Feb. 25, 1958 A. ALFORD 2,825,032

WAVE GUIDE MODE TRANSFORMER

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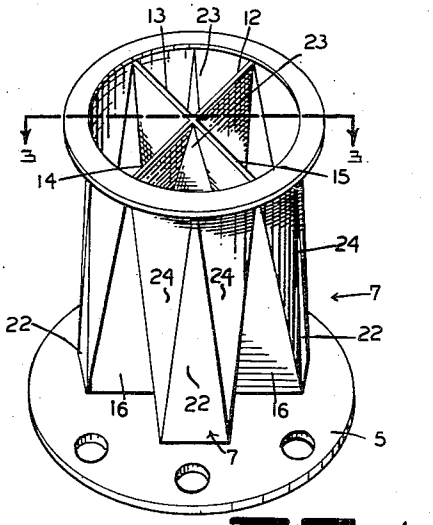


FIG. 1

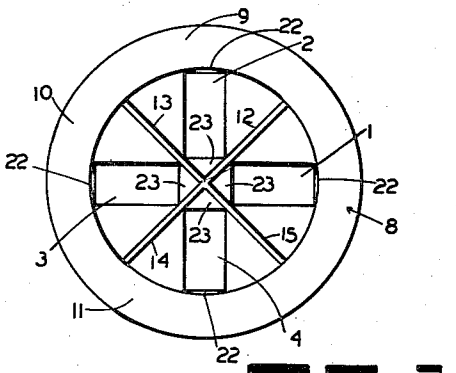


FIG. 2

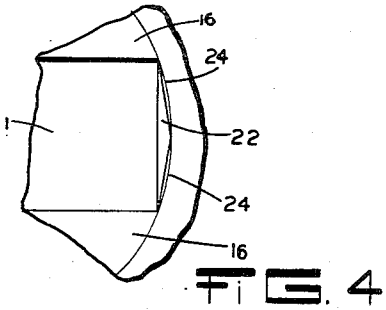


FIG. 4

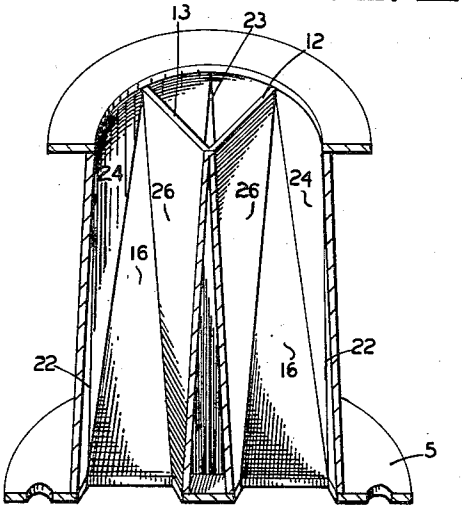


FIG. 3

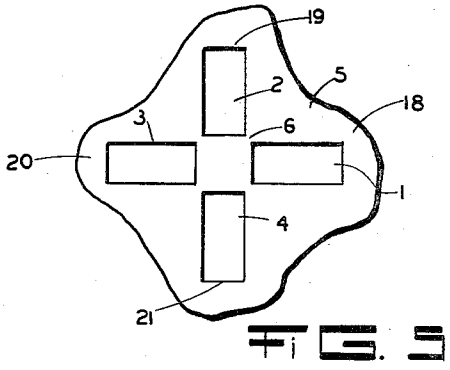


FIG. 5

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WAVE GUIDE MODE TRANSFORMER

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8 Claims. (Cl. 333—21)

The present invention relates to a means and method of producing certain wave modes in circular wave guides and in particular to the so called $T.E._{0,1}$ mode in circular wave guides.

This invention is an improvement over the arrangement shown in the copending application of Frank E. Parisi, Serial No. 261,882, filed December 15, 1951, and more particularly to the means of effecting a transition from the rectangular guides distributed at 90° about an axis to the circular guide of $T.E._{0,1}$ propagation with a very slight attenuation. The same principles apply also to the transition from eight equiangular slots positioned about a center as shown in Figure 7 of the above mentioned patent application to a circular guide of $T.E._{0,1}$ propagation.

The advantages and utility of the circular wave guide as a means of propagating micro waves has already been recognized. Further, in many types of apparatus and in many systems, such as rotating of radiation transmitters, the circular wave guide as has been pointed out in the copending application mentioned above, operate with marked advantages over other systems.

The present invention relates more particularly to coupling elements or the transition element from the section providing similar rectangular guide openings spaced at equal angular intervals about a central point to the circular wave guide.

