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WAVE GUIDE COUPLING DEVICE

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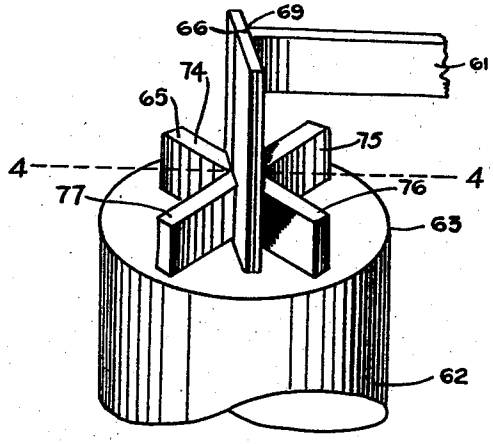


Fig. 1

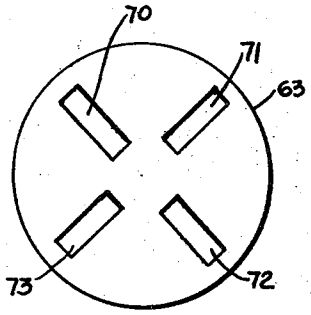


Fig. 2

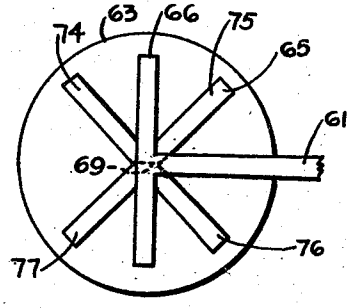


Fig. 3

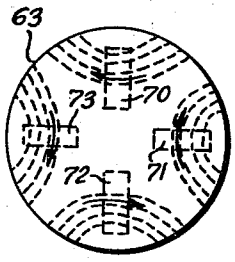


Fig. 5

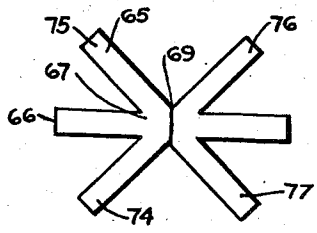


Fig. 4

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WAVE GUIDE COUPLING DEVICE

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Original application August 15, 1944, Serial No. 549,618. Divided and this application August 31, 1944, Serial No. 552,173

8 Claims. (Cl. 178—44)

1

This application is a division of my abandoned application Serial No. 549,618, filed August 15, 1944, and relates in general to the fields of ultra-high frequency signal transmission and more particularly concerns novel means for generating particular modes of wave transmission.

In micro-wave transmission in wave guides and in various other applications, it is often desirable to transmit a single oscillation mode. For example, for transmission over a considerable distance, it is well known that the TE_{01} mode of propagation is that which involves the lowest attenuation loss.

Moreover, for certain directional antenna structures, it is desirable to excite the antenna with a particular oscillation mode in order to obtain the required directional characteristic, as for example, a horizontally polarized energy distribution pattern omnidirectional in the horizontal plane. An antenna array comprising a plurality of stacked biconical horns upon a slotted cavity resonator gives an excellent horizontal polarization characteristic of high directivity. The antenna structure is simpler and has lower loss than the conventional stacked di-pole array and is better adapted to operation on ultra high frequencies. It therefore has considerable application in micro-wave transmission.

However, in order to obtain a uniform circular energy distribution from the stacked biconical horn antenna, it has been found that excitation must be accomplished by the TE_{01} mode of oscillation. Should other modes enter the cavity which feeds the antenna, the field distribution pattern at a distance from the antenna will no longer be quite circular, but will have pronounced symmetrical lobes, the number of which will be determined by the nature of the spurious oscillation modes. For example, it has been found that attempts to excite a TE_{01} oscillation mode have been accompanied by the generation of a considerable TE_{21} mode in a circular pipe.

