Oct. 24, 1967 C. E. ENDERBY 3,349,346

RECTANGULAR TO CIRCULAR WAVEGUIDE TRANSITION

Filed March 8, 1965 2 Sheets-Sheet 1

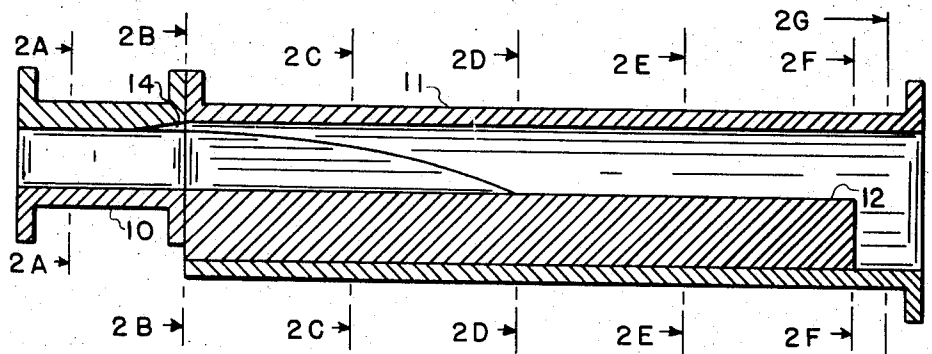


FIG. 1

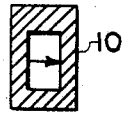


FIG. 2A

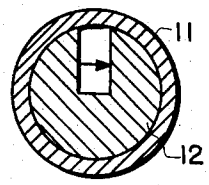


FIG. 2B

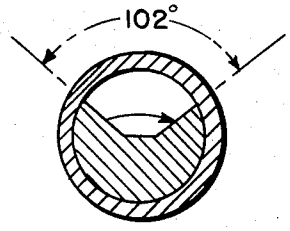


FIG. 2C

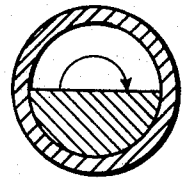


FIG. 2D

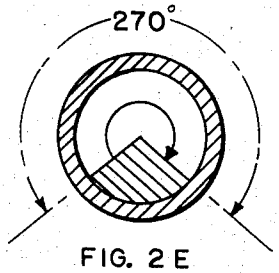


FIG. 2E

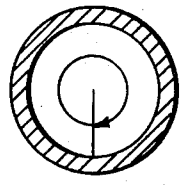


FIG. 2F

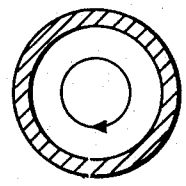


FIG. 2G

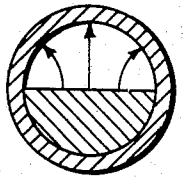


FIG. 2D'

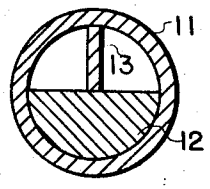


FIG. 2D"

