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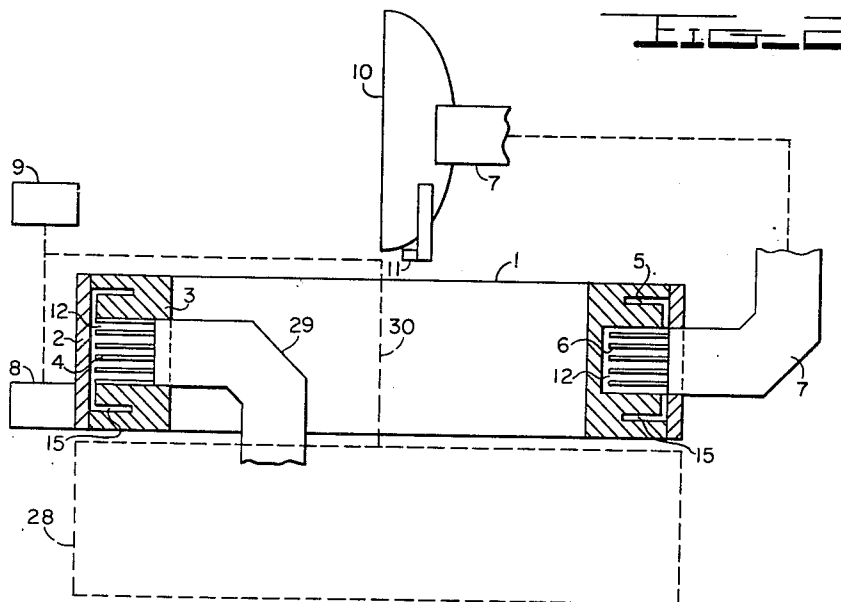
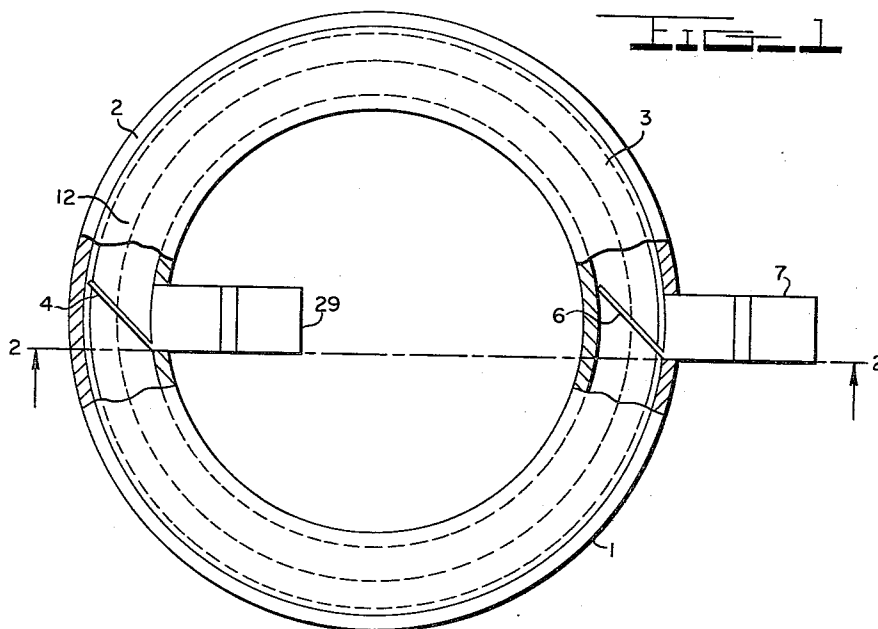
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2,595,186

