May 13, 1952 J. F. ZALESKI 2,596,458

WAVE GUIDE STUB

Filed April 23, 1949 2 SHEETS—SHEET 1

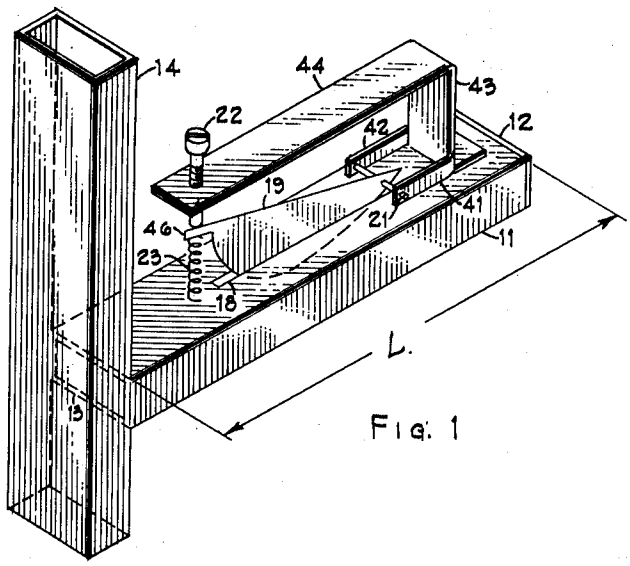


FIG. 1

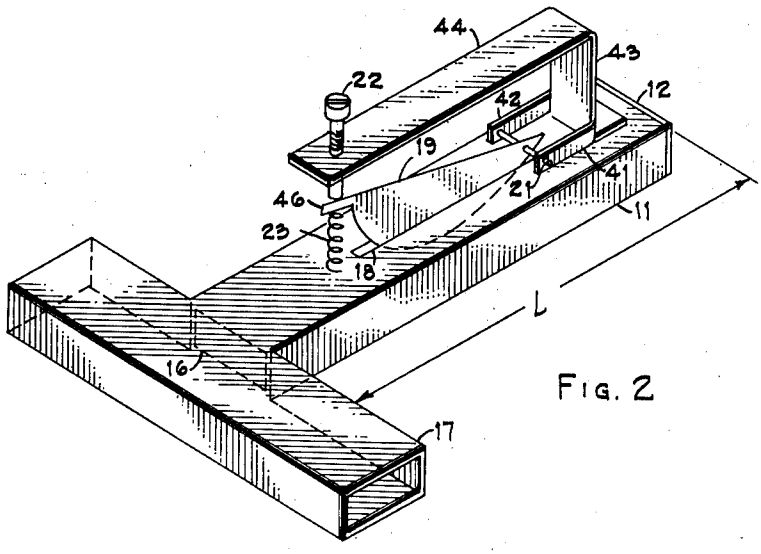


FIG. 2

Inventor
JOHN F. ZALESKI

By

Attorney

May 13, 1952 J. F. ZALESKI 2,596,458

WAVE GUIDE STUB

Filed April 23, 1949 2 SHEETS—SHEET 2

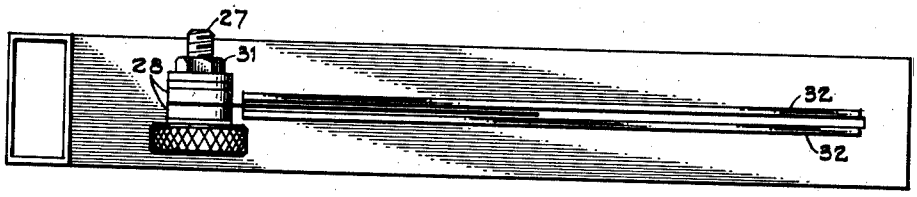


FIG. 4

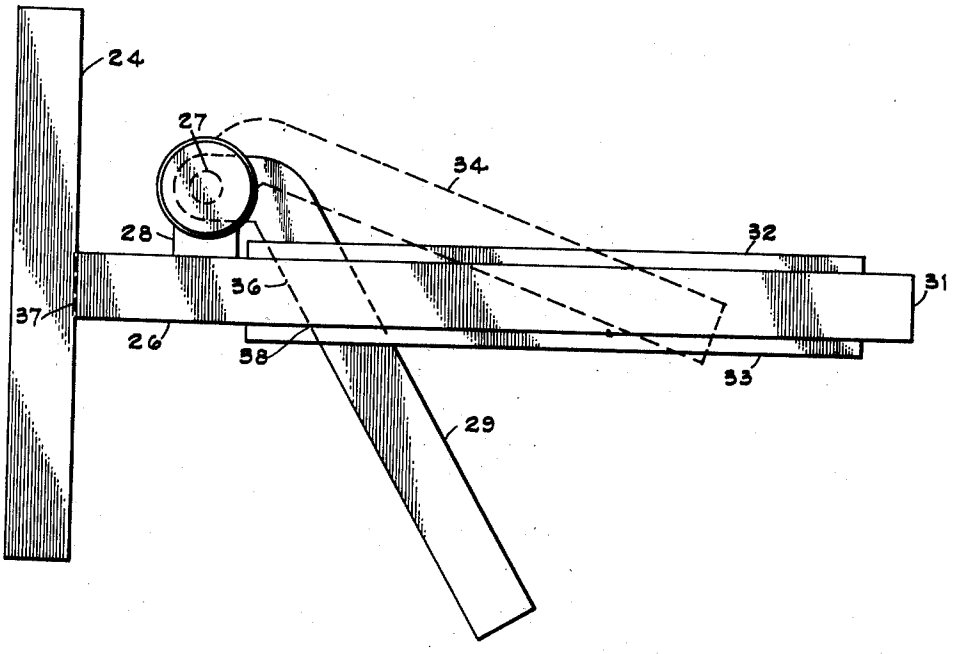


FIG. 3

Inventor
JOHN F. ZALESKI

By

Attorney

Patented May 13, 1952

2,596,458

UNITED STATES PATENT OFFICE

2,596,458

WAVE GUIDE STUB

John F. Zaleski, Queens Village, N. Y., assignor to General Precision Laboratory Incorporated, a corporation of New York

Application April 23, 1949, Serial No. 89,267

2 Claims. (Cl. 178—44)

1

This invention relates to a tunable wave guide stub and particularly to an improved device for introducing variable reactance into microwave circuits.

Circuits for microwave energy employ transmission lines which are uniquely different from those used in lower frequency circuits, and which in general consist of hollow wave guides, coaxial transmission lines or dielectric rods. Inductive and capacitive devices for use with such lines also bear little resemblance to those employed at lower frequencies.

One such device commonly used for continuous adjustments of impedance from a low positive reactance value through infinity to a low negative reactance value consists of a short length of rectangular hollow wave guide short-circuited at one end by a movable plunger and open at the other end for attachment to microwave guide in either series or shunt connection.

This form of device is designed for use with rectangular hollow wave guide and when connected into a broad side of such a guide to form a series arm its reactance is presented to the guide as series reactance, while if connected into a narrow side to form a shunt arm its reactance is in shunt with that of the guide. While such a tunable stub has been the best variable reactance means heretofore available and has been widely used it suffers from the faults of mechanical complexity and cost. The slidable plug must be precisely made and should incorporate quarter-wave or half-wave trap slots to prevent escape of microwave energy around its edges. Likewise these devices have sliding contacts which are disadvantageous.

