

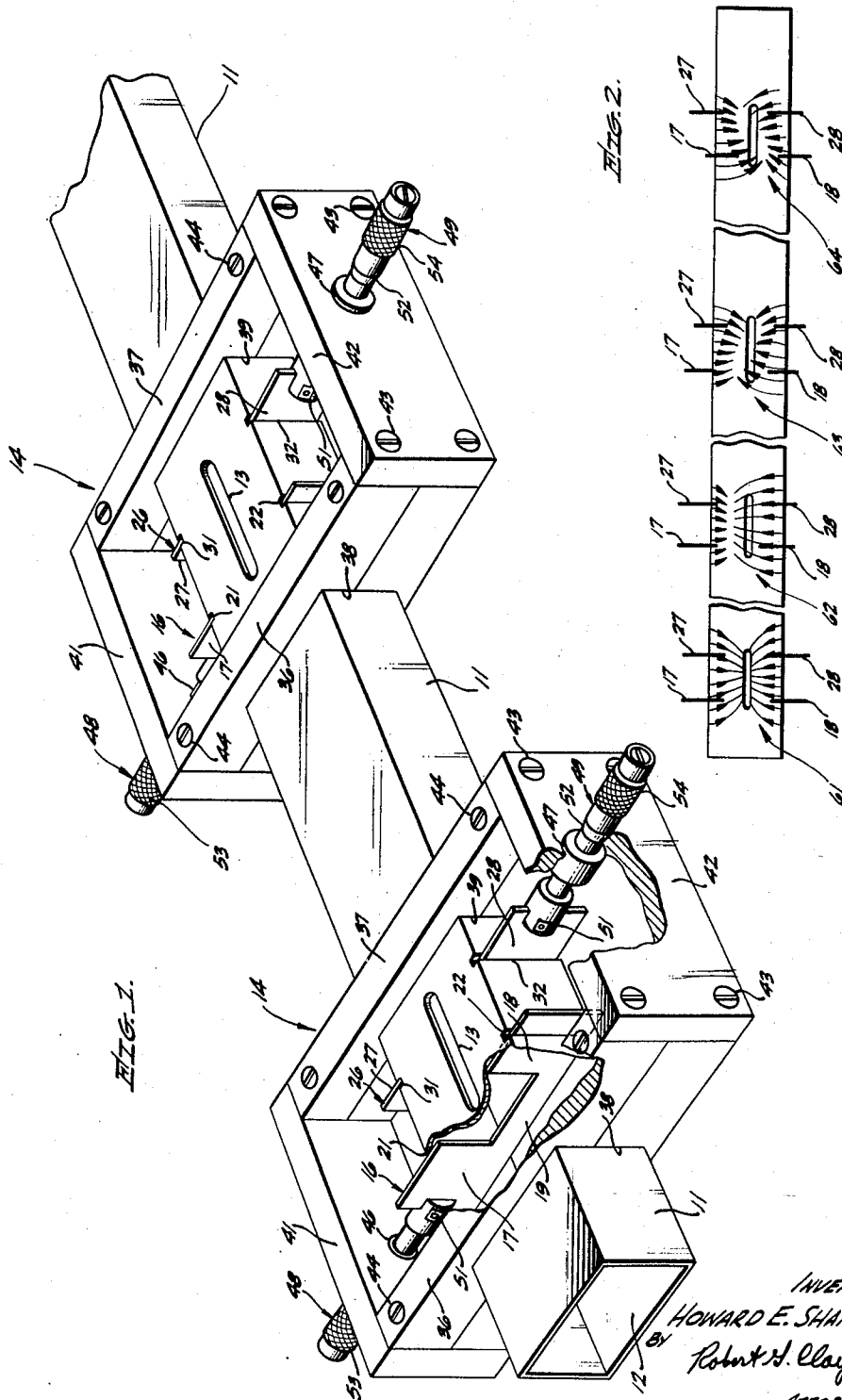
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MECHANICALLY VARIABLE COMPLEX SLOT

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MECHANICALLY VARIABLE COMPLEX SLOT

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The present invention relates to a variable conductance waveguide slot, and more particularly to a mechanically variable complex slot.

