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WAVE GUIDE STRUCTURE

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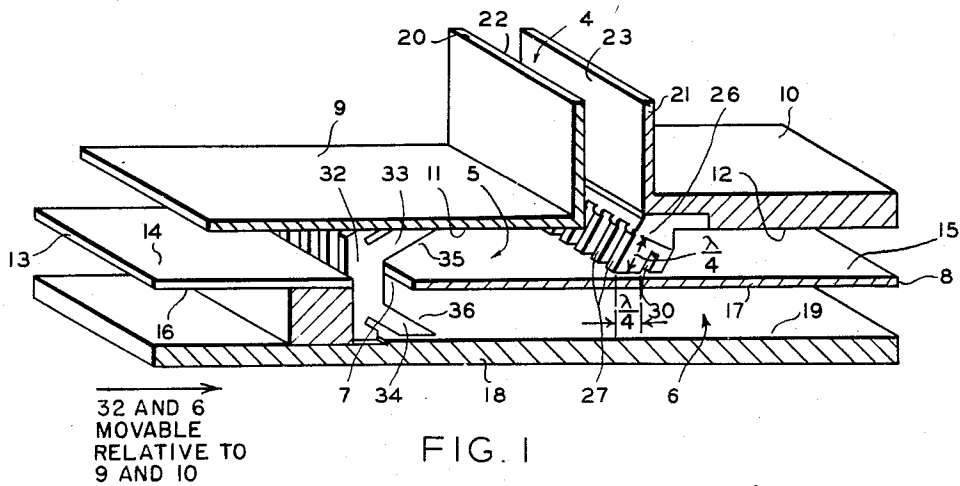