Since the TE_{21} oscillation can exist in a smaller diameter pipe than the TE_{01}, it is ordinarily difficult to remove this spurious mode. In the stacked biconical horn antenna structure, the TE_{21} wave will result in a pronounced four-way symmetry over the circular horizontal field distribution obtained by the TE_{01} wave alone.

In the past, attempts to generate the low attenuation TE_{01} oscillation mode have been accomplished by complex driving apparatus and have resulted in an impure wave, including several other oscillation modes. It has thus become the practice to attempt to resonate the antenna

2

structure whenever possible for the TE_{01} wave in order that maximum power output at this mode could be obtained.

My invention contemplates a wave guide transmission system including a number of transducers permitting the excitation in one central cavity of the TE_{01} wave in its pure state.

In order to excite the TE_{01} mode in a circular wave guide, my invention contemplates the use of a driving network which couples into the circular wave guide through symmetrically arranged slots, excited to an equal extent in the same time phase with respect to the circular wave of the TE_{01} mode and in the same sense. Feeding energy into the wave guide through a slot prevents any longitudinal field and thus prevents coupling to modes having longitudinal field patterns.

For carrying out my invention, the driving network is coupled into the circular guide in four symmetrical quadrants. All four quadrants are excited equally in the same sense and in the same time phase with respect to the circular wave of the TE_{01} mode.

In each quadrant, electrical energy is fed into the wave guide through a slot. The four slots are equally driven from a symmetrically branching wave guide. The symmetry insures equal excitation and appropriate phasing of each slot.

It is therefore an object of my invention to provide means for generating the TE_{01} wave in its pure state.

Another object of my invention is to provide transducers for coupling an oscillating source to a wave guide or the like which will transmit only the TE_{01} oscillation mode.

A further object of my invention is to provide a means for coupling a rectangular wave guide to a circular wave guide in such a manner that the transmitted wave excited in the circular wave guide is essentially the TE_{01} mode.

Another object of my invention is to generate the TE_{01} oscillation mode in pure form in a circular wave guide.

Still another object of my invention is to utilize a novel arrangement of symmetrical slits in an end plate of a wave guide resulting in the generation of a pure TE_{01} wave.

These and other objects of my invention will now become apparent from the following specification taken in connection with the accompanying drawings in which:

Figure 1 is a perspective view of a form of wave guide having means for exciting only the TE_{01} oscillation mode therein.

Figure 2 is a front view of the end plate utilized for closing the guide illustrated in Figure 1.

Figure 3 is a top view of the cavity driving means illustrated in Figure 1.

Figure 4 is a cross-sectional view of the slot driving means taken along the line 4—4.

Figure 5 is an illustration of the field distribution at slits in a plate.

As previously mentioned, it has long been known that the TE_{01} wave or the H_{01} wave is that mode of oscillation which under certain conditions is least attenuated during transmission. On the other hand, this oscillation mode has been difficult to excite without attendant development of undesirable high attenuation transmission modes.

In the parent case, of which this is a division, I have shown a stacked biconical horn array utilized to develop a field distribution having a uniform circular horizontal pattern. That is to say, the signal strength radiated from this antenna is independent of azimuth. However, for this purpose, it best operates if excited by the TE_{01} mode.

When excited by TE_{01} waves, the electric field is horizontal at all points and circular about the axis of the wave guide. Accordingly, the field pattern radiated is essentially an intense horizontally polarized signal and has omnidirectional vertical activity.

This antenna structure which has lower loss and far greater utility due to its simplicity than the usual stacked dipole array is, as stated, dependent for proper orientation upon the excitation by the TE_{01} in pure form.

In the following description, various means will be illustrated embodying my invention for generating a TE_{01} wave. It is to be understood that the application of the transducers to be described is not necessarily limited to the biconical horn antenna disclosed, but may be utilized wherever transmission of micro-wave for a considerable distance is required.

In Figures 1 to 4 there is illustrated a transducer for generating the TE_{01} transmission mode in pure form in a circular wave guide by utilizing a four-way symmetry.