INVENTOR.
CHARLES E. ENDERBY

BY Samuel E. Turner

ATTORNEY

Oct. 24, 1967 C. E. ENDERBY 3,349,346

RECTANGULAR TO CIRCULAR WAVEGUIDE TRANSITION

Filed March 8, 1965 2 Sheets-Sheet 2

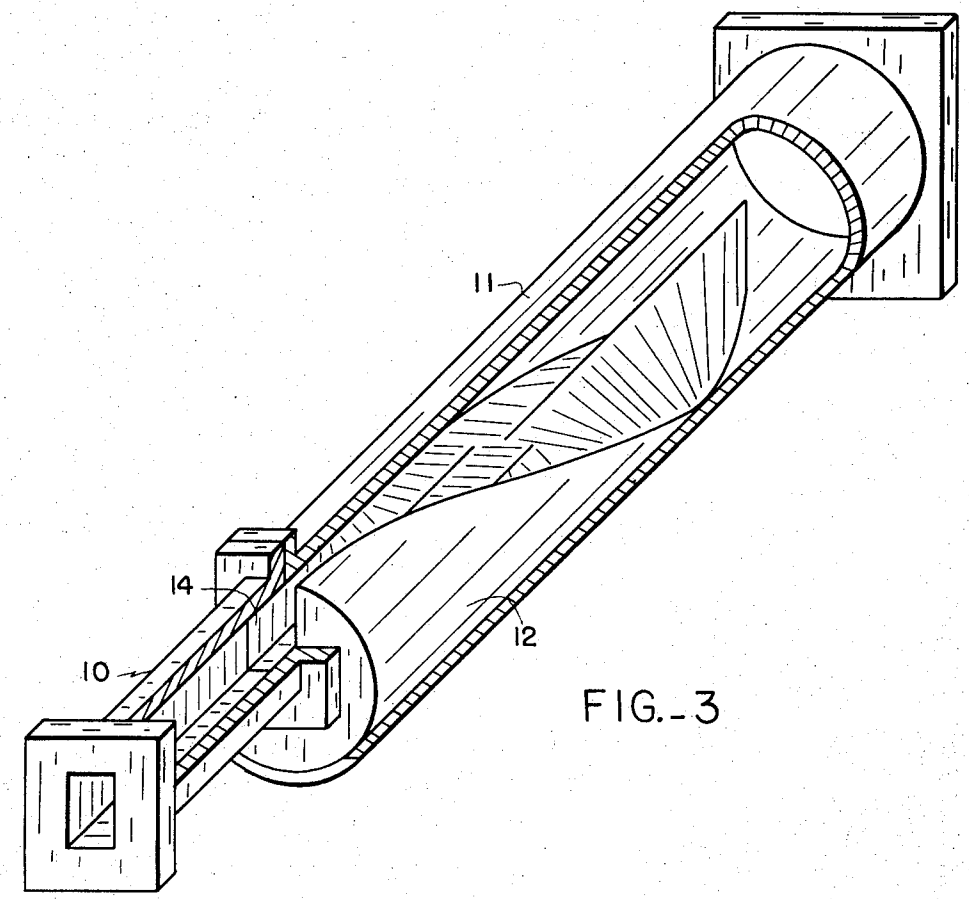


FIG._3

INVENTOR
CHARLES E. ENDERBY
BY Samuel E. Turner
ATTORNEY

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RECTANGULAR TO CIRCULAR WAVEGUIDE TRANSITION

Charles E. Enderby, Palo Alto, Calif., assignor to General Electric Company, a corporation of New York

Filed Mar. 8, 1965, Ser. No. 437,672
3 Claims. (Cl. 333—21)

ABSTRACT OF THE DISCLOSURE

A transition device between a rectangular waveguide having broad and narrow walls of predetermined transverse length and a circular waveguide having a predetermined radius, comprising: a first rectangular portion wherein one narrow wall is changed to an arcuate narrow wall over a predetermined longitudinal length, said arcuate narrow wall having a radius equal to the radius of said circular waveguide; a second portion of predetermined longitudinal length over which the internal cross-section area is increased by gradually increasing the circumferential length of said arcuate wall by pivoting said broad walls at their junctions with the other narrow wall to thereby form a semicircular cross-section at the end of said second portion; and a third portion of predetermined longitudinal length over which the internal cross-section area is gradually further increased by gradually folding at the center thereof the two halves of the straight wall of said semi-circular cross-section until said two halves coincide in a radially extending knife edge at the end of said third portion, and a radially extending conductive ridge position to substantially bifurcate the length of the third portion of said transition device, whereby an undesirable TE_{11} mode is suppressed.

This invention relates to a rectangular to circular waveguide transition structure and more particularly to a structure for providing wide-band, low-loss transition of electromagnetic waves propagating in the TE_{10} mode in a rectangular waveguide to the TE_{01} mode in a circular waveguide and vice versa.

Various structures for providing a transistion between a rectangular waveguide and a circular waveguide have been proposed. Previously proposed transition structures are shown, for example, by F. E. Parisi in U.S. Patent No. 2,825,031, issued Feb. 25, 1958 and by G. R. P. Marie in U.S. Patent No. 2,859,412, issued Nov. 4, 1958. Other examples are therein cited.

In general, prior transition structures require configurations that are difficult and expensive to construct if energy losses and excitation of undesirable modes are to be avoided. Furthermore, many of the previously proposed transition devices involve the intermediate conversion of, for example, an input rectangular TE_{10} mode to a rectangular TE_{20} mode, the latter mode then being converted to the desired circular mode.

