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WAVE GUIDE STRUCTURES

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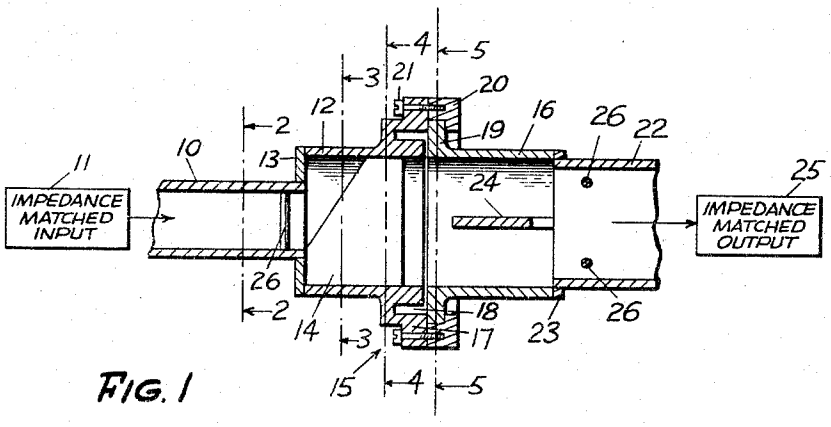


FIG. 1

FIG. 3

FIG. 2

FIG. 4

FIG. 5

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WAVE GUIDE STRUCTURES

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12 Claims. (Cl. 333—21)

This invention relates to microwave transmission devices, and more particularly to a rotary joint for wave guides which may be used, for example, in the antenna feed structure of a radar system.

In rotary joints which are axial with the wave guide, it is known to convert the wave guide from a rectangular type guide which may be excited, for example, in the TE_{11} mode, to a circular wave guide. During the transition from the rectangular guide to the circular guide, the mode of propagation is transferred from the TE_{11} mode to a TM_{01} mode. Since the field pattern of the latter mode is symmetrical about the axis of the circular guide, rotation of one section of the circular guide with respect to another section will produce no disturbance in the wave propagated therethrough. The wave may then be transferred back to another section of the rectangular guide and to the TE_{11} mode. Further, it is known that the transition from the rectangular guide to the circular guide may be accomplished by means of a planar member in the circular guide.

This invention discloses a particular shape and arrangement of the planar member in the circular guide whereby an efficient transition from the rectangular guide to the circular guide may be obtained over a wider range of frequencies than was heretofore possible.

In particular, this invention discloses a tapered planar member positioned in the circular guide colinear with the axis of the circular guide and the rectangular guide and perpendicular to the wider sides of the rectangular guide. The planar member is tapered along a line extending from the point of intersection of the planar member with one side of the rectangular guide to the wall of the circular guide opposite the side of the rectangular guide which intersects said planar member.

It has been found that by making the length of the planar member equal to substantially a multiple of a half wave length of the operating frequency, and the distance between the adjacent edges of the planar members of the transitions of both ends of the circular guide an odd multiple of a quarter wave length of the operating frequency, undesirable resonances or ringing effects in the joint may be eliminated.

Other and further advantages of the invention will be apparent as the description thereof progresses, reference being had to the accompanying drawing, wherein:

Fig. 1 illustrates a longitudinal, cross-sectional view of a rotary joint assembly embodying this invention;

Fig. 2 illustrates a transverse, cross-sectional view of the input rectangular wave guide taken along line 2—2 of Fig. 1, and showing the mode pattern propagated therein;

Fig. 3 illustrates a cross-sectional view of the device of Fig. 1 taken through the circular guide and tapered portion of one of the planar members along line 3—3 of Fig. 1, and illustrating the transitional mode pattern in the device;

Fig. 4 illustrates a transverse, cross-sectional view of the device shown in Fig. 1 taken through the circular wave guide and one of the planar members along line 4—4 of Fig. 1, and showing the transitional mode pattern; and

Fig. 5 illustrates a transverse, cross-sectional view taken along line 5—5 of Fig. 1, and illustrating the mode pattern existing in the rotary joint section of the circular guide.

