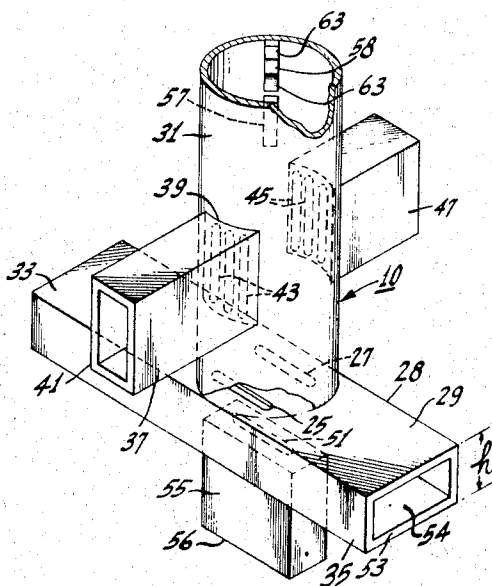
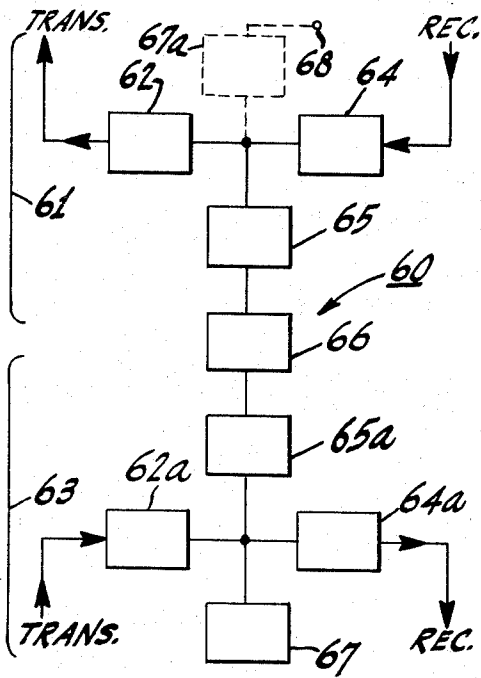
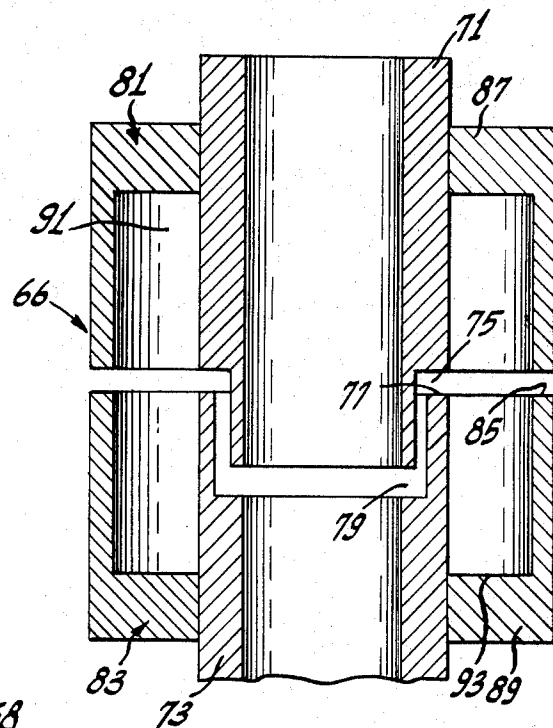
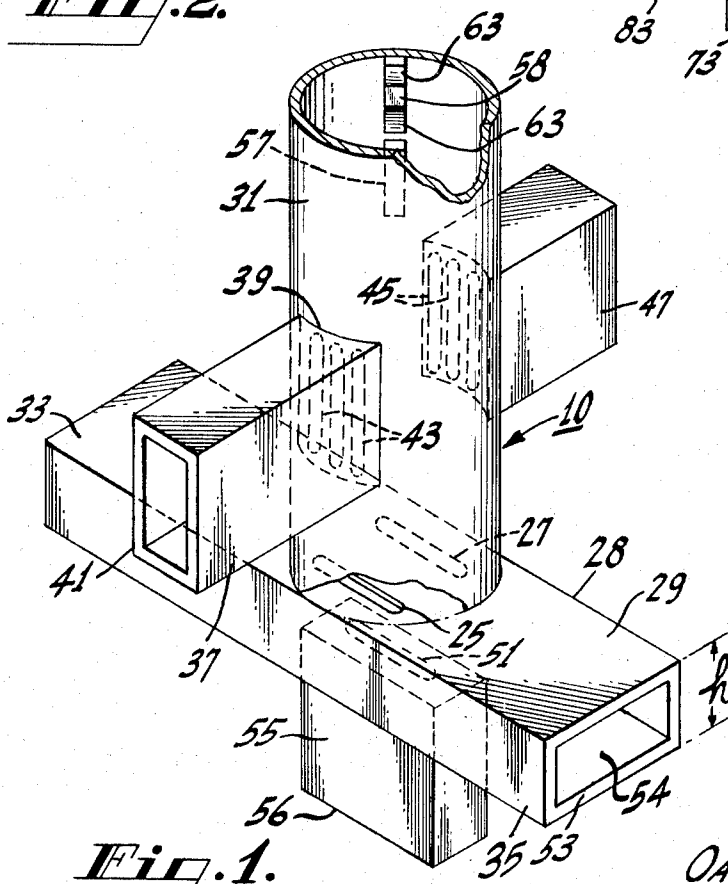


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[57] ABSTRACT

14 Claims, 3 Drawing Figures





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TM₀₁ MODE EXCITER AND A MULTIMODE EXCITER USING SAME

This invention herein described was made in the course of or under the contract or subcontract thereunder with the Department of the Air Force.