JOGGED WAVE GUIDE RING TYPE RADIO-FREQUENCY ROTARY JOINT

Filed Feb. 6, 1950

2 SHEETS—SHEET 1



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2 SHEETS—SHEET 2

FIG. 3

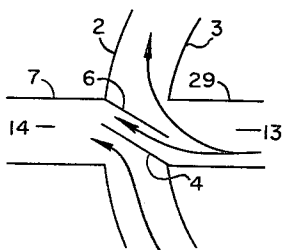


FIG. 4

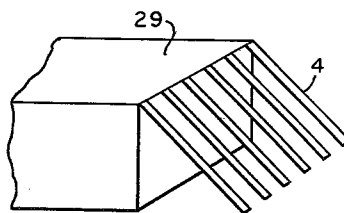


FIG. 5

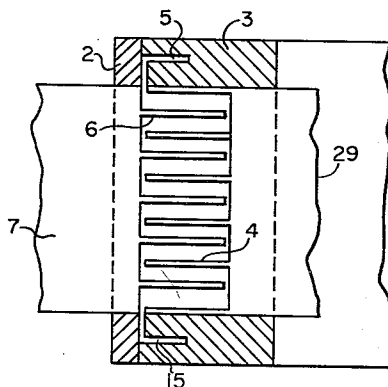


FIG. 6

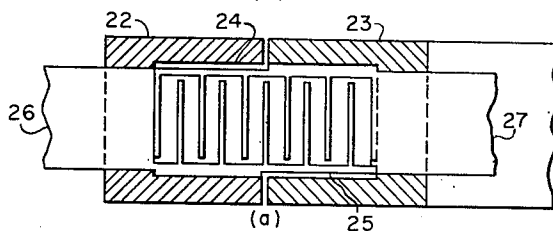
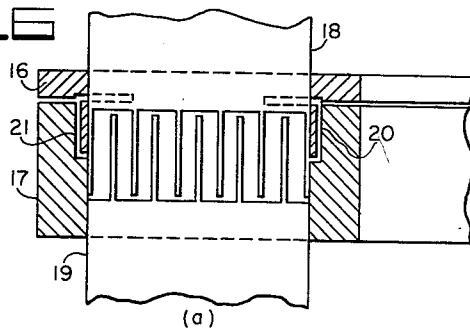


FIG. 7

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JOGGED WAVE GUIDE RING TYPE RADIO-FREQUENCY ROTARY JOINT

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5 Claims. (Cl. 250—33.63)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

1 This invention relates to rotary couplers for effecting efficient transfer of high radio frequency energy between two or more relatively moveable high frequency transmission paths.

More specifically, this invention relates to a rotary coupler which is in the form of an annular member having an annular cavity therein and which is used to couple high radio frequency energy between two or more relatively moveable wave guides which are in communication with the annular cavity.

A rotary coupler in the shape of a ring makes it possible to couple high frequency energy to a plurality of wave guides which are continuously rotatable about a common axis. Such is the case where energy is coupled to two radar antennas revolving about a common axis. All of the rotatable wave guides could be placed inside or outside of the ring and the stationary wave guides could be placed respectively outside or inside the ring without any interference between the various stationary and moveable parts. This result is not readily possible with other types of rotary couplers.

If the ring-shaped coupler consisted merely of the annular wall structure with the annular cavity therein, energy which is fed to this cavity would travel in both clockwise and counter-clockwise directions which would set up standing waves within the cavity. As is well known, standing waves are objectionable since they waste power and also because there is a greater danger of arc-over than is found under conditions where there is no standing waves.

The manner in which the energy is fed to the rotary coupler is important. A slot-type coupling between the stationary wave guide and the cavity within the coupler might seem to be an effective solution. A slot-type coupling is objectionable, however, since it is too sensitive to frequency variations because the amount of energy, which is coupled through the slot varies widely with relatively small changes in frequency. Also, the cross-over region is very broad and coupling varies greatly over this portion of rotation making large region of overlap of slots unusable.

Another important problem is to have a continuous flow of energy through the coupler at all times during its rotation over 360 degrees.

One object of the invention, therefore, is to provide a rotary type coupler wherein the structure permits the simple coupling between a plurality of transmission means some of which are movable with respect to another where large standing-wave ratios will not result.

2 Another object of this invention is to provide a rotary coupler of annular ring construction which will not be overly sensitive to frequency changes but will have band-pass characteristics similar to the transmission means between which the coupler is located.

Another object of this invention is to provide a rotary coupler of annular construction wherein a continuous flow of energy will be coupled between the stationary and movable transmission means throughout the 360 degrees of rotation.

Other and further objects and advantages of the invention will be apparent from the following description, the appended claims, and the accompanying drawings which are included and form part of this specification.

