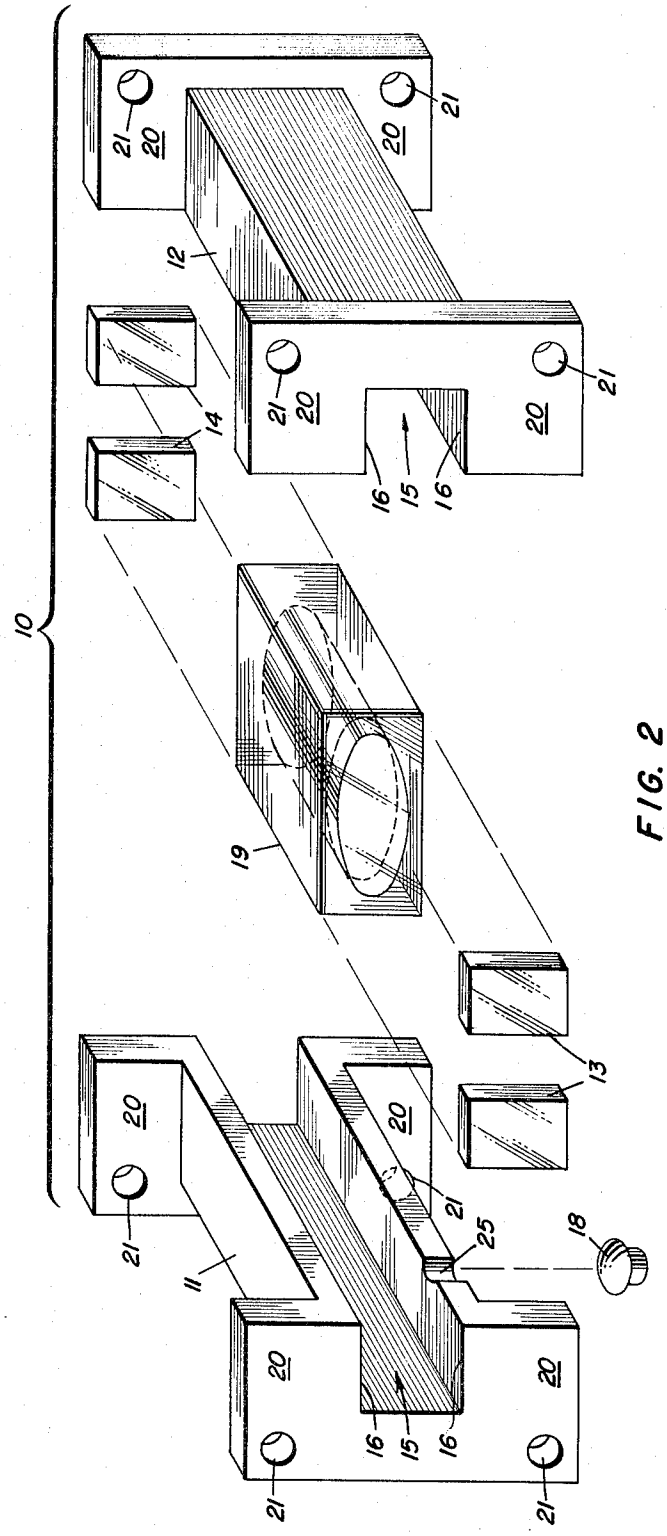


FIG. 2

United States Patent Office 3,311,852 Patented Mar. 28, 1967

3,311,852

HIGH FREQUENCY EXTERNALLY PULSED SWITCH TUBE

Morris Giller, Baltimore County, Md., assignor, by mesne assignments, to the United States of America as represented by the Secretary of the Navy

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9 Claims. (Cl. 333—13)

The present invention relates to microwave switching tubes and more particularly so externally pulsed microwave switching tubes using a halogen gas fill.

Switching tubes comprised of gas filled capsules find utility in situations requiring rapid repetition rate, high duty cycles of the order of 50 percent, rapid recovery, and low spike leakage power. In particular, tubes using a chlorine gas fill are capable of being switched from the unblocked to the blocked state in less than one-half microsecond and being returned to the unblocked state in approximately one-half microsecond. Similar tubes employing gases other than chlorine are capable of ionization, i.e., switching to the blocked state, in times comparable to chlorine filled tubes, but deionization times of the order of one-half microsecond have not been achieved.

Use of chlorine filled tubes, however, presents a problem of corrosion of electrodes exposed to the gas. Use of external electrodes can overcome the corrosion problem but requires careful placement of the electrodes for maximum coupling of the switching energy to the gas in order to reduce the power required.

It is an object of this invention to provide a halogen filled, externally pulsed, microwave switching tube.