This invention relates to mode exciters and more particularly to a TM₀₁ mode exciter.

A TM₀₁ mode electromagnetic wave in circular waveguide is characterized by a radially extending electric field with constant amplitude and phase as a function of angular rotation about the periphery. This characteristic of the TM₀₁ mode wave makes it ideal for use with rotary joint systems. This TM₀₁ mode wave is transferred unaltered across a rotating section of a circular waveguide rotating relative to another section of circular waveguide without presenting distortion or discontinuity between the circular waveguides.

One means of exciting the TM₀₁ mode wave in circular waveguide is by means of a coaxial probe fed from a TEM coaxial transmission line. The impedance bandwidth of this means for exciting a TM₀₁ mode wave has been found to be rather narrow.

Another scheme developed to excite a TM₀₁ mode wave is that of a right angle junction of a rectangular waveguide to a circular waveguide with a step transition at the interface so that a wave in the dominant TE₁₁ mode is suppressed. Although this approach has a greater impedance bandwidth than that obtained by the coaxial probe, suppression of the dominant TE₁₁ mode wave in circular waveguide is difficult. The addition of a diametrical conductive vane can aid in the suppression of the TE₁₁ mode waves at the expense of greater height of the structure in the direction of propagation. This suppression of the dominant TE₁₁ mode wave is a necessity when the dominant TE₁₁ mode wave is carrying different signal information and must be isolated from the TM₀₁ mode wave. It is therefore desirable to provide a TM₀₁ mode exciter which has relatively wide impedance bandwidth and one in which only an electromagnetic wave in the TM₀₁ mode is excited and not waves in the dominant TE₁₁ mode. There may also be a requirement in many applications for either a single exciter or a multimode exciter that is compact.

In some communication applications such as when using space satellites, the antenna scans the skies in azimuth and elevation and the receiver and transmitter are fixed. It is thus necessary to provide a joint which will allow the motion of the antenna and yet present no discontinuity along the joint between the antenna and the fixed receiver and transmitter. Since the rotary joint must present no discontinuity with continuous rotation, the parts of the joint must appear to the field patterns as circularly symmetrical. Likewise, it is required that both the transmit signal and receive signal travel along the same rotary joint. It may also be required that a third signal, which may be a tracking signal, travel along the same rotary joint. This dual channel or three channel rotary joint must be one in which there is a minimum of cross coupling between the transmit and receive signals and/or tracking signal traveling along this joint. This leads to the problem of the selection of the type of modes to be excited on either side of the joint and the manner in which these modes may most efficiently be excited so that the overall unit is relatively compact and yet maintain isolation between the signals.

Rotary joints of the type using TEM modes of propagation with coaxial lines are often used because they meet the proper symmetry for a rotary joint. This type of rotary joint using the coaxial lines is not practical however for many high average power applications because of the excessive heating of the inner conductor.

Systems for providing rotary joints using the TE₀₁ mode are known. This type of rotary joint becomes impractical in applications requiring limited space because of the large size type of TE₀₁ mode exciter design known in the present state of the art.

Another approach for providing a dual channel rotary joint is that of using counter rotating circularly polarized TE₁₁ modes for transmit and receive signals. This approach has a disadvantage in that the two field configurations are in the same basic mode types and any symmetrical impedance mismatch in the rotary junction section will result in cross coupling between the transmit channel and receive signals.

It is therefore an object of the present invention to provide a novel TM₀₁ mode exciter.

It is a further object of the present invention to provide an improved multimode exciter which is relatively compact and provides a minimum of cross coupling between signal channels.

Briefly, this and other objects of the present invention are accomplished by a pair of elongated apertures in a broad wall of a rectangular waveguide with a circular waveguide joined symmetrically to the apertured region which, in response to electromagnetic waves in the rectangular waveguide excite only the TM₀₁ mode in the circular waveguide. The pair of elongated apertures are located on the opposite sides of the center line of the waveguide and extend in the direction of the lengthwise axis of the rectangular waveguide.

This invention will be better understood by reference to the accompanying drawings in which:

FIG. 1 is a perspective view of a TM₀₁ mode exciter and a multimode exciter using same,

FIG. 2 is a block diagram of a dual channel rotary joint system, and

FIG. 3 is a sketch of the rotary joint section associated with the dual channel rotary joint system.