In the drawings:

Figure 1 is a top elevational partially cut-away view of the preferred embodiment of the ring rotary coupler;

Figure 2 is a cross-sectional view of Figure 1 along section line 2—2, and contains in addition other elements with which the rotary coupler is to be associated with;

Figure 3 is a diagrammatical representation of a view within the annular cavity of the ring rotary coupler of Figure 1 in a position of rotation where the stationary and movable wave guides communicating with the annular cavity are opposite each other;

Figure 4 shows a perspective view of the portion of the wave guide 29 at the point it enters the annular cavity of the rotary coupler;

Figure 5 shows an enlarged cross section of the annular cavity of the embodiment of Figures 1-2, which is the preferred embodiment, at a time when the finger-like projections are interleaved;

Figures 6 and 7 show fragmentarily other alternative embodiments of the invention.

Referring to Figures 1-2, the rotary coupler 1 consists generally of a movable annular member 2 having a generally rectangular cross-section and a stationary annular member 3 having a generally rectangular trough-shaped cross section. The stationary and movable annular members 3 and 2 are placed closely together so as to form an annular cavity 12 of rectangular cross-section. Communicating with annular cavity 12 is the chamber of a stationary wave guide 29 which is connected to the walls of the stationary annular member 3. Also communicating with the annular cavity 12; is the chamber of a wave guide 7 which is connected to the walls

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of the movable annular member 2 of the coupler. Wave guides 7 and 29 have the same rectangular cross-sectional dimensions as annular cavity 12. Wave guide 7 is connected to and revolves with antenna unit 10 which is shown diagrammatically with the outlines of a parabolic reflector.

The stationary rectangular wave guide 29 delivers the radio frequency energy from a source not shown, into the angular cavity 12 of the rotary coupler. Finger-like projections 4 are shown extending into the annular cavity from the end of wave-guide 29 at an angle with respect to the direction at which the energy is delivered by wave guide 29. These fingers act as a reflecting surface so as to cause the electro-magnetic waves to be bent into the annular cavity of the coupler. The annular cavity becomes a continuation of wave guide 29 and hence has substantially the same frequency characteristics. The fingers 4 are equivalent to a solid plate if the fingers are closely enough spaced and are each in a plane which is parallel to the electric field lines within the cavity which run parallel to the narrow dimension of the cavity. The design of the reflecting surface used in the bending of wave guides (see volume 9 of the Mass. Inst. of Technology Radiation Laboratory Series, 1948 Edition published by McGraw-Hill at pages 203-207) is applicable in determining the length of the fingers and the angle at which they extend into the cavity for best results.

For purposes of defining terms used in the claims, the phrases "effective reflecting projections" and "effective reflecting, finger-like projections" connotes interleaving projections (4, 6) which are spaced sufficiently close together to be equivalent to a solid plate.

Extending into the annular cavity from the end of the wave guide 7 is another set of finger-like projections 6 which bend the waves from the annular cavity into the chamber of wave guide 7. The fingers 6 are positioned to interleave with the fingers 4 as the wave guide 7 and annular member 2 rotate together so that there is no obstruction as the fingers pass each other. (See Figure 5.) Since projections 4 and 6 are equivalent to a solid piece of metal, it can be seen that energy will not be passing through the annular cavity in two directions so as to set up standing waves. For a wave guide whose dimensions were .90 inch by .40 inch, the finger-like projections 4 and 6 were .06 inch in width (i. e. the dimension across the cavity as seen in Figure 5) and the space between the fingers was .10 inch. These dimensions are representative only and are not critical.

From the ring construction, it can be seen that, if so desired, additional wave guides can be connected to the rotary coupler 1 at different radial points within and without the ring without any interference between the stationary and movable wave guides. This is an advantage of the ring-type coupler which is not found in other types of couplers.

Additional rotary couplers as outlined by dotted line 28 in Figure 2, can also be placed below coupler 1 and rotates about the same axis 30.