It is an object of the present invention to provide a relatively simple and easily constructed structure for efficiently converting a rectangular mode to a circular mode.

It is a more specific object of the invention to provide a wide-band, low-loss transition of an electromagnetic wave propagating in the TE_{10} mode in a rectangular waveguide to a TE_{01} mode for propagation in a circular waveguide.

It is a further object of the invention to prevent the propagation of undesired modes in a mode conversion structure.

It is another object of the invention to provide smooth and continuous transition from a given rectangular mode to a given circular mode without transition to an intermediate rectangular mode.

These and other objects are achieved according to the present invention by providing a transistion structure in which the internal cross-section area is smoothly altered over a predetermined length from a rectangular shape to a circular shape.

This is accomplished by first forming one narrow wall of the rectangular waveguide into an arc corresponding to the circumference of the circular waveguide. Then the broad walls of the rectangular waveguide are gradually flared by pivoting these broad walls at the corners of the straight narrow wall thus increasing the length of the arcuate narrow wall, until a cross-section of semi-circular shape is obtained. The semi-circular cross-section is then formed into the desired circular cross-section by gradually folding the two halves of the straight wall of the semi-circular shape toward one another, pivoting at the center of this straight wall, until this wall completely disappears.

The illustrated embodiment of the invention provides ease of construction in that the main transition member may be separately formed, as for example, by machining from solid stock, and then inserted into a section of circular waveguide.

To prevent formation and propagation of undesirable modes an elongated, radially positioned conductive ridge may be positioned to bifurcate the waveguide channel of the transition structure without interference with the conversion from the rectangular mode to the desired circular mode.

The invention is described more specifically with reference to the accompanying drawings in which:

FIGURE 1 is a longitudinal section elevational view of the transition structure of the invention;

FIGURES 2A–2G are successive cross-section views of the structure of FIG. 1 including representations of the electric fields.

FIGURE 2D' is a cross-section view taken at 2D showing the electric field of an undesirable TE_{11} mode;

FIGURE 2D'' is a cross-section view taken at 2D illustrating the addition of a radial vane or ridge for eliminating the undesirable TE_{11} mode; and

FIGURE 3 is a partially broken away perspective view of the transition structure of the invention.

Referring to FIGS. 1 and 3, the illustrated embodiment of the transition structure of the invention is formed of three conuctive members including a section of rectangular waveguide **10**, a section of circular waveguide **11** and a transition member **12**.

FIGS. 2A–2G are succesive cross-sections of the structure of FIG. 1 showing development of the transition member **12** and the gradual change of the TE_{10} mode in the rectangular cross-section of FIG. 2A to the TE_{01} circular mode in the circular cross-section of FIG. 2G.

As shown in FIG. 2A the rectangular waveguide section **10** has a rectangular cross-section of dimensions suitable for propagating the input electromagnetic wave in the TE_{10} rectangular mode at the frequency of interest. A single arrow represents the electric field, it being well-known that the TE_{10} mode in a rectangular waveguide has a transverse electric field parallel to the narrow walls which varies from a maximum intensity at the center of the waveguide to a minimum intensity at the narrow walls.

As best shown in FIG. 1, a right hand portion **14** of the upper narrow wall of rectangular waveguide section **10** is gradually formed into an arcuate shape so that at cross-section 2B this arcuate shape matches the curvature of the inside circumference of the circular waveguide **11**. Thus as shown in FIG. 2B the transition waveguide channel shape at cross-section 2B is rectangular with an arcuate upper narrow wall.

Between cross-sections 2B and 2D the transition waveguide channel shape evolves from rectangular to semi-

circular, the electric field changing correspondingly as shown by the electric field arrows of FIGS. 2B–2D. In effect, the broad walls of the rectangular shape of FIG. 2B are pivoted at their junctions with the lower narrow wall at a uniform rate until they become collinear with the lower narrow wall whereby the semicircular cross-section of FIG. 2D is obtained.

Between cross-sections 2D and 2G the waveguide shape evolves from semicircular to the full circular shape of circular waveguide **11**. In effect, this is accomplished by pivoting the equal halves of the straight wall of the semicircular shape (FIG. 2D) at its center at a uniform rate until these two halves terminate in a vertical knife edge (FIG. 2F). This completes the transition and the electric field lines are now formed in the concentric circles of the TE_{01} circular mode, the electric field of the TE_{01} mode having no radial components and having an intensity which varies from maximum at one-half wave-guide radius to minimum at the center and at the wall of the circular waveguide. (The inside diameter of circular waveguide section **11** is selected, in well-known manner, for propagation in the TE_{01} mode at the frequency of interest.)