The instant invention provides a tunable stub which substitutes for the sliding end plug an adjustable fin of thin sheet material projecting through a longitudinal slot into the interior of the guide. It thus substitutes for the intricate and costly sliding plunger a simply made and easily operated fin of sheet material, greatly simplifying the design and facilitating its employment.

The exact nature of the invention will be more readily understood from the following detailed description when considered with the attached drawing in which:

Figure 1 illustrates one form of the invention applied to a series stub.

Figure 2 illustrates a similar device as applied to a shunt stub.

Figure 3 is a side view of a modified form of the invention.

2

Figure 4 is a plan view of the modification of Figure 3.

In Figure 1 a section of hollow rectangular wave guide 11 is closed at one end by a solid conductive plate 12 soldered or brazed to the guide. At the other end 13 the guide is fastened into an opening in a broad side of another section of guide 14 so that the first section is a series arm of the second section. This second section 14 represents any wave guide or microwave equipment through which microwave energy may flow and which may require for any purpose a tunable wave guide stub attached as a series arm.

The stub section 11 is provided with a slot 18 cut in the center line of one of its broad faces and in which is variably positioned a fin 19 composed of metal or a good dielectric, the former being preferable as the effects produced thereby are somewhat more pronounced. The fin 19 is hinged to the stub section 11 by means of a hinge pin 21 which passes through one end of the fin and the cooperating arms 41 and 42 of a bracket 43 fastened to the stub section. This rotation of the fin about its pivot point 21 varies the depth of insertion of the fin in the stub section.