Referring now particularly to Figure 3, which shows diagrammatically one position of rotation between members 2 and 3 in which the problem of continuous energy flow presents itself. The position of the coupler is there shown where the input and output openings 13 and 14 respectively overlap. In such a position energy coming from wave guide 29 enters output opening 14 from

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two directions. Energy enters wave guide 7 directly from wave guide 29 as shown by one of the arrows and also from the annular cavity since energy can move also completely around the annular cavity and enter wave guide 7 from another path as shown by the bottom arrow. If the waves represented by the bottom arrow were 180 degrees out of phase with the waves coming directly from wave guide 29, then, during the period of overlap, the energy transmitted through the coupler would be substantially reduced. To prevent this, the mean circumference of the angular cavity is made so that the difference in path lengths for waves going around the circumference and those going straight through from 13 to 14 are a whole number of wave lengths at a frequency in the center of the band of frequencies for which the equipment will be used. If only one frequency will be used of course the entire coupler will be designed for this one frequency.

For the purpose of defining terms used in the claims, the phrase "means circumference path" refers to the mean path of the electromagnetic waves passing circumferentially around the annular cavity 12 during the period of overlap as represented by the top and bottom arrows of Figure 3. The term "straight through path" refers to the path length taken by the electromagnetic wave as it passes across the annular cavity during the period of overlap. This is represented by the center arrow of Figure 3.

Although projections 4 and 6 have disclosed as being a series of straight finger-like elements, they could be curved to represent a curved bend in a wave guide. One very important factor, however, is that the cross-sectional dimension at the end of projections 4 and 6 which is along the circumference of the ring formed by the annular cavity must be substantially less than the dimension of the opening 13 and 14 respectively which is along the circumference of the ring in order to prevent the projections from appreciably blocking the flow of energy out of opening 13 or into opening 14 during the position of overlap previously mentioned.

Although annular member 2 has been disclosed as being the movable member, it is clear that member 2 may be made stationary and member 3 made movable without deviating from the spirit of the invention. Many other modifications may be so made which is within the spirit of the invention such as using circular wave guides, and cavities rather than the rectangular wave guides and cavities as disclosed in the drawings. However, the rectangular wave guide arrangement is the preferred embodiment.

Figures 6 and 7 disclose other embodiments of the invention. In these figures, as in Figure 5, the axis of the annular coupler is along a vertical line. In the embodiment of Figure 6, the annular cavity is formed by wall members 16 and 17 which are brought together along a horizontal plane which makes feeding the coupler from above and below the coupler more desirable as by wave guides 18 and 19 respectively. Note also that the shorter dimension of the annular cavity is parallel to the axis of the coupler.

In Figure 7 the wall members 22, 23 which form the annular cavity are brought together along a vertical plane as in the preferred embodiment of Figure 5 but here this plane is located parallel to the shorter dimension, and is located along the mean circumference of the annular cavity. Also, wave guides 26 and 27 are located respectively outside and inside of the annular coupler.

Since the annular cavity is discontinuous at the point where the movable and stationary members come together, unless some means is used to make the discontinuity appear to be continuous, appreciable power losses may result. To this end cavities 5 and 15 of the embodiment of Figure 5, 21 and 20 of the embodiment of Figure 6, and 24 and 25 of Figure 7, are provided to reflect a low impedance at the operating frequency across the discontinuity in the main annular cavity 12. The total length of the passageway as seen in the cross-sectional views Figures 5-7 is in the neighborhood of half-wave length in the center of the band of frequencies to be used with the coupler. These cavities are equivalent to a shorted half-wave length transmission line where the impedance across the open end is the same as if there were a short circuit at that point.

In addition to the rotary coupler in Figure 1, other elements to be used with the coupler in a typical antenna installation is shown in diagrammatical form. Thus element 9 represents electric motor which is used to rotate the coupler together with the parabolic antenna reflector and antenna 10. Thus motor 9 simultaneously drives for example, gear mechanisms 8 and 11 which rotate annular member 2, wave guide 7, and the antenna 10 together as a unit.

It is to be understood that the embodiments specifically disclosed in the above descriptive matter and in the drawings are exemplary only, and numerous modifications may be made without deviating from the spirit of the invention.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed:

1. A rotary coupler wherein high frequency energy is coupled from at least one input wave guide to at least one other relatively rotatable output wave guide comprising a first and second set of relatively movable, complementary wall members positioned in contiguous relation to form an annular wave guide cavity therebetween, an opening in each of said sets of wall members which is in communication with the chambers of said respective input and output wave guides, said wave guides being fixedly connected to the wall members adjacent respectively to one of said openings, a first and second set of interleaving, parallel, effective reflecting projections extending into the annular chamber from an edge of the respective opening, said projections being oriented to direct energy from said input guide to said output guide through said annular cavity, the portion of said projections adjacent their unattached end having a cross-sectional dimension along the circumference of said annular cavity substantially less than the same cross-sectional dimension of said respective opening.