Referring to FIG. 1, there is illustrated the geometry of a multimode exciter 10 capable of exciting the TM₀₁ mode and two orthogonal TE₁₁ modes in circular waveguide 31. The TM₀₁ mode is excited in circular waveguide 31 by the circular waveguide 31 being joined to a properly apertured broad wall 28 of rectangular waveguide 29. The apertures 25 and 27 in the broad wall 28 are narrow, elongated and are equidistant from and on the opposite sides of the center line of the waveguide 29. The elongated length of the apertures 25 and 27 is in the direction of propagation of electromagnetic waves in the rectangular waveguide 29. The circular waveguide 31 is joined to the broad wall 28 such that the center line of the circular waveguide 31 extends perpendicular and through the center line of the rectangular waveguide 29 and midway between the apertures 25 and 27. One end 33 of waveguide 29 is shorted. This short-circuit may be provided by a conductive panel across the aperture of waveguide 29. At the opposite end 35 of waveguide 29 electromagnetic waves are coupled to or from the rectangular waveguide 29.

The electromagnetic wave signal energy travels along the rectangular waveguide 29 from end 35 in the dominant TE_{10} mode. The end 33 of the rectangular waveguide 29 is shorted at a distance from the elongated apertures 25 and 27 such as to provide the best impedance match at the rectangular waveguide input end 35. The signal energy traveling along the rectangular waveguide 29 in the TE_{10} mode excites electromagnetic waves in the TM_{01} mode in circular waveguide 31. The apertures 25 and 27 and the circular waveguide 31 are arranged and dimensioned to provide maximum energy transfer from the TE_{10} mode in the rectangular waveguide 29 to the TM_{01} mode in the circular waveguide 31.

By the placement of the two such elongated apertures or slots 25 and 27 in the broad wall 28 equidistant from and on opposite sides of the center line of the rectangular waveguide 29, the aperture currents are equal in magnitude and flow in opposite directions. In this manner, the TE_{11} mode in the circular waveguide 31 is suppressed at all frequencies and only the next two higher order modes, TM_{01} and TE_{21} , are excited. By the proper selection of the diameter of the circular waveguide 31, the undesired TE_{21} mode is below cutoff, thus leaving only the TM_{01} mode. Because of the reciprocity nature of such microwave devices, electromagnetic wave energy in the TM_{01} mode traveling along the circular waveguide 31 toward elongated apertures 25 and 27 are coupled out of rectangular waveguide 29 in the TE_{10} mode.

Referring to FIG. 1, a rectangular waveguide 37 is joined at right angles to the circular waveguide 31 to excite in the circular waveguide 31 electromagnetic wave energy in the linearly polarized TE_{11} mode. Input and output electromagnetic wave energy traveling along waveguide 37 is applied to or taken from the open end 41 of the waveguide 37. Coupling of this energy from rectangular waveguide 37 to circular waveguide 31 is provided by three elongated parallel apertures or slots 43 in the wall of circular waveguide 31. The breadth of the broad wall of the rectangular waveguide 37 extends along the lengthwise axis of the circular waveguide 31. The elongated apertures 43 in the wall of the circular waveguide 31 extend in the direction of the lengthwise axis of the circular waveguide 31 and parallel to the broad walls of waveguide 37. Electromagnetic wave energy applied at terminal 41 of rectangular waveguide 37 propagates in a dominant TE_{10} mode in the waveguide 37 toward the apertures 43. At the rectangular to circular waveguide interface 39 the linearly polarized TE_{11} mode electromagnetic waves are excited and the higher order TE_{01} and TE_{21} mode waves are excited in the circular waveguide 31. By the proper selection of the circular waveguide 31 diameter, the higher order TE_{01} and TE_{21} mode waves are below cutoff and die out rapidly within a short distance from the junction of the two waveguides.

Referring to FIG. 1, the elongated apertures 43 in the waveguide 31 are oriented at right angles relative to the elongated apertures 25 and 27 that are in rectangular waveguide 29. Because of this orthogonal relationship between narrow elongated apertures the energy in the linearly polarized TE_{11} mode excited at the apertures 43 sees only a reflective radio frequency short and not the elongated apertures 25 and 27. In accordance with

the principles of reciprocity of exciter couplers, properly oriented electromagnetic wave energy in the linearly polarized TE_{11} mode traveling along waveguide 31 excites in the rectangular waveguide 37 wave energy in the TE_{10} mode. This properly oriented TE_{11} mode wave energy is that wherein the electric field of the wave extends perpendicular to the broad walls of the waveguide 37.

By having a series of elongated narrow apertures 43 in the circular waveguide 31 rather than a single relatively wider aperture and rectangular waveguide coupled thereabout, the impedance discontinuity to the TM_{01} mode propagating in the circular waveguide 31 is less. As a further precaution to maintain the symmetry to the TM_{01} mode, identical three parallel elongated apertures 45 are made in the circular waveguide 31 directly opposite that of the three elongated apertures 43. A shorted section of waveguide 47 is symmetrically joined to the circular waveguide 31 at the region of the apertures 45 in the circular waveguide 31. The breadth of the broad walls of the waveguide 47 extends in the direction of the lengthwise axis of the circular waveguide. Since the wave energy in the TE_{11} mode in the circular waveguide 31 will be coupled through the elongated apertures 45, a further advantage is obtained in that the length of the short circuited rectangular waveguide 47 can be employed as an additional impedance matching element for the wave energy in the linearly polarized TE_{11} mode excited at the apertures 43.