This coupling section should have a length at least $1\frac{3}{4}\lambda$ long where λ is the longest space wave length in the operating band. The inside diameter of the circular wave guide end of the transition section should preferably be greater than $1\frac{1}{2}\lambda$ where λ is the longest space wave length in the operating band. The long side of each of the rectangular guides should preferably be $.55\lambda$ where λ is the longest space wave length in the operating band and the width is usually made $\frac{4}{9}$ of the longest side.

The upper frequency limit (the shortest space wave length) has not been well established but my experiments show that operations at $1\frac{1}{2}$ times the lowest frequency is completely satisfactory. For example, a transition or coupling section 3" long with a $2\frac{1}{2}$" inside diameter at the circular end and with five rectangular wave guides each having dimensions 9" by 4" has been successfully operated between 7200 mc. and 10,750 mc.

Below 7200 mc. and namely in the region between 7200 and 6600 the transitions or coupling section was still operative, but the standing wave ratio increased rapidly as the lowest frequency was approached.

Ribs, later mentioned and described, diametrically across the circular guide, were made .040" thick. This thickness was found to be non-critical, provided the ribs were not too thick. Tapering of the thickness of the ribs towards the circular end has the effect of still further reducing the already very small reflection introduced by the transition or coupling section. In many cases such tapering is not justified unless the ribs are fairly thick, for example, twice the thickness of the ribs used in my example.

In my tests I have tried transition sections with a central pyramid but without ribs. In such cases I have found at the circular end of the section, the desired $T.E._{0,1}$ mode was present, but it was intermixed with undesirable other modes. In other tests I have tried a central pyramid together with ribs as described, but with these ribs not making good contact with the outer walls of the transition section, and in these tests I found $T.E._{0,1}$ was present but also intermixed with undesired other modes. I found that the contact between these ribs and outer walls of the transition section is important in order to obtain the $T.E._{0,1}$ mode in very nearly pure state, that is, without being mixed with undesired modes.

The ribs should make good electrical contact continuously with each other and continuously with the pyramid as well.

My experiments show that the length of the central pyramid is not initial in that the pyramid can be made of the same length as the ribs, so that at the circular end, the pyramid does not protrude beyond the ribs. The pyramid can be made longer than the ribs or somewhat shorter than the ribs.

Care must also be taken in making the expanding wall structure of such a geometric pattern that the electric field is positively developed into a circular pattern in which at all radii about the central axis the electric field is at right angles to the radii.

In the transition element from four spaced rectangular guides about the central axis to the circular guide, the transition section terminates in four radial ribs or partitions about the central axis at 90°, while in eight spaced rectangular guides the transition section terminates in eight radial partitions or ribs about the central axis at 45°. While a larger number of guides may be used, it is believed that not much advantage is gained when the number exceeds eight.

The invention will be more clearly understood from the description set forth in the specification below, when taken in connection with the drawings, in which:

Figure 1 is a perspective view of the coupling section of the present invention.

Figure 2 is a plan view of the device of Figure 1 as viewed from the top.

Figure 3 is a perspective section taken on the line 3—3 of Figure 1.

Figure 4 shows an enlarged detail of a portion shown in Figure 2, and,

Figure 5 shows a fragmentary bottom view looking directly up from the bottom of Figure 2.

With reference to the drawings, Figure 5 shows four rectangular openings, **1**, **2**, **3**, **4**, spaced at 90° from one another. These openings as shown in Figures 3 and 5 are in the bottom plate **5** and are spaced around a central section **6** which is joined as a part of the plate **5**. Each of the rectangular openings **1**, **2**, 3 and **4**, has extending upwards from the top surface of the plate **5**, a conductive guide section **7** (Figure 1) which is comprised of a number of wall sections which expand from the rectangular opening to 90° sectors **8**, **9**, **10** and **11**. Each of these expanding enclosures is formed of a series of walls which have definite relation one to the other.

Looking down from the top of the coupling section which is all of electrical conductive material, and referring more particularly to Figure 2, there are four 90° conductive ribs or wall partitions **12**, **13**, **14** and **15**, radiating from a central point O and making full electrical continuous contact together at the center axis of the cylinder. These ribs or wall partitions are bordered on the outer radii extremities by walls **16**, **16**, etc., or the inner walls of the cylinder with which they make good and continuous electrical contact. The walls **16** actually

form isosceles triangles having as their base the bottom long sides of the openings **1**, **2**, **3** and **4**. The short sides of the openings **1**, **2**, **3** and **4**, also form the base of two other isosceles triangles. The outer walls of these wave guide openings, that is corresponding to the edges **18**, **19**, **20** and **21**, are indicated by the triangles **22** (Figure 2), while the inner isosceles triangles are indicated by the triangles **23**, **23**, Figures 1 and 3. At the upper end of the unit as viewed in Figure 1, the sections **24**, **24**, on each side of the section **22**, merge into a circular section along the contour of the circular guide as indicated in Figure 4. In fact the walls **24** may be curved from their vertex with a transverse circular section extending upwards as viewed in Figure 1 for the whole length of the isosceles triangle **24**, so that the intersection of the wall surfaces may form a continuous curve approaching the circular wall surface of the inside of the guide.