As illustrated in Figure 1, a rectangular wave guide 61 carrying energy from an ultra-high frequency source is coupled through a transducer to the circular wave guide 62. The transducer or coupling element is constructed with four-way symmetry so as to permit the excitation of the TE_{01} mode in the circular wave guide 62. An end plate 63 covering the circular wave guide 62 is perforated to provide as illustrated in Figure 1, four rectangular slots 70 to 73 dividing the circular surface into quadrants as shown.

Securely fitted to the metal end plate 63 is a transducer section 65 comprising four rectangular wave guide sections 74 to 77, positioned directly over the corresponding rectangular slots 70 to 73. These rectangular wave guide sections 74 to 77 are opened at that point where they contact the slits 70 to 73 and accordingly permit the transfer of energy from the guide sections to the circular wave guide 62.

The rectangular wave guide sections 74 to 77 extend radially inward and are coupled to another rectangular wave guide section 66 which as is illustrated in Figures 1, 3 and 4, is vertically disposed and provided with plate 69 to bisect the four wave guides, two of the wave guides 74 and 75 being on one side and wave guides 76 and 77 being on the opposite side of the plate.

This is more clearly shown in Figure 4 which shows the individual guide sections 74 to 77 opening into the guide section 66 at points such as 67. As is illustrated in this figure, the rectangular guide section 66 is bisected by a metal partition 69 which extends to the metal surface 63. The partition 69 in addition to bisecting the guide section 66 separates the four guide sections 74 to 77, covering the rectangular slits 70 to 73.

As illustrated in Figure 1, the vertical rectangular wave guide 66 extends beyond the four crossed guide sections 65, and is directly coupled to the input wave guide 61. Thus the energy fed over the wave guide 61 divides equally on both sides of the bisecting plate 69 of wave guide 66. Energy in each half of wave guide 66 in turn divides equally between the two wave guide sections 74 and 75 fed from one side of the barrier 69, and the two wave guides 76 and 77 fed from the other side of the barrier 69.

As will now be clear, the four wave guides 74 to 77 terminating in the slots 70 to 73 have a four-way symmetry in the circumferential or angular dimension, each quadrant of which produces an equal component of electromotive force in the same time phase and in a circumferential direction so as to be additive in effect. That is to say, the E. M. F. are in the same sense when passing continuously around the circumference. If there is negligible net longitudinal E. M. F., as is true with slot couplings and if the wave guide diameter is chosen greater than the cut-off diameter for the TE_{01} mode but smaller than the next mode which could also be excited by this drive, a TE_{01} mode in pure form will be excited.

This construction however keeps out entirely the TE_{21} mode. As schematically shown in Figure 5, the wave guide, if excited as shown by the dotted arrows, would have two opposed couplings to the TE_{21} and this mode will therefore fail to be excited.

Energy from the input wave guide 61 is thus coupled to the circular guide 62 through the symmetrical four-way drive illustrated in Figures 1 to 4 so that the field in the circular wave guide beyond the end plate 63 is that of the TE_{01} mode alone.

The circular wave guide 62, as already stated, is chosen such that its diameter is greater than that required to transmit the TE_{01} mode. However, this diameter is smaller than that required for transmission of the next higher mode.

If, however, it is desired to transmit this energy in a larger diameter pipe, and accordingly minimize attenuation, a flared fitting as shown in my parent application may be used as a coupler between wave guide section 62 and a larger diameter circular wave guide. As the TE_{21} mode is completely suppressed as described, the energy propagated in the larger diameter section is essentially the TE_{01} mode in pure form.

While for purposes of illustration I have shown a transducer provided with four slits, it will now be apparent that more than four slits symmetrically arranged may be used in generating the TE_{01} mode in a circular wave guide.

My invention thus may take on other forms and I do not wish to be limited by the illustrations herein given but only by the claims hereof.