It is a further object of this invention to provide a microwave switching tube wherein the switching times from the blocked to the unblocked condition and from the unblocked to the blocked condition are of the same order of magnitude.

It is a further object of this invention to provide a chlorine filled microwave switching tube characterized by a deionization time of approximately one-half microsecond.

The present device accomplishes the above objects by the use of a split waveguide segment as the electrodes to couple switching energy to the gas without causing any perturbation of the current distribution to be switched.

The exact nature of this invention as well as other objects and advantages thereof will be readily apparent from consideration of the following specification related to the annexed drawing in which:

FIG. 1 is an isometric view of the switching tube of the present invention;

FIG. 2 is an exploded view of the switch tube of FIG. 1;

FIG. 3 is a top view of the switching tube of the present invention showing its connection between two adjacent waveguides; and

FIG. 4 is an alternative construction for one of the elements shown in FIG. 2.

Referring now to FIG. 1, switch **10** is seen to comprise a segment of waveguide split into two sections **11** and **12** which are symmetrical about a longitudinal axis taken through the center of the waveguide bore. Within each of the split sections is placed a metallic insert **13**, preferably comprised of the same material as the waveguide itself, and attached to the waveguide in any suitable manner. As may be seen from FIG. 1, inserts **13** extend the full distance between the split walls **15** but do not extend the full distance from the unsplit walls **16** to the split **17** itself, thereby providing a window normal to and symmetrical about the longitudinal axis of the waveguide bore but of substantially smaller area than the waveguide cross sectional area.

If necessary, a further metallic insert **18** may be arranged to protrude into the waveguide interior.

Behind inserts **13** is located a gas-containing capsule **19** whose cross sectional area is substantially equal to that of the interior of the waveguide.

Behind gas containing capsule **19** may be placed a second pair of metallic inserts **14** which are of the same size and configuration as metallic elements **13**.

Waveguide sections **11** and **12** are provided with cover flanges **20** having holes **21** drilled therein to facilitate attachment of the switch to adjacent waveguide sections.

A terminal post **22** may be attached to each of waveguide sections **11** and **12**. If necessary, a matching inductance **23** may be attached between the two waveguide sections. Additionally, radio frequency switching energy will be applied at these terminals by means of a source R.F. for keying the gas capsule.

When switch **10** is assembled and placed between two adjacent waveguides, it is advantageous that the width of the slot **17** be approximately equal to the thickness of the waveguide wall **24**. In a manner analogous to the well known slotted line, proper choice of the slot dimension will assure that substantially no perturbations in the microwave current distribution within the waveguide will occur, and therefore that very little energy is coupled through the slot into space.

FIG. 2 shows the internal arrangement of switch **10** in more detail. Gas capsule **19** is disposed between window pairs **13** and **14** within the two waveguide sections. Gas capsule **19** may comprise any suitable material transparent at microwave frequencies containing therein a sealable cavity in which the gas may be contained at a suitable low pressure. The capsule may be comprised of quartz, glass, or the like. The capsule is of such size as to fit snugly within the interior of the cavity defined by the two sections of waveguide **11** and **12**.

Capsule **19** and window pairs **13** and **14**, located in front of and behind the capsule, respectively, define a resonant cavity within the two waveguide sections. The placement of window pairs **13** and **14** within the waveguide, and the relative distance therebetween, will determine both the resonant frequency and the bandwidth of the resonant cavity. Additionally, a protruding metallic member **18** may be inserted in front of window pair **13** for the purpose of further controlling the resonant characteristics of the cavity. Member **18** is insulated from at least one of the waveguide sections **11** or **12** in any suitable manner such as by a cutout portion **25** in waveguide section **11** or by means of some suitable insulating sleeve attached to member **18**.

FIG. 3 shows the manner in which the microwave switch of the present invention may be connected between adjacent sections of waveguide. As may be seen, switch **10** is connected to waveguides **26** and **27** by means of four insulating screws **28**. Waveguide sections **26** and **27** may advantageously include choke flanges **29** and **30**, respectively, to prevent flow of current across the joint and thereby limit coupling out into space to microwave energy from the waveguide. As indicated, at microwave frequencies, sections **11** and **12** of the split waveguide appear as a continuous unsplit segment and contribute negligible voltage standing wave ratio and insertion loss.

In order to prevent flanges **29** and **30** from short circuiting the waveguide sections **11** and **12** at the switching frequency, spacers **31** are provided between the flanges. Both the spacers **31** and the screws **28** may be comprised of an insulating material such as Teflon or the like. A suitable radio frequency transmission line by which external pulses are provided to the switch tube are connected to the waveguide sections **11** and **12** by means of terminals **22**. At the switching frequency, the two wave-

guide sections **11** and **12**, being isolated from each other, may act as electrodes to couple switching energy to the gas capsule **19** thereby ionizing it without direct contact with the corrosive gas. The high power microwave energy will further ionize the gas producing the required high attenuation.