It will be noted that the partition section **12**, **13**, **14**, and **15**, when viewed in the cross section of Figure 3 are also formed with triangular shaped walls **26**, **26**, and that the center elements formed by the walls **23** (see Figure 2), comprise a four sided regular pyramid whose axis coincides with the center of the guide. As has been previously mentioned, the length of this guide transition section should be at least $1\frac{3}{4}\lambda$ long where λ is defined as above, and it may be longer. Where there are eight rectangular guide openings deposited uniformly about the central axis, each guide is treated in the same way. In such cases the triangles have more acute vertex angles and the central pyramid elements instead of being four sided would be eight sided. Otherwise the same constructional arrangement applies and the same general dimensions.

In the transition elements of the present invention, the radial plates are in the direction of the magnetic field and at every point the electric field is perpendicular to the plane of the sectional partitions so that the circular mode is accurately developed by the transition from the rectangular wave guides.

Having now described my invention, I claim:

1. A wave guide connecting system for converting from a group of rectangular guides to a single circular guide, the rectangular guides being arranged symmetrically about a center equiangularly spaced from each other, with the long sides of the rectangles parallel to the radius between the sides comprising means forming rectangular apertures adapted to coincide with the ends of said rectangular guides, a plurality of conductive partitions aligned in radial planes 90° apart at the circular guide with an axis coaxially aligned with the circular guide, a wall enclosure having a cylindrical shape at one end with the axis thereof coinciding with the axis of the circular guide and a plurality of wall elements forming isosceles triangles with the vertices of some of said triangular wall elements formed at the intersection of adjacent walls of the rectangular apertures and the vertices of the other of said triangular wall elements formed at the intersection of the partitions with each other and with the wall at the cylindrical end and also at the cylindrical end midway between the intersection of said partitions and the cylindrical wall.

2. A wave guide section for converting from a group of rectangular guides to a single circular guide the rectangular guides being arranged symmetrically about a center with each guide having an inner positioned side and three other outer sides forming rectangular openings equiangularly spaced from each other with the long sides of the rectangles parallel to the radius between the sides comprising means forming rectangular apertures adapted to coincide with the ends of said rectangular guides, an enclosing conductive wall having a cylindrical shape at one end and merging to the outer sides of the rectangular apertures at the other end, a center core forming a continuous conductive surface extending from the inner sides of the rectangular apertures at one end and merging to a center point at the other end coinciding with the cylindrical axis of said circular guide at said other end, and symmetrically spaced radial partitions at 90° apart at the circular guide end between each rectangular aperture extending to and inductively connected to said conductive wall and said center core.

3. A device as set forth in claim 2 in which said walls forming said core, and the partitions are formed as adjoing isosceles triangles with alternate adjacent vertices at opposite ends of said connecting sections.

4. A device as set forth in claim 2 in which the section has an axial length not less than $1\frac{3}{4}\lambda$ where λ is the longest space wave length on the operating band.

5. A device as set forth in claim 2 in which the section has an axial length of substantially 2.2λ where λ is the longest space wave length in the operating band.

6. A device as set forth in claim 2 in which said center core is formed as a rectangular pyramid.

7. A device as set forth in claim 2 in which said radial partitions are at right angles to each other.

8. A wave guide connecting member having a plate at one end with four rectangular apertures arranged with their long axes at 90° angles with each other and spaced from a common center slightly greater than half the width of the apertures, an annulus terminating the other end of the connecting member having its axis aligned with said common center, a series of substantially isosceles triangles forming wall elements and arranged alternately with alternate vertices and bases forming the corners and sides respectively of the four rectangular wave guide openings, with the triangles having their bases forming the short inner side of the rectangular openings continuous at adjacent edges to form a rectangular pyramid with the center coaxial with said axis and with the isosceles triangles having their vertices at the corners adjacent the inner sides of the rectangular apertures forming partitions at 90° about said axis and with the other isosceles triangles forming and merging into a continuous wall with said cylinder.

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