Referring now to Figs. 1 and 2, there is shown an input rectangular wave guide **10** which may be made, according to a well-known design, of metal having its input end coupled to an impedance matched input **11**. The opposite end of guide **10** from the input end is connected to a circular wave guide **12** whose diameter may be, for example, substantially equal to the diagonal dimension of the rectangular wave guide. The area of the end of circular guide **12** which surrounds rectangular guide **10** is closed by a metallic plate **13** having a rectangular hole therein which allows the passage of guide **10** therethrough. Guide **10**, guide **12**, and plate **13** are all rigidly attached together by any desired means such as, for example, soldering such that the ends of guides **10** and **12** fall in the same plane.

Positioned in circular guide **12** is a planar member **14** which is colinear with the axis of guides **10** and **12**, and is perpendicular to the wider sides of the guide **10**. Member **14** extends from one side of circular guide **12** to the other and has an overall length along the axis of guide **12** which, as shown here by way of example, is substantially a half wave length of the operating frequency. However, the length of member **14** could be substantially any multiple of a half wave length of the operating frequency.

Positioned along the circular guide **12** is a rotatable joint **15** such that a second portion **16** of the circular guide may be rotated with respect to the first-mentioned portion **12** of the circular guide about the common longitudinal axis thereof. The rotating joint **15** may be any desired type and is shown here, by way of example, as a simple choke joint comprising a flange **17** integral with guide **12** and having an annular slot **18** therein, the depth of said slot approximating a quarter wave length in accordance with well-known design practice. A mating flange **19** on guide **16** covers the slot **18**, and a retaining ring **20** is rigidly fastened to flange **17** by, for example, screws **21**. Ring **20** engages flange **19** to thereby hold flange **19** in close proximity with flange **17** and guide **16** coaxial with guide **12**. The circular guide **16** is attached to an output guide **22** similar to guide **10** by a plate **23** similar to plate **13**. The transition between guide **16** and guide **22** is accomplished by a tapered planar member **24** identical to member **14**, and the output of guide **22** is fed to an impedance matched output **25**.

While accurate adjustment of planar members **14** and **24** in the circular guide will produce a good impedance match, inaccuracies in said adjustment may be compensated for by inductive irises placed in guides **10** and **22**, respectively, adjacent the points of connection to the circular guide section. Each of these inductive irises may be, for example, a pair of conductive rods **26** extending between the wider sides of the rectangular guide adjacent each of the narrower sides and lying substantially in the same transverse plane of the guide.

Referring now to Fig. 2, there is shown the mode of propagation in the incoming and outgoing guides **10** and **12**. This mode is the TE_{11} mode and is characterized by electrostatic lines between the wider walls of the guide with the lines being concentrated toward the center of the guide, as shown by arrows **27**.

Fig. 3 illustrates the mode pattern of the wave entering the circular guide **12** from guide **10** through the section occupied by the planar member **14**. As the tapered section approaches the wall of the circular guide, the electrostatic lines **27** in the center which were the

TE_{11} mode become shorter and shorter and the energy becomes evenly split into two halves propagated in the TE_{11} mode on either side of the planar member, as shown by vectors **28**.

Fig. 4 shows the transition when the tapered planar member **14** has reached the wall of the guide **12** and the power has been split into two equal parts, one on each section of the guide, said power being propagated in the TE_{11} mode, as shown by arrows **28**, the wave in one side being 180 degrees out of phase with the mode in the other side of the guide.

Fig. 5 shows the transition to the TM_{01} mode which occurs at the end of the planar member **14** and is the result of the addition of the two out-of-phase waves emanating from the two portions of the circular guide divided by the member **14** to produce the resultant axially symmetrical pattern **29**. It has been found that the transition to the TM_{01} mode is most efficient if the edge of the member **14** where the transition occurs is abrupt rather than tapered. The distance between the adjacent edges of planar members **14** and **24** is shown here, by way of example, as a quarter wave length. However, substantially any odd number of quarter wave lengths may be used.

It has been found that, for an overall joint structure using three centimeter waves, a band width of one and one-half per cent or 150 megacycles may be transmitted through this structure with a standing wave ratio which does not exceed 1.15 to 1 over this entire band of frequencies. The main contributing factor which produces the wide band pass is the beginning of the taper of members **14** and **24** at the junction of the respective wave guides.