In general, slots disposed along the centerline of a rectangular waveguide do not radiate because the current distribution within the waveguide is such that there is zero value of current in the area of the slots. Slots may be cut off the centerline in the broad wall of a waveguide which will radiate, and those slots which are angularly disposed radiate with a phase difference with respect to those slots parallel to the centerline. Such angularly disposed slots are, for the purposes of this application, termed complex slots.

Also, as has been previously taught, slots along the centerline of the broad wall of a waveguide may be made to radiate by inserting a device resulting in asymmetrical disturbance of the current distribution within the waveguide. This latter teaching is discussed in detail in an application for Letters Patent, Serial No. 740,160, filed June 5, 1958, for Variable Conductance Waveguide Slot by Howard E. Shanks and Bernard J. Maxum.

The previous methods and structure for making centerline waveguide slots radiate have principally provided for variation of the radiation in amplitude with possible phase reversal, if desired. The amplitude of the radiation from these slots depends on the intercepted current density and the value of the component of the current which is transverse to the slot. The phase reversal is dependent upon the direction in which the current component crosses the slot, and this latter, in the previously devised methods, has been limited to one or the other transverse direction.

The present invention, in brief, comprises a section of rectangular waveguide having at least one centerline slot and two variable irises disposed transversely within the waveguide, one at either end of the slot. With such arrangement it is possible to disturb the current distribution within the waveguide so that current crosses in one direction at one end portion of the slot and in the other direction at the other end portion. Thus, such centerline slot resembles the above referenced complex slot, but the phase is variable from zero to 360 degrees.

It is therefore an object of the device of the present invention to provide a variable complex slot.

Another object is to provide a variable conductance slot which may be varied as to phase and amplitude of radiation.

Still another object is to provide a variable conductance slot wherein radiation from the end portions is separately and selectively variable.

A further object is to provide a centerline waveguide slot with asymmetrical means disposed within the waveguide for variably controlling the phase and amplitude of radiation from the slot.

Other objects and advantages of the invention will be apparent from the following description considered together with the accompanying drawing, in which:

Fig. 1 is a perspective view, partly in section, of the device of the invention; and

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Fig. 2 is a schematic plan view illustrating several current patterns for different positions of the irises of Fig. 1.

Referring to Fig. 1 in detail, there is shown a rectangular waveguide 11 for propagating electromagnetic energy from a source (not shown) which may be coupled to input port 12. Resonant slots 13 are provided in a broad wall of the waveguide 11 extending along the longitudinal centerline thereof. When the electromagnetic energy propagated through the waveguide 11 is in the dominant mode, TE_{10} , the current distribution in the area of the slots has a zero value and therefore there is no radiation from the slots.

To make the slots 13 radiate, the same structure generally indicated at 14 is provided with respect to each slot and only one will be described in detail with similar reference numerals being applied in each instance. A first metallic iris 16 having inductive side plates 17 and 18 connected by an impedance matching capacitive plate 19 at the lower portions thereof is disposed transversely within the waveguide 11. Aligned and oppositely disposed sidewall slots 21 and 22 extend transversely between the broad walls in a plane which intersects slot 13 at one end to slidably receive extensions of side plates 17 and 18. A second similar metallic iris 26 is disposed at the other end of the slot 13 and comprises inductive side plates 27 and 28 and impedance matching capacitive plate (not shown) with the side plates engaging sidewall slots 31 and 32 of waveguide 11. Such sidewall slots 21, 22 and 31, 32 normally do not radiate because current flow in waveguide 11 at the sidewalls is parallel to these slots.