Electromagnetic energy in a third mode isolated from the other two modes can be excited in the circular waveguide 31 by an elongated narrow aperture 51 in the broad wall 54 of rectangular waveguide 29 and a third rectangular waveguide 55 is symmetrically joined to this aperture 51. The broad wall 54 is opposite that of broad wall 28 of waveguide 29. The aperture 51 extends along the center line of the waveguide 29 and is centered with respect to an extension of the axis of the circular waveguide 31 and is centered with respect to an extension of the apertures 25 and 27. The rectangular waveguide 55 is positioned such that the width of the broad wall is in the direction of the lengthwise axis of the waveguide 29.

When electromagnetic wave energy is coupled at end 56 of waveguide 55, the signal propagates in the TE_{10} mode toward the aperture 51. Since the aperture 51 is symmetrically placed relative to the apertures 25 and 27, the currents at the apertures 25 and 27 are equal in magnitude and flow in the same direction. Therefore wave energy in the TE_{10} mode at the waveguide 55 excites in the circular waveguide 31 wave energy in the linearly polarized TE_{11} mode. Due to the orthogonal relationship between the elongated narrow apertures 25 and 27 in waveguide 29 and the elongated narrow apertures 43 in the waveguide 31, the polarization of the linearly polarized TE_{11} mode waves excited through apertures 25 and 27 into circular waveguide 31 is orthogonal with respect to the polarization of the TE_{11} mode signal waves excited through apertures 43. Consequently, wave energy excited through apertures 25 and 27 is isolated from the wave energy excited through apertures 43. Due to the reciprocal nature of these devices, properly oriented linearly polarized TE_{11} mode wave energy traveling along circular waveguide

31 is transferred through apertures 25 and 27 and aperture 51 to rectangular waveguide 55 in the TE_{10} mode without being coupled through aperture 43. This properly oriented TE_{11} mode wave energy is that where the electric field of the wave is perpendicular to the elongated apertures 25 and 27.

The wave energy coupled through aperture 51 in waveguide 29 is isolated from terminal 35 of waveguide 29 because the height h of the rectangular waveguide 29 is insufficient to support an electromagnetic field of a mode which would get excited in waveguide 29. The wave energy in the TE_{10} mode traveling along waveguide 29 is isolated from waveguide 55 because the centered placement of the narrow elongated aperture 51 makes it at the lowest coupling point of the waveguide 29.

It is often desirable, particularly when the electromagnetic waves must propagate across a rotary joint, to transform the orthogonal linearly polarized TE_{11} mode waves excited at apertures 43 and those excited by the combination of apertures 25, 27 and 51 into respective right and left circularly polarized TE_{11} mode signals. Referring to FIG. 1, ridges 57 and 58 are placed on the opposite sides of the circular waveguide 31. These ridges 57 and 58 lie in a plane oriented at a 45° angle relative to that of waveguide 37 and the lengthwise axis of apertures 25 and 27. The incoming linearly polarized TE_{11} mode waves excited at apertures 43 and orthogonal apertures 25 and 27 and applied toward ridges 57 and 58 may each be resolved into two orthogonal components of equal amplitude and phase, one which is aligned parallel to the plane of the ridges 57 and 58 and the other perpendicular. The different loading caused by the ridges 57 and 58 to these two orthogonal components results in an unequal phase velocity for these two components. By the proper design of ridges 57 and 58, as is well known in the state of the art, the two orthogonal components emerging from the far end of the ridges 57 and 58 which make up the polarizer have equal amplitudes with quadrature phasing or circular polarization.

Linearly polarized TE_{11} mode waves excited at the apertures 43 in the circular waveguide 31 are converted to a circular polarized TE_{11} mode waves in a first direction. The orthogonal linearly polarized TE_{11} mode waves excited at the apertures 25 and 27 are converted to circular polarized TE_{11} mode waves rotating in a direction opposite the first direction.

Since ridges 57 and 58 are symmetrical relative to the center of the circular waveguide 31, they do not cause any mode conversion between the TM_{01} mode and the TE_{11} mode. Also the ridges may be designed to have a relatively small penetration, about one-eighth inch, for example, into the circular waveguide so as to minimize the impedance discontinuity to the TM_{01} mode waves. Because of this small penetration, the length of the ridges to obtain quadrature phasing may be relatively long from about eight to ten inches for receive signals in the 7250 to 7750 megahertz frequency range. The ends 63 of the ridges are tapered to reduce the impedance discontinuity presented by the ridges.

Referring to FIG. 2, there is illustrated a block diagram of a dual channel rotary joint system 60. The system 60 is made up of a first multimode exciter and

polarizer system 61 and a second multimode exciter and polarizer system 63 and a rotary joint section 66 coupled therebetween. The multimode exciter and polarizer system 61 may be a rotating structure coupled to a rotating antenna and the multimode exciter and polarizer system 63 may be a stationary structure coupled to a stationary receiver and transmitter. The multimode exciter and polarizer system 61 is made up of a TM_{01} mode exciter 62, a linearly polarized TE_{11} mode exciter 64 and a polarizer section 65. The multimode exciter and polarizer system 63 is made up of a TM_{01} mode exciter 62a, a linearly polarized TE_{11} mode exciter 64a, a reflection absorbing load 67, and a polarizer section 65a.