2. A rotary coupler wherein high frequency energy is coupled from at least one input wave guide to at least one other relatively rotatable output wave guide comprising a first and second set of relatively movable, complementary wall members positioned in contiguous relation to form an annular wave guide cavity therebetween, an opening in each of said sets of wall members which is in communication with the chambers of said respective input and output wave guides, said wave guides being fixedly connected to the wall members adjacent respectively to one of said openings, a first and second set of interleaving,

parallel, effective reflecting, projections extending into the annular chamber from an edge of the respective opening, said projections being oriented to direct energy from said input guide to said output guide through said annular cavity, the portion of said projections adjacent their unattached end having a cross-sectional dimension along the circumference of said annular cavity substantially smaller than the same dimension of said respective opening, the mean circumference of said annular cavity being such that the path length difference between the mean circumference path and the straight through path is a whole number of wave-lengths at the operating frequency so that at no time will there be a substantial interruption in the amount of energy being transferred between the said wave guides.

3. A rotary coupler wherein high frequency energy is coupled from at least one input wave guide to at least one other relatively rotatable output wave guide comprising a first and second set of relatively movable, complementary wall members positioned in contiguous relation to form an annular wave guide cavity therebetween, an opening in each of said sets of wall members which is in communication with the chambers of said respective input and output wave guides, said wave guides being fixedly connected to the wall members adjacent respectively to one of said openings, a first and second set of interleaving, parallel, effective reflecting, finger-like projections extending into the annular chamber from an edge of the respective opening, said fingers of each set lying substantially in a plane parallel to the axis of the said annular cavity, and having a length and extending at an angle with respect to the annular chamber walls that they act as effective reflectors of the high frequency electromagnetic waves, said projections having all of its cross-sectional dimensions substantially smaller than the corresponding dimensions of said openings.

4. An antenna coupling system wherein high frequency energy is coupled from at least one wave guide to at least one other relatively rotatable wave guide which is to be connected to a rotatable antenna comprising the combination of a first annular wall member, a second annular wall member which is rotatable with respect to said first annular wall member and which is placed coaxially with and in close proximity to said first wall member to form a substantially enclosed annular wave guide cavity, an opening in each of said first and second wall members communicating with the passageway of said respective former and latter wave guides, a first and second set of interleaving, parallel, effective reflecting, projections extending into the annular chamber from an edge of one of said respective openings, said projections being oriented to direct energy from said one guide to said other guide through said annular cavity, the portion of said projections which are adjacent its unattached end having a cross-sectional dimension along the circumference of said annular cavity substantially less than the same cross-sectional dimension of said respective openings, the mean circumference of said annular cavity being such that the path length difference between the means circumference path and the straight through path is a whole number of wave-lengths at the operating frequency so that at no time will there be a substantial interruption in the amount of energy being transferred between the said wave guides, a rotatable antenna, means connecting

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said rotatable wave guide to said antenna, and means for continuously rotating said antenna, rotatable wave guide, and rotatable wall member together as a unit.

5. An antenna coupling system wherein high frequency energy is coupled from at least one wave guide to at least one other relatively rotatable wave guide which is to be connected to a rotatable antenna comprising the combination of a first annular wall member, a second annular wall member which is rotatable with respect to said first annular wall member and which is placed coaxially with and in close proximity to said first wall member to form a substantially enclosed annular wave guide cavity, an opening in each of said first and second wall members communicating with the passageway of said respective former and latter wave guides, a first and second set of interleaving, parallel, effective reflecting, projections extending into the annular chamber from an edge of one of said respective openings, said projections being oriented to direct energy

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from said one guide to said other guide through said annular cavity, the portion of said projections which is adjacent the unattached end having a cross-sectional dimension along the circumference of said annular cavity substantially less than the same cross-sectional dimension of said respective openings, a rotatable antenna, means connecting said rotatable wave guide to said antenna, and means for continuously rotating said antenna, said rotatable wave guide, and rotatable wall member together as a unit.

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