As an example of a manner of making the lateral position of irises 16 and 26 adjustable within slot 13, two matching side elements 36 and 37 are externally mounted in spaced-apart relation at either side of slot 13 on waveguide 11 parallel to the irises and engage the waveguide by apertures 38 and 39, respectively. To provide a rigid framework, end brackets 41 and 42 are suitably secured to the respective ends of side elements 36 and 37, as by screws 43. For convenience of installation and fabrication, the side elements 36 and 37 may be divided longitudinally and secured together, as by screws 44. The end brackets 41 and 42 each have apertures 46 and 47 to receive conventional micrometer type rotary-to-linear motion translators 48, 49, respectively, which engage an extension of one side plate of each iris 16 and 26, as by pins 51. Vernier scales 52 are provided for each translator 48, 49 to permit fine adjustment thereof and calibration of the characteristics of the slot radiation. Thus, by rotating knobs 53 and 54, respectively, the amount of each inductive side plate within the waveguide 11 is adjustable.

Considering now the operation of the variable conductance slot 13, when constructed in accordance with the foregoing, and, as an aid in the understanding thereof, reference is made to the schematic plan view of Fig. 2. With the irises 16 and 26 symmetrically positioned by suitable manipulation of translators 48 and 49 within the waveguide 11 with respect to the slot 13, current flows equally in the inductive side plates 17, 18 and 27, 28 of each iris to provide equal values of induced magnetic field on each side of the waveguide. Therefore, the current distribution, as disturbed by irises 16 and 26 within the waveguide 11, is still symmetrical and no radiation results, as indicated by the current distribution pattern indicated by curved lines 61 of Fig. 2.

When the irises 16 and 26 are respectively displaced in the same direction toward one side wall of waveguide 11 to dispose a greater portion of one inductive side plate of each iris within waveguide 11 an asymmetry is intro-

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duced in the current distribution and more current flows in side plates 17 and 27 than in the other side plates 18 and 28. Thus, there is a greater value of induced magnetic field on one side of the waveguide 11 and the current distribution, as illustrated in current pattern 62, is forced away from the side having the greater value of induced magnetic field. The result of the foregoing is a substantial value of current component transverse to the slot 13 and therefore the slot radiates.

With one iris 16 moved transversely in one direction and the other iris 26 moved oppositely, a current distribution pattern 63 results with components of current transverse to the slot in one direction at one end thereof and in the opposite direction at the other end. When the position of the irises 16 and 26 is reversed with respect to that just described, the current distribution is altered in the opposite direction, as seen in current pattern 64.

From the foregoing it is apparent that by suitable adjustments of the translators 48 and 49, radiation of variable amplitude and phase is attainable from the slot 13. A single variable conductance complex slot in a waveguide is useful as a variable coupler or as a switch. A plurality of such slots suitably spaced apart along the centerline of a waveguide, as indicated by the two slots shown in Fig. 1, is particularly useful as an antenna array for obtaining those complex patterns of radiation which are dependent upon the phase of the individual radiating elements as well as upon the amplitude. Also, such waveguide slot arrangement may readily be remotely controlled as by selsyns which, in turn, are easily adapted to programming by devices such as computers for adjustment of the slots individually.

In the foregoing, the description and illustration of the structure of the invention has been set forth in particularity with respect to resonant slots along the longitudinal centerline of the broad wall of the waveguide. It is to be noted, however, that the applicable principles are not limited to such centerline resonant slots, but may be equally applied with respect to resonant slots having any position through a broad wall of the waveguide. For an array of resonant slots off-the-center line a complex type of calibration procedure is involved, which makes it desirable to use the described centerline resonant slots.

While the salient features of the present invention have been described in detail with respect to a particular embodiment, it will be readily apparent that numerous modifications may be made within the spirit and scope of the invention, and it is therefore not desired to limit the invention to the exact details shown except insofar as they may be defined in the following claims.