The TM_{01} mode exciters 62 and 62a are each constructed in accordance with FIG. 1 wherein dual elongated apertures are cut in the broad walls of a first rectangular waveguide and a circular waveguide is joined symmetrically thereto. The linearly polarized TE_{11} mode exciters 64 and 64a are each constructed like that in FIG. 1 wherein apertures similar to apertures 43 are located in the circular waveguide and a second rectangular waveguide similar to rectangular waveguide 37 is joined symmetrically thereto. The polarizers 65 and 65a are each provided by a pair of ridges similar to 57 and 58 of FIG. 1 in the circular waveguide which ridges lie in a plane oriented at a 45° angle with respect to that of the second rectangular waveguide.

In the dual channel rotary joint system, the two circular waveguide sections associated with the exciters are each positioned in aligned relation to the other with the free ends of the circular waveguide section spaced from each other by a rotary joint section 66. The reflection absorbing load 67 of multimode exciter and polarizer system 63 is provided by a third waveguide and aperture centered in the broad wall of the first waveguide opposite that having dual slots therein. This configuration is like that illustrated in FIG. 1 wherein waveguide 55 is junctured with waveguide 29 having aperture 51 therein. This third waveguide which forms a part of load 67 has microwave signal-absorbing material therein. As described previously in connection with FIG. 1, neither wave energy in the TM_{01} mode nor the wave energy in the properly oriented linear TE_{11} mode associated with the second waveguide are coupled to load 67. Any linear TE_{11} mode signals orthogonal to the above properly oriented linear TE_{11} mode signals, such as that caused by reflections from the rotary joint section 66, would be coupled to load 67. This absorption of the small reflected wave reduces the output signal variation as a function of angular rotation of the rotating multimode exciter and polarizer system 61 relative to the fixed multimode exciter and polarizer system 63. This absorption of the reflected waves further reduces the voltage standing wave ratio of the linearly polarized TE_{11} mode channel associated with exciters 64 and 64a with only a small power loss for reasonably small impedance mismatches.

Referring to FIG. 3, there is illustrated in cross section the rotary joint section 66 which is made up of two circular waveguide sections 71, 73. Circular waveguide sections 71 and 73 may be an extension of the circular waveguides which are in aligned relation to each other and which are each represented in FIG. 1 as circular

waveguide 31. Waveguide section 71 has a reduced wall thickness and cross section at one end near the center of the rotary joint 66 such as to fit coaxially within and along the waveguide section 73 having an increased aperture with a gap 75 between the two waveguide sections 71 and 73. The length of the overlap of the two sections 71 and 73 from the exterior gap point 77 to the interior gap point 79 is approximately one-quarter wavelength long at the mean operating frequency of the dual channel rotary joint system between the transmit and receive frequency band. By making the gap between the two circular waveguide sections 71 and 73 small, a low characteristic impedance coaxial line one-quarter wavelength long at the mean frequency stated above between gap points 77 and 79.

A pair of one-quarter wave choke flanges 81 and 83 are mounted coaxial with and to the respective circular waveguide sections 71 and 73. The flanges 81 and 83 are mounted close to each other with a gap 85 between the flanges. The gap 85 is arranged to be aligned with the exterior gap point 77. The flanges 81 and 83 are shorted at ends 87 and 89 with the respective waveguide sections 71 and 73 one-quarter wavelength at the mean frequency of the dual channel system from the gaps 75 and 85. By the placement of the gap 85 in the middle between two flanges, both flanges being identical, two one-quarter wavelength chokes are provided in series. Since the two circular waveguide sections 71 and 73 provide a relatively low impedance transmission line and since the gap 85 is a quarter wavelength from the short circuited points 87 and 89, the gap 85 presents a relatively high impedance relative to that of the gap 75. Because there are two quarter wavelength flanges in series, the gap 85 presents an even higher impedance relative to that of the overlapped circular waveguide sections 71 and 73. This series impedance further increases the overall bandwidth of the system.

The rotary joint must operate with a minimum of discontinuity for both electromagnetic waves in the TE_{11} mode and in the TM_{01} mode of propagation. The relative phase velocity in the quarter wavelength coaxial line made up of sections 71 and 73 spaced by the gap 75 is unity for waves in the TM_{01} mode. Electromagnetic waves in the TM_{01} mode have a constant phase voltage around the gap 79. Electromagnetic wave energy in a circularly polarized TE_{11} mode in the circular waveguide generates a progressively-phased voltage around the gap 79. The one-quarter wavelength coaxial line formed by the overlap of the waveguide sections 71 and 73 becomes a coaxial waveguide supporting waves in the TE_{11} mode. Because of the close spacing between the inner and outer conductors of this coaxial one-quarter wavelength transmission line, the relative phase velocity for the waves in the TE_{11} mode is only a few percent greater than that of the waves in the TM_{01} mode. The overall operation of the dual channel rotary joint system 60 can be understood by reference to FIG. 2. Transmit signal energy from a fixed transmitter is coupled to TM_{01} mode exciter 62a of multimode exciter and polarizer 63. This transmit signal energy excites waves in the TM_{01} mode in the circular waveguide system of multimode exciter and polarizer 63. The transmit signal energy in the TM_{01} mode in the