I claim:

1. In a high frequency system, a rectangular wave guide for carrying energy from a high frequency source, a second wave guide of circular cross-section and a coupling element connected on the ends of said wave guides comprising a

pair of coupling rectangular wave guides coupled at one end to said first mentioned wave guide, the energy in said first wave guide dividing equally in each of said pair of wave guides, and four additional rectangular wave guides, each pair of said additional wave guides being coupled to one of said first mentioned pair of wave guides, the energy in each of said first mentioned pair of wave guides in turn dividing in each of the wave guides coupled thereto and each of said last mentioned pairs of wave guides being in turn coupled to said circular wave guide, and having a four way symmetry for exciting the TE_{01} mode in said second wave guide.

2. In a high frequency system, a rectangular wave guide carrying energy from a high frequency source; a second wave guide of circular cross-section having a plate closing one end thereof, said plate having at least four symmetrically disposed slits therein, means comprising a corresponding number of coupling rectangular wave guides fed from said rectangular wave guide, and extending to said plate, each of said last mentioned wave guides having open ends juxtaposed to the slits in said plate, and a pair of rectangular wave guides, each coupled at one end to said first mentioned rectangular wave guide and at the other end to individual pairs of said coupling wave guides.

3. In a high frequency system, a rectangular wave guide carrying energy from a high frequency source; a second wave guide of circular cross-section having a plate closing one end thereof, said plate having at least four symmetrically disposed slits therein; means comprising a corresponding number of rectangular wave guides fed from said rectangular wave guide, extending radially and connected to said plate, each of said radial wave guides having open ends connected to corresponding slits in said plate, and means coupling the opposite ends of rectangular wave guides to said first mentioned wave guides.

4. In a high frequency system, a rectangular wave guide carrying energy from a high frequency source; a second circular wave guide having a flat plate closing one end thereof, said plate having at least four radial slits symmetrically disposed therein and means comprising a corresponding number of wave guides fed from said rectangular wave guide, and extending radially with respect to said second guide to said plate, each of said last mentioned wave guides having open ends juxtaposed to the slits in said plate.

5. In a high frequency system, a rectangular wave guide carrying energy from a high frequency source; a second circular wave guide having a flat plate closing one end thereof, said plate having at least four rectangular radially and symmetrically disposed slits therein, and

means comprising a corresponding number of wave guides radially disposed with respect to said circular wave guide and fed from said rectangular wave guide, and extending to said plate, each of said last mentioned wave guides having open ends juxtaposed to the slits in said plate.

6. In a high frequency system, a rectangular wave guide carrying energy from a high frequency source; a second circular wave guide having a flat plate closing one end thereof, said plate having at least four rectangular symmetrically disposed slits therein and a transducer comprising four rectangular wave guides radial with respect to said circular wave guide and fed from said rectangular wave guide at one end and having openings at their opposite ends cooperating with said slits for transferring energy to said circular wave guide.

7. In a high frequency system, a rectangular wave guide carrying energy from a high frequency source; a second circular wave guide having a plate closing one end thereof, said plate having at least four rectangular symmetrically disposed slits therein, and a transducer comprising four wave guides radially disposed with respect to said circular wave guide and terminating in rectangular openings providing a four way symmetry, said wave guides being fed at one end from said rectangular wave guide, said openings being juxtaposed to said slits in said plate, producing therein equal components of electromotive force in the same time phase and additive for the TE_{01} mode.

8. In a high frequency system, a rectangular wave guide carrying energy from a high frequency source; a second circular wave guide having a plate closing one end thereof, said plate having at least four rectangular symmetrically disposed slits therein, and a transducer comprising four wave guides terminating in rectangular openings providing a four-way symmetry, said wave guides being fed at one end from said rectangular wave guide, said openings being juxtaposed to said slits in said plate, producing therein equal components of electromotive force in the same time phase and additive for the TE_{01} mode, and balancing out the TE_{21} mode.

WILLIAM E. BRADLEY.

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