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WAVEGUIDE SWITCH

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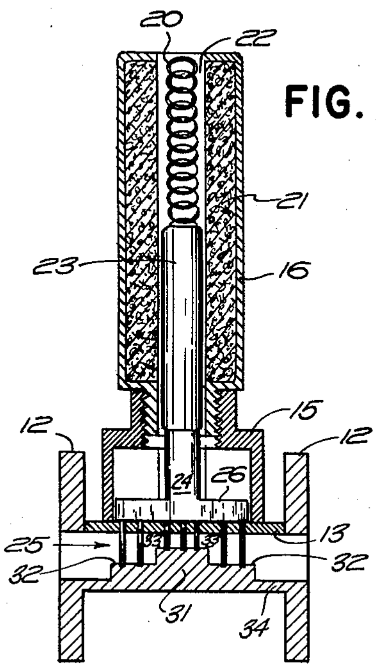


FIG. 2A

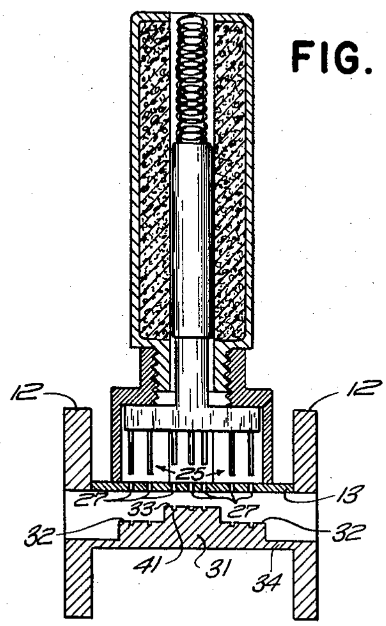


FIG. 2B

FIG. 3A

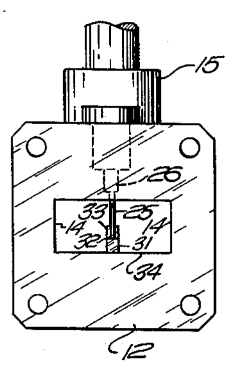
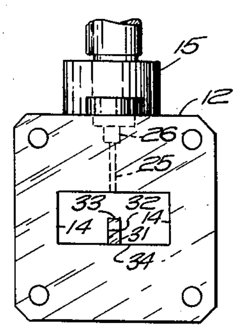


FIG. 3B



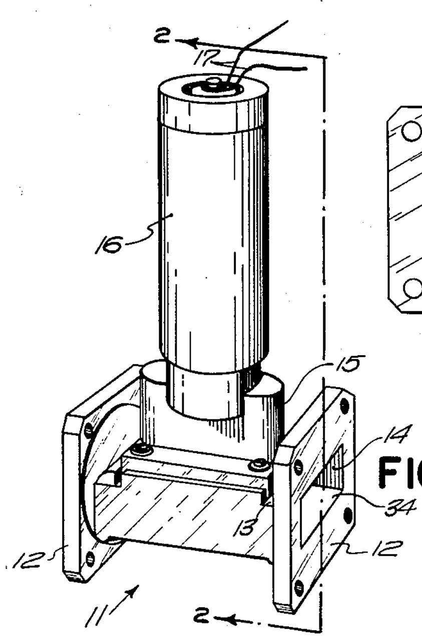


FIG. I

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WAVEGUIDE SWITCH

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5 Claims. (Cl. 333—98)

The present invention relates in general to microwave switches and more particularly concerns a novel waveguide switch for selectively controlling the flow of microwave energy through a waveguide while minimizing impedance mismatch caused by its insertion into a wave transmission system.

Where a number of radar sets are operated in close proximity, energy transmitted by an active set is sometimes received by a nearby inactive set. The received power is often so great that the mixer crystal of the inactive set is burned out, the T-R tube of the inactive set then being disabled. To alleviate this difficulty, it has been suggested that a shorting plate be positioned between the antenna and mixer when the set is inactive. However, a slot in a waveguide wall permitting the projection and withdrawal of a shorting stub seriously interferes with the impedance properties of the waveguide. Due to mismatches, the overall system sensitivity is appreciably reduced.

The present invention contemplates and has as a primary object the provision of a waveguide switch for selectively controlling the flow of microwave energy through the waveguide without appreciably disturbing its impedance characteristics in the open position.

According to the invention, the electric field within the waveguide is selectively shorted by the extension through small openings in the waveguide wall, of a plurality of coplanar, thin conducting rods aligned parallel to the electric field. The spacing between openings and rods is large compared to the cross-sectional dimensions of either. As a result, these openings cause virtually no interference with the charge distribution along the waveguide wall with the switch in the open position.

A feature of the invention resides in locating an impedance matching element within the waveguide opposite the openings. This reduces the distance traveled by the rods during switching and, consequently, the switching time. Yet, the open switch causes negligible effect on the waveguide impedance characteristics.

Other features, objects and advantages of the invention will become apparent from the following specification when read in connection with the accompanying drawing in which:

Fig. 1 is a perspective view of a short waveguide section having a solenoid-actuated waveguide switch arranged according to the invention;

Fig. 2A is a cross-sectional view of the waveguide switch taken along plane 2—2 of Fig. 1, illustrating the switch in the closed position;

Fig. 2B is the same view as Fig. 2A, but with the switch open;

Fig. 3A is a fragmentary end view of the waveguide switch, showing the switch in closed position; and

Fig. 3B is the same view as Fig. 3A, but with the switch open.

With reference now to the drawing and more particularly Fig. 1 thereof, there is illustrated a perspective view of a solenoid-operated waveguide switching section. The

waveguide section **11** has end flanges **12** adapted for attachment to other waveguide sections by means of choke joints or other suitable well known coupling means. The top wide wall **13** is perpendicular to both narrow walls **14** and supports a lower housing **15** of the switch actuating mechanism. An upper cylindrical housing **16**, attached to lower housing **15**, encloses a solenoid energized through leads **17**.

Additional structural details are better seen by referring to the sectional view of Fig. 2 which exposes the actuating mechanism. The solenoid **21** surrounds a cylindrical cavity **22**, which in turn accommodates compression spring **20** and magnetic plunger **23**. Thin coplanar, cylindrical rods **25** are rigidly suspended like the tines of a fork from a support **26**, the latter being attached to the lower end of plunger **23** by an extension **24**. As plunger **23** is displaced within the cavity **22**, rods **25** slide through openings **27** in the top wide wall **13**. Their downward travel is limited by a conducting plate **31** formed with steps **32** and **33** symmetrically disposed about its midpoint, and a plurality of appropriately spaced receiving openings **41**.

Conducting plate **31** is in surface contact with lower wide wall **34** and is centrally disposed between and parallel to narrow walls **14**. The length of each of the two end steps, measured along the guide, is approximately a quarter of the wavelength of microwave energy normally propagated in the waveguide system into which the switch is coupled. The steps are so positioned that cancellation of reflections is effected over a relatively wide frequency band when the switch is open. For a discussion of suitable design techniques, reference is made to a paper by Henry J. Riblet entitled General Synthesis of Quarter-Wave Impedance Transformers at page 36 of the "IRE Transactions on Microwave Theory and Techniques" for January 1957, and more specifically, to the first full paragraph on Page 40.

Figs. 2B and 3B, show the switch open with rods **25** fully withdrawn from the inside of the waveguide, and section **11** transmits energy between adjacently connected waveguide sections without mismatch.

Figs. 2A and 3A show the switch closed with the rods **25** in contact with conducting plate **31**. In this position energy is not transferred through section **11** but instead is substantially all reflected. As a practical matter, it has been observed that the rods **25** need not contact plate **31**. In fact, better isolation has been obtained by locating the rods with their ends separated from plate **31** by a narrow air gap.

In a representative application of the novel switch section between an antenna and a receiver mixer crystal, the downward pressure on stem **23** exerted by spring **20** forces rods **25** into the waveguide section when solenoid **21** is deenergized. The rods **25** are withdrawn when solenoid **21** is energized. This is especially advantageous since leads **17** may be connected so that solenoid **21** is energized and deenergized when the associated radar set is turned on and off, respectively. Should the radar lose power, whereby the T-R tube becomes inoperative, spring **20** would immediately close the switch to protect the mixer crystal.

When the switch is closed with rods **25** down, section **11** is effectively divided into two adjacent, parallel waveguide sections characterized by cutoff frequencies above the frequency of the incident microwave energy. This creates a severe mismatch and virtually all the incident microwave energy is reflected.

When the switch is opened by withdrawing rods **25** from the interior of section **11**, the stepped plate **31** prevents mismatch. This occurs because reflections from the vertical edges of each of the two steps, separated as they are by substantially a quarter of a wavelength, are wholly cancelled.

A compact fast-operating waveguide switch has been described for selectively isolating microwave circuits while minimizing impedance mismatches. An X band switch constructed as shown and described exhibits a VSWR of less than 1.1 over the band from 8500 mc. to 9600 mc. with the switch open.

Numerous modifications of and departures from the specific embodiment described herein may be practiced by those skilled in the art without departing from the inventive concepts. Consequently, the invention is to be construed as limited only by the spirit and scope of the appended claims.

What is claimed is:

1. A microwave switch comprising, a waveguide section capable of propagating microwave energy having a transverse electric field, said waveguide section having an outer conducting wall formed with a plurality of small openings on a line parallel to the waveguide section axis and separated by a distance greater than the dimension along said line of any one of said openings, and an oppositely disposed conducting wall having a thin inwardly extending conductive plate, the inner edge of said conductive plate being arranged oppositely of and parallel to said line of small openings, a plurality of conducting rods normally positioned within said waveguide in engagement with said inner edge of said conductive plate and parallel to the direction of said electric field in a plane along said axis, said plane effectively dividing the internal volume of said waveguide into adjacent waveguide sections having cutoff frequencies above the frequency of said microwave energy, and means for selectively displacing said rods through respective ones of said openings between said position within and a position without said waveguide section, said conductive plate being arranged to minimize attenuation of said microwave energy with said rods displaced to said position without said waveguide.

2. A microwave switch comprising, a rectangular waveguide having a pair of parallel wide walls perpendicular to a pair of parallel narrow walls, a first of said wide walls formed with a plurality of small openings along a line perpendicularly bisecting the width of said first wall, said openings being separated by a distance greater than the dimension along said line of any one of said openings, an impedance matching element formed of a conducting plate in contact with the second of said wide walls and spaced from said first wide wall, said plate being in a plane parallel to said narrow walls and including said openings, a plurality of conducting rods adapted to reside within said waveguide parallel to said narrow walls in the space between said plate and said openings, and means for selectively displacing said rods through respective ones of said openings between a position within said space and a position outside said waveguide.

3. Apparatus in accordance with claim 2 wherein said conducting plate is formed with at least one pair of steps separated along the axis of said waveguide, each step being approximately one-quarter wavelength long measured along the axis of said waveguide.

4. Apparatus in accordance with claim 2 and further comprising, a plunger carrying a support member, said rods extending from said support member, said support member being parallel to said wide walls, a solenoid surrounding said plunger, and resilient means for forcing said support member against said first wide wall.

5. A microwave switch comprising, a waveguide section for normally propagating microwave energy having a transverse electric field, a thin conducting plate disposed within said section along the direction of normal energy propagation and parallel to said electric field, a plurality of thin conducting rods adapted to reside within said waveguide in the plane including said conducting plate, thereby effectively dividing said section into adjacent waveguides having cutoff frequencies above the frequency of said normally propagated microwave energy, and means for selectively displacing said rods between said position within and a position outside said waveguide section, said conducting plate including means for preventing impedance mismatch with respect to incident energy at said normally propagated microwave frequency when said switch is open.

References Cited in the file of this patent

UNITED STATES PATENTS

2,362,561	Katzin	Nov. 14, 1944
2,558,664	Pease	June 26, 1951
2,588,262	Matare	Mar. 4, 1952
2,734,171	Heins	Feb. 7, 1956
2,804,599	Broussaud	Aug. 27, 1957
2,876,423	Lasho	Mar. 3, 1959

OTHER REFERENCES

Bollinger et al.: Abstract of application Serial No. 694,044, published November 21, 1951, 640 O.G. 1032.