What is claimed is:

1. A variable conductance waveguide slot coupler comprising a rectangular waveguide having a resonant slot in a broad wall thereof, first and second iris means mounted within said waveguide and respectively disposed at opposite ends of said slot, and means coupled to said first and second iris means for individually varying the positions thereof to alter current distribution of energy propagated through said waveguide and control radiation from said slot.

2. A variable conductance waveguide slot coupler comprising a rectangular waveguide having a resonant slot through one broad wall of said waveguide along the longitudinal center line thereof, first iris means disposed within said waveguide at one end of said slot, second iris means disposed within said waveguide at the other end of said slot, and means for individually varying the position of said first and second iris means to alter current distribution of energy propagated through said waveguide and cause said slot to radiate.

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3. A variable conductance waveguide slot coupler comprising a rectangular waveguide, a resonant slot through one broad wall of said waveguide along the longitudinal centerline thereof, first and second iris means mounted transversely within said waveguide and respectively disposed at opposite ends of said slot, and means disposed externally of said waveguide and coupled to said first and second iris means for individually varying the position of such iris means to alter current distribution of energy propagated through said waveguide and control radiation of energy from said slot in amplitude and phase.

4. A variable conductance waveguide slot coupler comprising a rectangular waveguide, a resonant slot through one broad wall of said waveguide along the longitudinal centerline thereof, first and second iris means mounted transversely within said waveguide and respectively disposed at opposite ends of said slot, each of said iris means including inductive side elements slidably engaging side wall openings of said waveguide, and means coupled to at least one side element of each of said irises for individually varying the inductive effect of said side elements to alter current distribution of energy propagated through said waveguide and control radiation from said slot in amplitude and phase.

5. A variable conductance waveguide slot coupler comprising a rectangular waveguide having a resonant slot through one broad wall thereof, first and second iris means slidably mounted transversely within said waveguide between substantially nonradiating side wall apertures and respectively disposed at opposite ends of said slot, each of said iris means including two spaced-apart inductive side plates with an impedance matching capacitive plate disposed therebetween, and means mechanically coupled to each of said iris means for individually controlling the transverse position thereof to alter current distribution of energy propagated through said waveguide and control radiation from said slot in amplitude and phase.

6. A variable conductance waveguide slot coupler comprising a rectangular waveguide having a resonant slot through one broad wall thereof, first and second iris means slidably mounted within said waveguide between substantially nonradiating side wall apertures and respectively disposed at opposite ends of said slot, each of said iris means including two spaced-apart inductive side plates having portions extended through said side wall apertures with an impedance matching capacitive plate disposed therebetween, a frame mounted on said waveguide about said slot, and first and second means supported by said frame and respectively coupled to said iris means for establishing the transverse positions thereof to alter current distribution of energy propagated through said waveguide and control radiation from said slot in amplitude and phase.

7. A multiphase and multipattern antenna comprising a section of rectangular waveguide having a plurality of spaced-apart resonant slots through a broad wall along the longitudinal center line thereof, a plurality of adjustable irises transversely mounted within said waveguide and respectively disposed at opposite ends of each of said slots, and means individually coupled to each of said irises for separately adjusting the transverse positions thereof and controlling the amplitude and phase of radiation from said slots by asymmetrical disturbance of current distribution in the area of each slot as established by energy propagated through said waveguide.

8. A multiphase and multipattern antenna comprising a section of rectangular waveguide having a plurality of spaced-apart resonant slots through a broad wall along the longitudinal centerline thereof, a plurality of adjustable irises transversely mounted within said waveguide and slidably engaging substantially nonradiating side wall apertures, one of said irises disposed at each end of each

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of said slots and each iris including spaced-apart inductive side plates extended through said apertures with an impedance matching capacitive plate disposed therebetween, a separate frame mounted on said waveguide about each of said slots, and separate means supported by said frames for controlling the transverse position of each of said irises to asymmetrically disturb current distribution of energy propagated through said waveguide and provide

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amplitude and phase control of radiation from said slots individually.

References Cited in the file of this patent

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