To facilitate this adjustment an adjusting screw 22 and compression spring 23 cooperate with an extension 46 on the fin 19 in such fashion that the fin may be moved in either direction without lost motion. To this end the screw 22 is in threaded engagement with a leg 44 of the bracket 43 and has its end bearing on the upper edge of the extension 46 of the fin 19 while the spring 23 is positioned between the upper surface of the stub section 11 and the under edge of the extension 46. Rotation of the adjusting screw in one direction thus causes the fin 19 to be rotated in a counterclockwise direction against the force of the spring 23 and increases the depth of insertion of the fin 19 in the stub section 11. Rotation of the adjusting screw in the other direction, however, permits the spring 23 to rotate the fin 19 in the opposite direction and results in a reduced depth of penetration of the stub 11 by the fin 19.

The fin may be shaped as illustrated, that is, constituting a segment of a circle, or it may be of any other desired shape so long as the shape chosen is such that variation in depth of insertion produces a gradual change in the area of the fin which is contained in the stub section 11.

If desired the slot 18 may be provided with coamings in the form of one-quarter wave or one-half wave traps to prevent radiation thereby

as more fully illustrated and described in the copending application Serial No. 86,293, dated April 8, 1949, of John F. Zaleski, now Patent No. 2,591,329 issued April 1, 1952.

Fig. 2 illustrates the closed-end guide stub 11 of Fig. 1 attached as a shunt arm to a narrow side of another section of wave guide 17 which, like the guide 14 of Fig. 1, represents any wave guide or microwave equipment through which microwave energy may flow and which may require for any purpose the attachment of a tunable wave guide stub, but which, differing from Fig. 1, requires the attachment of the stub as a shunt arm. Since in Figure 2 the wave guide stub, fin and associated mechanisms are similar to those depicted in Fig. 1 similar reference characters have been accorded thereto and repetitive description is unnecessary.

In Fig. 1 it is assumed that microwaves of a frequency such as is normally employed with the size of rectangular hollow guide chosen are transmitted through the guide section 14. With the fin 19 removed entirely from the interior of the guide, the sign and amount of the reactance which the stub 11 offers in series with the guide 14 at the stub opening 13 depends entirely upon the magnitude of its length L. This reactance has a value of infinity when L equals one-quarter wavelength in the guide or any odd integral multiple thereof, and is zero if L is one-half wavelength or any multiple of it. Between these values the reactance offered ranges through all inductive and capacitive values. For instance, when L is between $\frac{1}{2}\lambda_g$ and $\frac{3}{4}\lambda_g$, where λ_g is the wavelength in the guide, or in general between

$$\frac{N\lambda_g}{2} \text{ and } \left(\frac{N\lambda_g}{2}+\frac{\lambda_g}{4}\right)$$

where N is any integer, the reactance is inductive and ranges from zero to infinity. For lengths between $\frac{3}{4}\lambda_g$ and λ_g or in general from

$$\left(\frac{N\lambda_g}{2}+\frac{\lambda_g}{4}\right) \text{ to } (N+1)\frac{\lambda_g}{2}$$

the reactance is capacitive and ranges from infinity to zero.

It has been found that when a fin such as fin 19 in Fig. 1 is inserted longitudinally into a broad side of a hollow rectangular wave guide, microwaves passing through the guide are retarded, and the amount of retardation is representative of both the depth of insertion and the length of the inserted portion of the fin. If the insertion be made at the longitudinal center line or in general in a region of maximum electric field and in a direction parallel to the lines of electric field intensity, the effect will be most pronounced and will be unaccompanied by any appreciable loss of energy.

The ends of the inserted portion of the fin are tapered to prevent impedance discontinuities and accompanying loss of energy. The length of the fin is made of the order of six or seven wavelengths and its maximum depth of insertion is limited only by high voltage breakdown or short-circuiting of the guide. Under these conditions a retardation of microwave energy of over 180 electrical degrees is easily attainable.

It is notable that the retarding action of the fin on microwaves passing by it is doubly effective: microwaves entering from the guide 14 are retarded as they pass the fin and after reflection from the closed end 12 are retarded a second time as they return toward the guide 14.