While the rectangular to circular waveguide transition as described hereinbefore has been found relatively free of conversion to undesirable modes, there is the possibility of the excitation of an unwanted TE_{11} circular mode in particular. Representative electric field lines of the TE_{11} mode in the semicircular cross-section are shown in FIG. 2D'. This TE_{11} mode may be substantially eliminated, without disturbance of the TE_{01} mode, by providing the previously mentioned radially-positioned narrow conductive ridge shown as a ridge **13** in FIG. 2D'' positioned to bifurcate the waveguide channel of the transition structure. The ridge **13** may extend the entire length of the transition structure or a lesser portion thereof as required. (To maintain clarity of the drawing the ridge **13** is not shown in FIGS. 1 and 3.) The ridge **13** terminates the electric field lines of the TE_{11} mode thus providing substantial suppression thereof.

Construction of the described rectangular to circular waveguide transition is relatively simple compared to prior devices of this type. The transition member **12** may be separately machined from solid round stock and then inserted into the circular waveguide section **11**. The arcuate portion **14** is similarly separately machined in the upper narrow wall of rectangular waveguide **10** before attachment, by means of suitable flanges, to the assembled circular waveguide section **11** and the contained transition section **12**. The ridge **13** may conveniently be supported in a longitudinal slot (not shown) machined in the wall of the circular waveguide **11**.

Representative dimensions of a rectangular to circular waveguide transition according to the invention constructed for operation at K_u band (16Gc) are as follows: the rectangular waveguide section **10** had inside dimensions of 0.510'' by 0.255'', the length of the portion **14** (transition to arcuate shape) being 0.540''. The circular waveguide section **11** had an inside diameter of 1.090''. The transition member **12** had a length of 13'', the cross-sections 2B–2F being equally spaced. The ridge **13** may

have a thickness of .040'', and a length of at least 9'' as measured to the left from cross-section 2F.

While the invention has been described in terms of a rectangular to circular waveguide transition, it is noted that the described structure can also be employed in the reverse direction for transition of an electromagnetic input wave in the TE_{01} mode in the circular waveguide to a TE_{10} mode in the rectangular waveguide.

Thus what has been described is a relatively simple wideband, low-loss mode transition structure.

While the principles of the invention have been made clear in the illustrative embodiments, there will be obvious to those skilled in the art, many modifications in structure, arrangement, proportions, the elements, materials, and components, used in the practice of the invention, and otherwise, which are adapted for specific environments and operating requirements, without departing from these principles. The appended claims are therefore intended to cover and embrace any such modifications within the limits only of the true spirit and scope of the invention.

What is claimed is:

1. A transition device between a rectangular waveguide having broad and narrow walls of predetermined transverse length and a circular waveguide having a predetermined radius, comprising: a first rectangular portion wherein one narrow wall is changed to an arcuate narrow wall over a predetermined longitudinal length, said arcuate narrow wall having a radius equal to the radius of said circular waveguide; a second portion of predetermined longitudinal length over which the internal cross-section area is increased by gradually increasing the circumferential length of said arcuate wall by pivoting said broad walls at their junctions with the other narrow wall to thereby form a semicircular cross-section at the end of said second portion; and a third portion of predetermined longitudinal length over which the internal cross-section area is gradually further increased by gradually folding at the center thereof the two halves of the straight wall of said semicircular cross-section until said two halves coincide in a radially extending knife edge at the end of said third portion, and a radially extending conductive ridge positioned to substantially bifurcate the length of the third portion of said transition device, whereby an undesirable TE_{11} mode is suppressed.

2. The transition device defined by claim **1** wherein said longitudinal lengths of said second and third portions are equal.

3. The transition device defined by claim **1** wherein said changes in cross-section shape of said first and second waveguide portions occur at a longitudinally uniform rate.

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ELI LIEBERMAN, *Primary Examiner.*

HERMAN KARL SAALBACH, *Examiner.*

RONALD D. COHN, *Assistant Examiner.*