circular waveguide propagates through the polarizer 65a, along sections 71 and 73 of the rotary joint section 66 through polarizer section 65 to the TM_{01} mode exciter 62 in the rotatable multimode exciter and polarizer system 61. At the TM_{01} mode exciter 62, transmit signal energy in the TM_{01} mode is converted to energy in the TE_{10} mode in a rectangular waveguide. Received signal energy from a rotating antenna is coupled to the linearly polarized TE_{11} mode exciter 64 of rotatable multimode exciter and polarizer system 61. At the exciter 64, the received signal energy in the TE_{10} mode traveling along a rectangular waveguide is converted to wave energy in the linearly polarized TE_{11} mode in the circular waveguide. The linearly polarized TE_{11} mode wave energy is circularly polarized at the polarizer section 65. This circularly polarized TE_{11} mode signal energy is coupled along the aligned circular sections 71 and 73 of rotary joint 66 to the polarizer 65a of the multimode exciter and polarizer system 63. At the polarizer 65a, the received energy in the circularly polarized TE_{11} mode is converted to received energy in linearly polarized TE_{11} mode and is coupled to the linearly polarized TE_{11} mode exciter 64a. At the exciter section 64a, the received signal energy in the linear TE_{11} mode is converted to received signal energy in the TE_{10} mode in rectangular waveguide through apertures similar to that of apertures 43 in FIG. 1. This received signal energy is then coupled to a fixed receiver terminal. As mentioned previously, linearly polarized TE_{11} mode wave energy reflected from the rotary joint section 66 is coupled through the dual aperture in the broad wall and the single aperture on the opposite side of the broad wall of the waveguide. These reflected signals from the rotary joint are then coupled to the waveguide section 67 which includes an absorbing load.

In the operation of the system as described herein with a receiver operating between 7250 to 7750 MHz and a transmitter operating between 7900 and 8400 MHz, the TM_{01} mode exciter had the following dimensions:

Rectangular waveguide 29 is WR 137 waveguide (1.372 inch height $\times$ 0.622 width inside dimensions),

Apertures 25 and 27: width 0.11 wavelengths and length 0.566 at the mean transmitter operating frequency, apertures 25 and 27 offset from center line of rectangular waveguide 29 0.263 wavelengths at the mean transmitter operating frequency or about 0.378 inch from the center line, and apertures each about 0.15 inch width and 0.770 inch long,

Waveguide 29 is terminated in a short circuit about 1.1 inches from the center of the apertures 25 and 27,

Circular waveguide 31: diameter 0.9 wavelengths at the mean operating frequency between transmitter and receiver frequency or for the arrangement described about 1.3 inch diameter,

Rectangular waveguides 37 and 47 (WR-112) for mean receiver frequency described about 0.497 inch height $\times$ 1.122 inch width inside dimension,

Apertures 43 and 45: width 0.116 inch, length 1.10 inch,

The ridges were about $\frac{1}{8}$ inch in depth and about 10.962 inches long,

The waveguide 55 is WR-90 waveguide, and Aperture 51: 0.062 inch wide $\times$ 0.770 inch length,

In the operation of one described above, each mode exciter had a VSWR of less than 1.2 to 1 over a band of at least 7 percent. When two such exciters were placed together and joined by means of the rotary joint described, the output signal variation as a function of angular rotation was found to be less than 0.05 db over both transmit and receive frequency bands.

While the above description was that of a dual channel rotary joint waveguide system, this multimode exciter and polarizer system as shown in FIG. 1 is capable of providing a three channel waveguide system. The first or the transmit channel waveguide system is that provided by the excitation of waves in the TM_{01} mode and waves through the rotary joint section as described above, including the two TM_{01} mode exciters 62 and 62a of FIG. 2. The second or receive channel is that provided by the excitation of waves in the TE_{11} mode, the circular polarization of these waves and coupling of these circular polarized TE_{11} mode waves through the rotary joint section 66 as described in connection with exciters 64 and 64a and polarizer 65 and 65a. A third channel waveguide system can be had by excitation of waves in a second linearly polarized TE_{11} mode orthogonal to the first by the combination of the dual apertures on one of the broad walls of the rectangular waveguide and the single aperture on the opposite broad wall of that waveguide as illustrated by apertures 25, 27 and 51 in waveguide 29 of FIG. 1. Since the linear TE_{11} mode waves associated with the second channel are orthogonal to the third, the channels are isolated from each other and when passed through the polarizer they have opposite directions of circular polarization. By removing the absorption material in load 67 of FIG. 2 and using the associated waveguide as a part of the third channel system and by adding a similar coupling structure 67a (indicated by dashed lines in FIG. 2) at the multimode exciter and polarizer system 61, a third channel system may be provided. In the third channel system a signal is excited in the linear TE_{11} mode at exciter 67. This signal is circular polarized at 65a and is coupled through the rotary joint section 66 to polarizer 65. At polarizer 65 this third channel signal is converted from circular to linear polarization and is coupled through exciter 67a to a third channel terminal 68 in the rotating multimode exciter and polarizer system 61.