By means of a fin such as described in a wave-guide stub such as stub 11 in Figs. 1 and 2, the electrical length of the stub is increased as the fin is lowered into the guide, for the retardation produced by the fin is equivalent to a phase lag and the effect is electrically similar to the effect produced by increasing the physical length L of the stub. This permits adjustment of the stub by means of the fin to have any value whatever of reactance. For instance, if the length L is chosen to be

$$\frac{\lambda_g}{2}$$

and the fin is made large enough to be capable of producing at maximum insertion a retardation of at least 180°, then the electrical length of the stub may be varied by means of the fin from a length of

$$\frac{\lambda_g}{2}$$

when the fin is out of the guide to an electrical length of λ_g when the fin is inserted to its maximum permissible depth. As before described these lengths offer at the open mouth 13 of the stub all possible values of reactance ranging from zero through all inductive values to infinity, then from infiity through all capacitive values to zero. These values are interposed in series with the guide section 14 in Fig. 1.

In Fig. 2 exactly the same description applies except that the reactance values are applied at the open mouth 16 of the stub 11 in shunt with the impedance of the guide 17.

In Fig. 3 is illustrated a second form of tunable stub which may, like the first form, be connected to a waveguide carrying microwaves as either a series arm as shown in Fig. 1 or a shunt arm as shown in Fig. 2. In Fig. 3 the connection as a series arm is chosen for illustration. The stub 26 is connected to the waveguide 24 through which microwaves are transmitted. The end 31 of the stub 26 may be either closed or open since in this form of the invention little of any microwave energy will reach the end. The stub contains two longitudinal slots, one in the center line of each broad face, and each is protected by two coamings forming wave traps 32 and 33 such as described in the copending application mentioned supra. These wave traps produce high impedance at the slots for microwave energy attempting to escape therefrom.

A fin 29 in the shape of a strip of sheet material is hinged by a screw 27 to two bosses 28—28, more clearly shown in Fig. 4. The screw is supplied with a nut 31 so that when tightened it clamps the bosses 28 against the fin 29 and prevents it from turning. By loosening the nut the fin may be moved into and clamped at any position such as the one shown in Fig. 3 by full lines or that shown by the dashed outline 34. In these two positions shown and at any intermediate position the edge 36 of the fin near the guide section 24 serves as a short-circuiting post across the guide, the effective position of the short circuit being near the point 38 where the fin passes through the lower slot. This short circuit prevents the passage beyond that effective point of any microwave energy and reflects with little or no loss all energy impinging upon it. In addition, in all oblique positions the edge 36 serves as a phase retarder so that the electrical distance from the end 37 of the stub to the point of effective short-circuit is increased, and is greater than it would be without this phase-retarding

fin effect. This phase-retardation is accomplished without the production of any impedance discontinuity because of the oblique position of the edge **36** in the guide.

The lines of intersection of the plane of the fin with the planes of the broad faces of the guide are high impedance regions because of the action of the trap coamings, so that microwave energy is prevented from passing between the fin and the guide faces even when high potential is present.

Although rectangular hollow wave guide is used as an example in the embodiment of this invention, any other type of microwave guide can be employed instead, for use with an adjustable fin, as is more fully explained in the copending application mentioned supra.

In Figs. 1 and 2 a screw is employed for adjusting the fin and in Fig. 3 a clamping hinge is used. However any other convenient method for adjustment of the position of insertion of the fin may be employed instead.

What is claimed is:

1. A microwave tunable wave guide stub comprising, a rectangular wave guide section provided with longitudinal opposed openings in each of the broad faces thereof, a fin of sheet metallic conductive material pivoted at one end to the external face of said wave guide section at a point adjacent one end of one of said longitudinal openings, said fin extending through said openings and across the narrow dimension of said wave guide section, means for adjusting the angular position of said fin about said pivot, said fin being so shaped and the limits of angular adjustment being such that in any position of adjustment the area of the fin contained within

the wave guide section increases gradually from one end.

2. A microwave tunable wave guide stub comprising, a wave guide section provided with longitudinal opposed openings in the periphery thereof, a fin of sheet metallic conductive material pivoted at one end to the external face of said wave guide section at a point adjacent one end of one of said longitudinal openings, said fin extending through said opening and across said wave guide section, means for adjusting the angular position of said fin about said pivot, said fin being so shaped and the limits of angular adjustment being such that in any position of adjustment the area of the fin contained within the wave guide section increases gradually from one end.

JOHN F. ZALESKI.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,427,098	Keizer	Sept. 9, 1947
2,433,368	Johnson	Dec. 30, 1947
2,457,695	Liskow	Dec. 28, 1948

FOREIGN PATENTS

Number	Country	Date
591,369	Great Britain	Aug. 15, 1947

OTHER REFERENCES

"Microwave Transmission Circuits," edited by George F. Ragan, Radiation Laboratory Series, Vol. 9, first edition, published by McGraw-Hill, copyright May 21, 1948.