Obviously, other frequencies may be used than those disclosed, and other types of rotating joints may be used without departing from the spirit and scope of this invention. Therefore, applicant does not wish to be limited to the particular details of the modification described herein, except as defined by the appended claims.

What is claimed is:

1. A signal wave translation device comprising a rectangular wave guide, a circular wave guide junctioned to said rectangular wave guide, a plate attached to said circular wave guide and said rectangular wave guide at their junction, said plate being substantially perpendicular to the longitudinal axes of said guides, said plate filling the end of said circular guide and having a rectangular aperture therein, and means for impedance matching said rectangular guide to said circular guide comprising a planar conductor positioned in said circular guide, said conductor having a tapered edge which substantially intersects the junction between said guides at one side of said rectangular guide and at one edge of said rectangular aperture.

2. A signal wave translation device comprising a rectangular wave guide, a circular wave guide junctioned to said rectangular wave guide, a plate attached to said circular wave guide and said rectangular wave guide at their junction, said plate being substantially perpendicular to the longitudinal axes of said guides, said plate filling the end of said circular guide and having a rectangular aperture therein, and means for impedance matching said rectangular guide to said circular guide comprising a planar conductor positioned in said circular guide colinear with the axis thereof, said conductor having a tapered edge which substantially intersects the junction between said guides at one side of said rectangular guide and at one edge of said rectangular aperture.

3. A signal wave translation device comprising a rectangular wave guide, a circular wave guide junctioned to said rectangular wave guide, a plate attached to said circular wave guide and said rectangular wave guide at their junction, said plate being substantially perpendicular to the longitudinal axes of said guides, said plate filling the end of said circular guide and having a rectangular aperture therein, and means for impedance matching said rectangular guide to said circular guide comprising a planar conductor positioned in said circular guide perpendicular to the widest sides of said rectangular guide, said conductor having a tapered edge which substantially intersects the junction between said guides at one side of said rectangular guide and at one edge of said rectangular aperture.

4. A signal wave translation device comprising a rectangular wave guide, a circular wave guide junctioned to said rectangular wave guide, a plate attached to said circular wave guide and said rectangular wave guide at their junction, said plate being substantially perpendicular to the longitudinal axes of said guides, said plate filling the end of said circular guide and having a rectangular aperture therein, and means for impedance matching said rectangular guide to said circular guide comprising a planar conductor positioned in said circular guide colinear with the axis thereof and perpendicular to the widest sides of said rectangular guide, said conductor having a tapered edge which substantially intersects the junction between said guides at one side of said rectangular guide and at one edge of said rectangular aperture.

5. A signal wave translation device comprising a rectangular wave guide, a circular wave guide junctioned to said rectangular wave guide, a plate atttached to said circular wave guide and said rectangular wave guide at their junction, said plate being substantially perpendicular to the longitudinal axes of said guides, said plate filling the end of said circular guide and having a rectangular aperture therein, and means for impedance matching said rectangular guide to said circular guide comprising a planar conductor positioned in said circular guide, said conductor being substantially a half wave length long at the operating frequency of said device, said conductor having a tapered edge which substantially intersects the junction between said guides at one side of said rectangular guide and at one edge of said rectangular aperture.

6. A signal wave translation device comprising a rectangular wave guide, a circular wave guide junctioned to said rectangular wave guide, a plate attached to said circular wave guide and said rectangular wave guide at their junction, said plate being substantially perpendicular to the longitudinal axes of said guides, said plate filling the end of said circular guide and having a rectangular aperture therein, and means for impedance matching said rectangular guide to said circular guide comprising a planar conductor positioned in said circular guide colinear with the axis thereof and perpendicular to the widest sides of said rectangular guide, said conductor being substantially a half wave length long at the operating frequency of said device and having a tapered edge which substantially intersects the junction between said guides at one side of said rectangular guide and at one edge of said rectangular aperture.