Projecting element **18** may be placed in front of window pair **13** to increase the bandwidth of the resonant cavity defined by window pairs **13** and **14**. Since member **18** contacts at most only one section of the waveguide at the switching frequencies, it does not provide a short circuit for the switching energy. However, at the microwave frequency, for the same reason that the split waveguide appears to be a continuous section, projecting member **18** also appears to be simply an extension of a continuous waveguide segment.

FIG. 4 shows another possible configuration which may be used to define the resonant cavity. It comprises metallic inserts **13'** and **14'** which serve as window pairs. Each insert is equal in height to the distance between the unsplit walls of the waveguide section and extends up to but not into the slit between the assembled waveguide sections. Each insert has a notch **32** therein which permits the passage therethrough of microwave energy. Again, at the switching frequency the inserts **12'** and **14'** appear to be part of the two separate electrodes but at the microwave frequency appear as a continuous section with a notch for passage of energy.

Obviously, many other modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A microwave switch comprising

a segment of waveguide, longitudinally split to provide symmetrical sections,

window means within the waveguide defining a resonant cavity,

retaining means within the cavity to retain an ionizable medium therein, through which microwave energy may pass when the medium is in its unionized state, and through which microwave energy may not pass when the medium is in its ionized state, and

terminal means connected to the two symmetrical waveguide sections to supply radio frequency energy thereto to initiate ionization of the medium within the retaining means.

2. A microwave switch comprising a waveguide segment having two open ends,

the waveguide being comprised of two distinct sections electrically isolated from each other at radio frequencies but electrically continuous at microwave frequencies,

means to provide microwave energy at one end of the waveguide segment,

means to receive microwave energy at the other end of the waveguide segment,

switching means contained within the waveguide segment having two states of conductivity with respect to passage therethrough of microwave energy,

means to provide a radio frequency potential difference between the two distinct sections of waveguide segment whereby the presence of a potential difference will cause the switching means to assume one state of conductivity and block passage of microwave energy through the waveguide, and the absence of a potential difference will cause the switching means to assume a second state of conductivity to permit the passage of microwave energy through the waveguide.

3. A microwave switch comprising

a segment of rectangular waveguide having two pairs of parallel walls and having at the ends thereof cover flanges adapted for attachment to adjacent waveguides,

each wall of one of the pairs of parallel walls and the cover flanges being longitudinally split to divide the waveguide segments into two separate sections,

each of the sections containing a pair of metallic inserts in parallel spaced relation,

the plane of each insert being normal to the longitudinal axis of the waveguide,

each of said inserts being equal in height to the distance between the split parallel walls, and extending from the unsplit wall toward the longitudinal split,

an enclosed capsule containing an ionizable gas, arranged to fit snugly within the cavity defined by the two pairs of metallic inserts and the two pairs of parallel walls, and

electrical terminals on each of the waveguide sections to which may be applied a radio frequency potential difference for ionizing the gas within the enclosed capsule.

4. The microwave switch of claim **3** in which the outside dimensions of the assembled switch are equal to the dimensions of a similar unsplit waveguide segment, and

wherein the width of the split is substantially equal to the thickness of the waveguide wall.

5. The microwave switch of claim **4** further including a metallic projection extending into the waveguide bore and electrically isolated from at least one of the waveguide sections.

6. The microwave switch of claim **5** wherein each of the metallic inserts is rectangular in shape and extends a portion only of the distance from the unsplit wall to the longitudinal split.

7. The microwave switch of claim **5** wherein each of the metallic inserts is generally rectangular in shape and extends the entire distance from the unsplit wall up to the longitudinal split between the waveguide sections and wherein

each insert has therein a transverse notch extending part of the distance from the split between the waveguide to the unsplit walls.

8. A microwave transmission system including the microwave switch in claim **3**, and

first and second rectangular waveguides, each having at one end thereof a choke flange attached to one of the cover flanges of the microwave switch.

9. The microwave transmission system of claim **8** further including

spacer means inserted between each choke flange and cover flange to prevent metal to metal contact of the rectangular waveguides with the microwave switch,

whereby at microwave frequencies the two rectangular waveguides and the microwave switch appear as a single continuous waveguide, but at radio frequencies, the two rectangular waveguides and the two sections of the waveguide segment are mutually electrically isolated.

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ELI LIEBERMAN, *Primary Examiner.*

M. NUSSBAUM, *Assistant Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,311,852 March 28, 1967

Morris Giller

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 36, after "provide" insert -- two --.

Signed and sealed this 28th day of November 1967.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents