

Aug. 19, 1958

J. T. FRASER

2,848,688

MICROWAVE SWITCHING CIRCUIT

Filed April 9, 1956

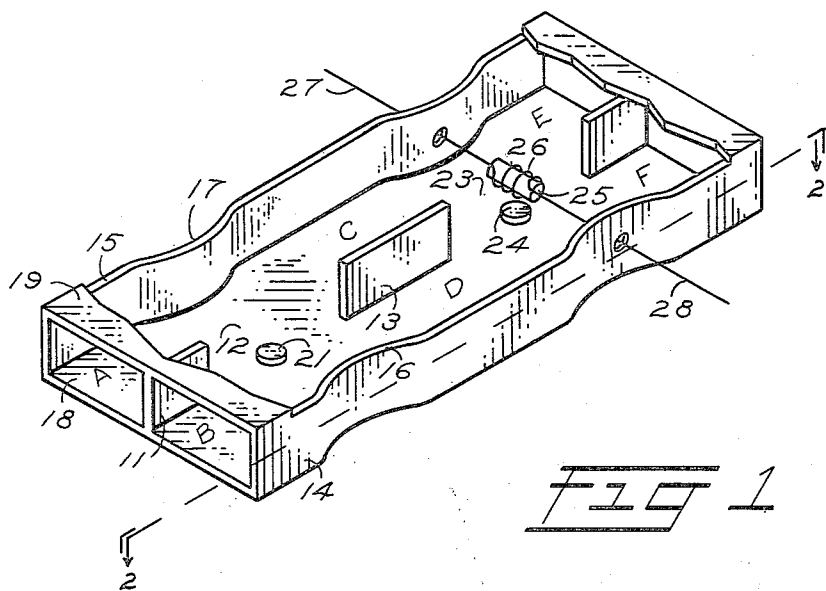


FIG 1

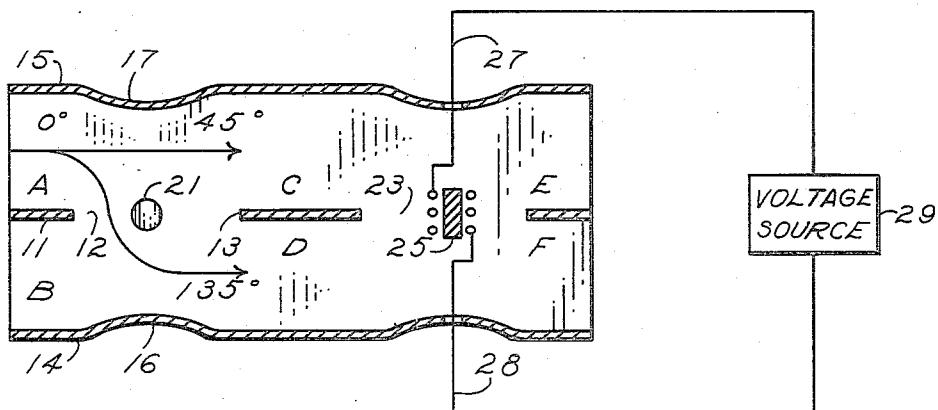


FIG 2

INVENTOR.
JULIUS T. FRASER
BY *H. A. Machef*
ATTORNEY

1

2,848,688

MICROWAVE SWITCHING CIRCUIT

Julius T. Fraser, Ossining, N. Y., assignor to General Precision Laboratory Incorporated, a corporation of New York

Application April 9, 1956, Serial No. 577,022

5 Claims. (Cl. 333—7)

This invention relates to apparatus for switching microwave energy from one to another transmission path.

In the past there have been known microwave switching devices which depend for their action upon the ionization of gases under low pressure. Such switches are usually arranged to be actuated by the presence of a predetermined power level within the waveguide and, although this kind of actuation is suitable for some purposes, it is frequently desirable to switch the wave energy regardless of the amount of power being transmitted. To meet this need, switches involving the movement of mechanical elements have been devised but these are inherently slow in operation, the speed being limited by the inertia of the moving parts.

An object of this invention is to provide a microwave switch which can divert power from one path to another regardless of the power level.

Another object is to provide a microwave switch which can be actuated rapidly.

Another object is to provide a microwave switch without moving parts.

Another object is to provide a microwave switch which is compact.

In accordance with the invention, two "short slot" hybrid junctions are axially aligned. In to the coupling space in one of the hybrid junctions is placed an element which is active in the Faraday magneto optical sense. A magnetic field is applied to this element and variation in its strength and direction causes a corresponding variation in the division of power between the two output arms.

For a clearer understanding of the invention reference may be made to the following detailed description and the accompanying drawing in which:

Figure 1 is an isometric view of a preferred embodiment of the invention; and

Figure 2 is a horizontal cross sectional view taken on the plane 2—2 of Figure 1.

Referring now to the drawing, there is shown a structure comprising basically two standard rectangular waveguides arranged side by side and having a common narrow wall or side 11. A portion of the common wall is cut away to form a coupling space 12 within the structure, beyond which the wall reappears as shown at 13. Thus there are defined four waveguide arms A, B, C and D. In the region of the coupling space 12 the outer narrow walls 14 and 15 are drawn slightly toward each other as shown somewhat exaggerated at 16 and 17. Each broad side 18 and 19 has a small protuberance, one of which is shown at 21, in the center of the coupling space to aid in matching the discontinuity.

The apparatus so far described has come to be called a short slot hybrid junction and has the property that if microwave energy be introduced into the arm A, it will divide at the coupling space 12 and equal amounts will appear in arms C and D while no energy will appear in arm B. The energy in arm C will, however, be advanced in phase by 45° relative to the phase it would have had

2

in the absence of the coupling space 12, while the energy in arm D will be advanced in phase by 135° with respect to its original phase. The junction is symmetrical and a similar division of energy would take place if microwave energy were introduced into any other arm. This hybrid junction per se has been described in the literature and is not the subject of the present invention. For further details reference may be made to an article by Henry J. Riblet entitled "The Short Slot Hybrid Junction," published in the Proceedings of the I. R. E., volume 40, No. 2, February 1952, page 180, and to an article by Harold Heins entitled "Radar Duplexer Uses Dual TR Tubes," published in "Electronics" for August 1954, page 149.

Referring again to the drawing, the common wall 13 is continued along the axis of the structure for a short distance and then is again cut away so as to form another coupling space 23 which space, together with the remaining walls, defines a second short slot hybrid junction having arms, C, D, E and F. As before, the outer narrow walls are drawn together slightly and two protuberances, one of which is shown at 24, are provided on the broad faces of the structure. In approximately the geometric center of the coupling space 23 there is placed a small rod 25 of a material which is active in the Faraday magneto optical sense. Such materials include polyirons and ferrites and are often referred to simply as ferrites and will be so designated in the present specification and claims. These materials, and their polarization rotation capabilities, are more fully described in the Luhrs and Tull Patent No. 2,644,930, issued July 7, 1953.

The rod 25 must be supplied with a magnetic field and this field may be obtained by various arrangements of coils or permanent magnets within or without the waveguide but for illustrative purposes is shown as being obtained from a coil 26 wound directly around the rod 25. The leads 27 and 28 support the coil 26 and rod 25 and pass through holes in the walls 14 and 15. The leads are connected to a source of voltage 29.

In the absence of the rod 25 and coil 26, the wave energy in arm C would divide equally between arms E and F, the energy passing to arm E being shifted in phase an additional 45° or a total of 90°, while the energy passing to arm F would be shifted an additional 135° or a total of 180°. The energy in arm D would also divide equally between arms E and F, the portion passing to arm E being shifted an additional 135° or a total of 270° while that appearing in arm F would be shifted an additional 45° or a total of 180°. The two components entering arm E would thus cancel since they would be of equal amplitude but opposite phase while the two components entering arm F would be in phase with each other and therefore additive. In other words, all of the power would appear in arm F, none of it appearing in arm E.

Applicant has discovered that the presence of the rod 25 and coil 26 without any current flowing in the coil 26 upsets the balance of the junction so that power appears in both arms E and F. Application of a D. C. voltage of one polarity to the conductors 27 and 28 causes the power in arm E to increase while the power in arm F decreases. Reversal of the polarity causes the opposite effect, that is, the power in arm F increases while the power in arm E decreases.

The exact nature of the fields existing in the region of the coupling space 23 with the rod 25 magnetized is not fully understood. It is believed, however, that the polarization rotation caused by the ferrite rod 25 interacts with the complex modes introduced by the coupling space 23 to cause a resulting overall phase shift the magnitude of which depends upon the magnitude and polarity of the magnetic field passing through the rod 25. What-

3

ever the explanation, tests show that the division of power between arms E and F can be controlled simply by adjusting the polarity and magnitude of the current through the magnetizing coil 26.

It is thus seen that applicant has provided apparatus for diverting microwave power from one arm to another regardless of whether the power level is low or high. The inductance of the small ferrite rod 25 and the small coil 26 are small enough that a rapid switching action may be obtained by exciting the coil with alternating current.

What is claimed is:

1. A microwave switch comprising two collinear waveguide short slot hybrid junctions axially aligned, each of said junctions including a coupling space, a ferrite element in the coupling space in one of said junctions, and means for applying a magnetic field to said element perpendicular to the narrow waveguide walls.

2. A microwave switch comprising two waveguide short slot hybrid junctions axially aligned, each of said junctions including a coupling space, a ferrite element occupying a portion of the coupling space of one of said junctions, and means for applying a magnetic field to said element perpendicular to the narrow waveguide walls.

3. A microwave switch comprising, two waveguide short slot hybrid junctions axially aligned, each of said junctions including a coupling space, a ferrite element positioned approximately in the center of the coupling space of one of said junctions, a coil wound around said element, the axis of said coil being perpendicular to the narrow waveguide walls, and a source of voltage connected to said coil.

4. A microwave switch comprising, two collinear wave-

4

guide short slot hybrid junctions, each of said junctions including a coupling space, an element active in the Faraday magneto optical sense positioned in approximately the geometric center of the coupling space of one of said junctions, a coil wound around said element and having its axis substantially parallel to the broad waveguide walls and perpendicular to the narrow waveguide walls, and a voltage source connected to said coil.

5. A microwave switch comprising, a pair of rectangular waveguides having a common narrow wall, two intermediate portions of said common wall being cut away thereby forming two coupling spaces in which microwave energy in said waveguides may interact, an element active in the Faraday magneto optical sense positioned in approximately the geometric center of one of said coupling spaces, a coil wound around said element and having its axis substantially parallel to the broad waveguide walls and perpendicular to the narrow waveguide walls, two conductors connected respectively to opposite ends of said coil and extending through holes in opposite outer narrow walls of said waveguides, and a source of voltage connected to said conductors.

References Cited in the file of this patent

UNITED STATES PATENTS

2,679,631	Korman	May 25, 1954
2,728,050	Van de Lindt	Dec. 20, 1955
2,745,069	Hewitt	May 8, 1956
2,798,205	Hogan	July 2, 1957

FOREIGN PATENTS

980,648	France	Dec. 27, 1950
---------	--------	---------------