7. A signal wave translation device comprising a circular wave guide, a rectangular wave guide junctioned to each end of said circular wave guide, a plate attached to said circular wave guide and said rectangular wave guide at their junction, said plate being substantially perpendicular to the longitudinal axes of said guides, said plate filling the end of said circular guide and having a rectangular aperture therein and means for impedance matching each of said rectangular guides to said circular guide comprising a planar conductor positioned in said circular guide, said conductor having a tapered edge which substantially intersects the junction between said guides at one side of said rectangular guide and at one edge of said rectangular aperture.

8. A signal wave translation device comprising a circular wave guide, a rectangular wave guide junctioned to each end of said circular wave guide, a plate at-

tached to said circular wave guide and said rectangular wave guide at their junction, said plate being substantially perpendicular to the longitudinal axes of said guides, said plate filling the end of said circular guide and having a rectangular aperture therein and means for impedance matching each of said rectangular guides to said circular guide comprising a planar conductor positioned in said circular guide colinear with the axis thereof, said conductor having a tapered edge which substantially intersects the junction between said guides at one side of said rectangular guide and at one edge of said rectangular aperture.

9. A signal wave translation device comprising a circular wave guide, a rectangular wave guide junctioned to each end of said circular wave guide, a plate attached to said circular wave guide and said rectangular wave guide at their junction, said plate being substantially perpendicular to the longitudinal axes of said guides, said plate filling the end of said circular guide and having a rectangular aperture therein and means for impedance matching each of said rectangular guides to said circular guide comprising a planar conductor positioned in said circular guide colinear with the axis thereof and perpendicular to the widest sides of said rectangular guide, said conductor having a tapered edge which substantially intersects the junction between said guides at one side of said rectangular guide and at one edge of said rectangular aperture.

10. A signal wave translation device comprising a circular wave guide having a rotatable joint therein, a rectangular wave guide junctioned to each end of said circular wave guide, a plate attached to said circular wave guide and said rectangular wave guide at their junction, said plate being substantially perpendicular to the longitudinal axes of said guides, said plate filling the end of said circular guide and having a rectangular aperture therein and means for impedance matching each of said rectangular guides to said circular guide comprising a planar conductor positioned in said circular guide, said conductor having a tapered edge which substantially intersects the junction between said guides at one side of said rectangular guide and at one edge of said rectangular aperture.

11. A signal wave translation device comprising a circular wave guide, a rectangular wave guide junctioned to each end of said circular wave guide, a plate attached to said circular wave guide and said rectangular wave guide at their junction, said plate being substantially perpendicular to the longitudinal axes of said guides, said plate filling the end of said circular guide and having a rectangular aperture therein and means for impedance matching each of said rectangular guides to said circular guide comprising a planar conductor positioned in said circular guide, said circular wave guide being substantially an odd number of quarter wave lengths long at the operating frequency of said device, said conductor having a tapered edge which substantially intersects the junction between said guides at one side of said rectangular guide and at one edge of said rectangular aperture.

12. A signal wave translation device comprising a circular wave guide having a rotatable joint therein, a rectangular wave guide junctioned to each end of said circular wave guide, a plate attached to said circular wave guide and said rectangular wave guide at their junction, said plate being substantially perpendicular to the longitudinal axes of said guides, said plate filling the end of said circular guide and having a rectangular aperture therein and means for impedance matching each of said rectangular guides to said circular guide comprising a planar conductor positioned in said circular guide, said circular wave guide being substantially an odd number of quarter wave lengths long at the operating frequency of said device, said conductor being substantially a half wave length long at the operating frequency of said device and having a tapered edge which substantially intersects the junction between said guides at one side of said rectangular guide and at one edge of said rectangular aperture.

References Cited in the file of this patent

FOREIGN PATENTS

617,381 Great Britain ---------- Feb. 4, 1949

OTHER REFERENCES

Ragan: Microwave Transmission Circuits, vol. 9, Radiation Laboratory Series, published, 1948, McGraw-Hill Book Co. Pages 397 and 379. Copy in Div. 69.

Publication, "Microwave Transmission Circuits," edited by Ragan, vol. 9 of Radiation Laboratory Series, published by McGraw-Hill in 1948; pages 400–402. Copy in Div. 69.