What is claimed is:

1. A TM_{01} exciter comprising:

a rectangular waveguide structure having a pair of broad walls extending between a pair of narrow walls for propagating electromagnetic waves, said rectangular waveguide structure having a pair of apertures disposed on one of the broad walls of said rectangular waveguide structure with said apertures being located on opposite sides of that center line of said one broad wall between the two narrow walls, and a circular waveguide structure joined normal to said one broad wall of said rectangular waveguide structure with the circular waveguide structure being symmetrically disposed relative to said apertures to provide, when an electromagnetic wave is propagated toward the junction through the rectangular waveguide in the TE_{10} mode, maximum energy transfer into the circular

waveguide structure in the TM_{01} mode with energy in TE_{11} mode being suppressed.

2. The combination as claimed in claim 1 wherein said apertures are elongated and extend along a portion of the length of said rectangular waveguide.

3. The combination as claimed in claim 2 wherein said elongated apertures are equidistant from the center line of the rectangular waveguide.

4. A multimode exciter comprising:

a first rectangular waveguide structure for propagation of electromagnetic waves,

said first rectangular waveguide structure having a pair of broad walls extending between a pair of narrow walls, said first rectangular waveguide structure having a pair of elongated apertures disposed in one of the broad walls of said first rectangular waveguide structure with the apertures being symmetrically disposed on opposite sides of that center line of said one broad wall between the two narrow walls,

a circular waveguide structure disposed normal to said one broad wall of said first rectangular waveguide structure with the circular waveguide structure symmetrically disposed relative to the pair of elongated apertures to provide, when electromagnetic wave energy is propagated toward the junction along the first rectangular waveguide in the TE_{10} mode, maximum energy transfer into the circular waveguide structure in the TM_{01} mode with energy in the TE_{11} mode being suppressed,

said circular waveguide structure having at least one elongated aperture extending along the lengthwise axis of the circular waveguide wall,

a second rectangular waveguide structure joined normal to said circular waveguide structure with the second rectangular waveguide structure being disposed relative to said aperture in the wall of said circular waveguide structure to provide, when electromagnetic wave energy is propagated toward the junction of the second rectangular waveguide structure and said circular waveguide structure through the second rectangular waveguide structure in the TE_{10} mode, maximum energy transfer into the circular waveguide structure in the TE_{11} mode.

5. The combination as claimed in claim 4 wherein the broad wall of said second rectangular waveguide structure is parallel to the lengthwise axis of said circular waveguide structure.

6. The combination as claimed in claim 5 wherein a pair of ridges are located within said circular waveguide structure.

7. The combination as claimed in claim 6 wherein said pair of ridges are aligned on opposite sides of said circular waveguide structure such that the angle formed by the intersection of a plane through the cross sectional center of the ridges and a plane through the cross sectional center of the second rectangular waveguide is equal to about 45 degrees.

8. The combination as claimed in claim 7 wherein a plurality of narrow elongated rectangular apertures are located in the wall of said circular waveguide structure with said second rectangular waveguide structure mounted perpendicular to said circular waveguide structure about the region of said apertures.

9. The combination as claimed in claim 8 wherein said narrow elongated apertures in said circular waveguide structure have their lengthwise axis parallel to the broad walls of said second rectangular waveguide.

10. The combination as claimed in claim 9 including a third rectangular waveguide structure perpendicular to and aligned with on opposite side of said circular waveguide structure relative to said second rectangular waveguide structure, said third rectangular waveguide structure being terminated in a short circuit with the broad wall along the lengthwise axis of said circular waveguide, said circular waveguide having a plurality of elongated apertures at the junction region of said third rectangular waveguide to said circular waveguide structure.

11. A multimode exciter comprising:

a first rectangular waveguide structure for propagation of electromagnetic waves,

said first rectangular waveguide structure having a pair of slot-like apertures disposed in one of the broad walls of said first rectangular waveguide structure with the apertures being symmetrically disposed on opposite sides of the center line of said waveguide,

a circular waveguide structure disposed normal to said one broad wall of said first rectangular waveguide structure with the circular waveguide symmetrically disposed relative to said pair of apertures to provide, when electromagnetic energy is propagated toward the junction along the first rectangular waveguide in the TE_{10} mode, maximum energy into the circular waveguide in the TM_{01} mode,

said first rectangular waveguide having a single slot-like aperture centered along a broad wall opposite said first-mentioned broad wall,

a second rectangular waveguide structure disposed normal to said opposite broad wall of said first rectangular waveguide structure to provide, when electromagnetic energy is propagated toward the single aperture along said second rectangular waveguide in the TE_{10} mode, maximum energy transfer into the circular waveguide in the linear TE_{11} mode.

12. A waveguide system including a rotary joint for the coupling of signals within at least two frequency bands through said rotary joint comprising:

a first circular waveguide structure,

a second circular waveguide structure spaced from said first circular waveguide structure by said rotary joint,

said first and second circular waveguide structures each having first and second ports,

means responsive to signals within a first of said frequency bands at the first port of said first circular waveguide structure for exciting said signals within a first of said frequency bands in the TM_{01} mode along said first circular waveguide structure,

means for coupling said signals within said first frequency band in the TM_{01} mode from the first circular waveguide structure through the rotary joint to said second circular waveguide structure,

means responsive to said signal within said first frequency band signals in the TM_{01} mode at said

second circular waveguide structure for the coupling of said signals within said first frequency band in the TM_{01} mode out of the first port of said second circular waveguide structure,

means responsive to signals within a second of said frequency bands at the second port of said second circular waveguide structure for exciting said signal within said second frequency band in the linearly polarized TE_{11} mode along said second circular waveguide structure,

means along said second circular waveguide structure responsive to said second frequency band signals in said linearly polarized TE_{11} mode for transforming said second frequency band signals to circularly polarized TE_{11} mode signals,

means for coupling said second frequency band signals in the circularly polarized TE_{11} mode from said second circular waveguide structure through said rotary joint to said first circular waveguide structure,

means at said first circular waveguide structure responsive to said second frequency band signals in said circularly polarized TE_{11} mode for transforming said second frequency band circularly polarized TE_{11} mode signals to second frequency band linearly polarized TE_{11} mode signals, and

means responsive to said second frequency, linearly polarized TE_{11} mode signals at said first circular waveguide structure for the coupling of said signal in said second frequency band out of the second port of said first circular waveguide structure.

13. A waveguide system including a rotary joint for the coupling of signals within at least two frequency bands through said rotary joint comprising:

a first circular waveguide structure,

a second circular waveguide structure,

said first and second circular waveguide structures having a common axis coupled to each other end to end through said rotary joint, each of the free ends of each of said circular waveguide structures being joined to two mutually perpendicular rectangular waveguides, said rectangular waveguides having their axes perpendicular to the axis of said circular waveguide structures,

the first rectangular waveguide of said two rectangular waveguides and said first circular waveguide structure in coupling relation with each other so that signals within a first of said frequency bands along said first rectangular waveguide provide maximum energy transference into the circular waveguide structure in the TM_{01} mode and propagation of said signals within the first frequency band in the TM_{01} mode occurs, whereupon said TM_{01} mode signals propagate along said first circular waveguide structure through said rotary joint to said second circular waveguide structure, the second rectangular waveguide of said two rectangular waveguides joined to said second circular waveguide structure communicating with said second circular waveguide structure so as to provide coupling of said signals within the first frequency band in the TM_{01} mode out of said second rectangular waveguide,

a third rectangular waveguide structure joined to said second circular waveguide structure commu-

nicating with said second circular waveguide structure to provide maximum energy transfer of said signals within the second frequency band of said two frequency bands to said second circular waveguide structure in the linearly polarized TE_{11} mode along said second circular waveguide structure,

means along said second circular waveguide structure responsive to the second frequency band signals in said linearly polarized TE_{11} mode for transforming the second frequency band signals to circularly polarized TE_{11} mode signals whereupon said circularly polarized TE_{11} mode signals are coupled along said second circular waveguide structure and said rotary joint to said first circular waveguide structure,

means at said first circular waveguide structure responsive to the second frequency band signals in said circularly polarized TE_{11} mode for transforming said second frequency band signals to linearly polarized TE_{11} mode signals, and

a fourth rectangular waveguide structure joined to said first circular waveguide structure communicating with said first circular waveguide structure so that said TE_{11} mode signals within the second frequency band are coupled out of said second rectangular waveguide structure joined to said first circular waveguide structure.

14. In combination:

a first rectangular waveguide having a pair of apertures in one broad wall equally disposed on opposite sides of said one broad wall of said first rectangular waveguide,

a first and a second circular waveguide spaced from and communicating with each other by a rotary joint, said first circular waveguide joined normal to said first rectangular waveguide with said first circular waveguide disposed relative to said apertures to provide maximum transfer of energy through the first rectangular waveguide in the TE_{10} mode to said first circular waveguide in the TM_{01} mode, said first circular waveguide having at least one aper-

ture along the waveguiding wall,

a second rectangular waveguide positioned normal to said first circular waveguide and about said aperture in the wall of said first circular waveguide so as to be in coupling relation to said first circular waveguide for the coupling of energy in the linearly polarized TE_{11} mode from said first circular waveguide to said second rectangular waveguide,

said second circular waveguide having an aperture along the waveguiding wall,

a third rectangular waveguide having a pair of apertures in one broad wall equally disposed on opposite sides of said one broad wall of said third rectangular waveguide,

said second circular waveguide mounted normal to said third rectangular waveguide with the second circular waveguide disposed relative to said apertures to provide maximum transfer of energy from the second circular waveguide in the TM_{01} mode to the third rectangular waveguide in the TE_{10} mode,

a fourth rectangular waveguide joined normal to said second circular waveguide and about said aperture in the waveguiding wall of said second circular waveguide so as to be in coupling relation to said second circular waveguide to provide maximum energy transfer through the fourth rectangular waveguide in the TE_{10} mode into the second circular waveguide in the linearly polarized TE_{11} mode, said first and said second circular waveguides each having ridges within said respective first and second circular waveguides, said ridges in said second circular waveguide in response to said linearly polarized TE_{11} mode signals providing circularly polarized TE_{11} mode signals at said rotary joint, said ridges within said first circular waveguide responsive to said circularly polarized TE_{11} mode signals coupled to said first circular waveguide through said rotary joint converting said circularly polarized TE_{11} mode signals to linearly polarized TE_{11} mode signals.

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