FIG. 1

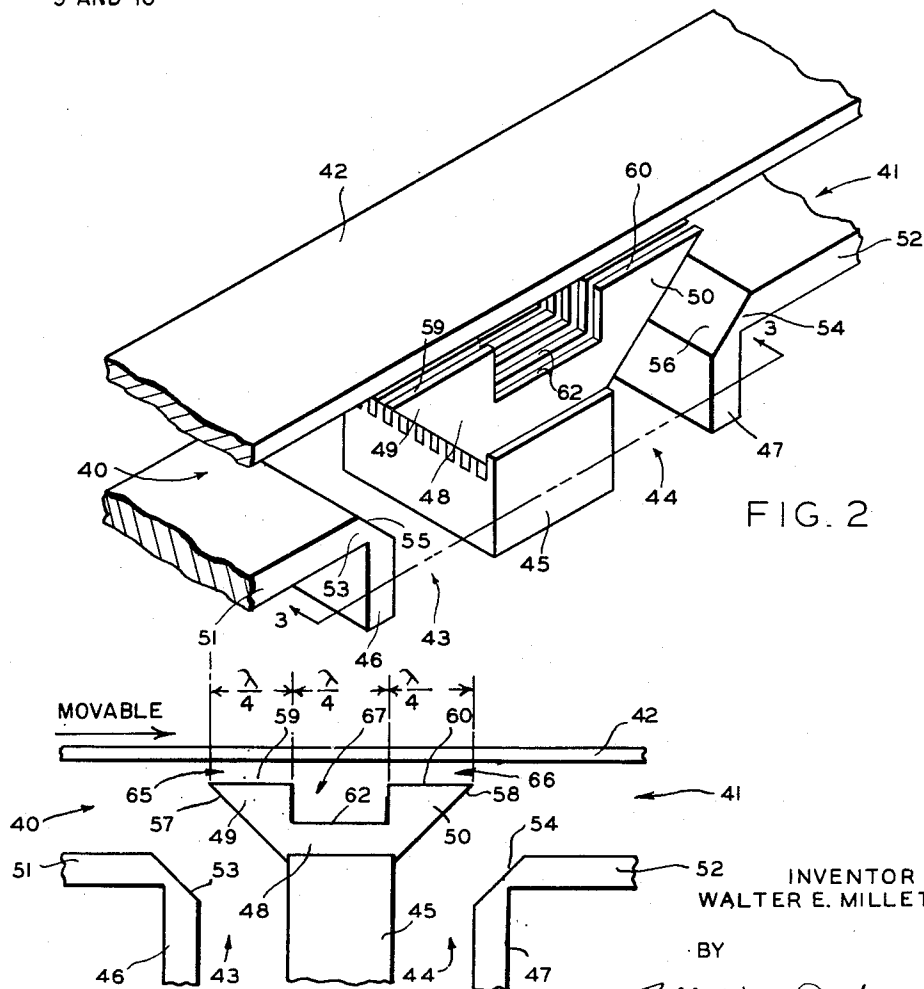


FIG. 2

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FIG. 3

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WAVE GUIDE STRUCTURE

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1 Claim. (Cl. 333—31)

This invention relates to electrical apparatus and more particularly to electromagnetic energy guiding means.

The electromagnetic energy guiding means herein disclosed may be briefly described as comprising, in its basic form, a plurality of spaced metallic plates which in effect afford a continuous reflecting surface. For examples of the uses to which such a structure may be applied, reference may be had to the application of Walter O. Gordy, Serial No. 629,167, filed November 16, 1945, and which issued as Patent No. 2,521,844 on September 12, 1950, dealing generally with a wave guide scanner. The reference to the cited patent is made herein merely to illustrate the utility of the present invention, both in the Foster wave guide mentioned therein, and in the invention of that application.

One of the advantages of the present invention is that it provides means for guiding or reflecting electromagnetic energy out of or into a wave guide through an aperture in one of its walls while permitting the free relative motion of the wave guide walls, as will appear. A further advantage lies in its efficiency in this regard, since substantially all of the energy is reflected in the desired direction without any substantial amount thereof being reflected toward the incident energy source. Another advantage of the invention is that it provides the equivalent of an electromagnetic energy reflecting surface without requiring a continuous surface to be used.

Further objects, advantages, and novel features of the invention will become apparent from the description contained herein, wherein reference is made to the accompanying drawing in which:

Fig. 1 illustrates an embodiment of the invention in which electromagnetic energy is transferred between parallel plate wave guides by means of reflecting teeth at an aperture in a common wall, and further in which energy is transferred between one of the parallel plate wave guides and a wave guide perpendicular thereto by means of a second set of reflecting teeth.

Fig. 2 illustrates another embodiment of the invention adapted to transfer or direct energy from two wave guides to two other wave guides respectively communicating therewith; and

Fig. 3 illustrates a face view taken along line 3—3 of Fig. 2.

Referring now to Fig. 1, the structure includes a parallel plate wave guide 4 which is perpendicular to and communicates with a parallel plate wave guide 5. Another parallel plate wave guide 6 has its walls parallel to those of wave guide 5 and communicates therewith through an aperture 7 in a common wall 8. As will appear more fully hereinafter, wave guide 5 may be adjustable in length. The adjustment may be accomplished by causing the wave guide members which form wave guide 6, together with the reflecting teeth mounted upon a wall thereof, to be movable with respect to the remaining wave guide walls. Members 9 and 10, forming the upper wall of wave guide 5 as shown in Fig. 1, afford conductive plane surfaces 11 and 12, respectively, in wave guide

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5. Members 13 and 8, which form the wall common to wave guides 5 and 6, afford conductive plane surfaces 14 and 15, respectively, in wave guide 5. Surfaces 11 and 12 lie in substantially the same plane, and surfaces 14 and 15 likewise lie in a common plane parallel to the plane of surfaces 11 and 12. Members 13 and 8 also afford, in wave guide 6, conductive surfaces 16 and 17, respectively, which lie in a common plane. Member 18, forming the lower wall of wave guide 6, as shown in Fig. 1, affords conductive plane surface 19 substantially parallel to surfaces 16 and 17. Surfaces 11, 12 and 14, 15 thus define parallel plate wave guide 5, and surfaces 19 and 16, 17 define parallel plate wave guide 6. Members 20 and 21, forming wave guide 4, are secured at right angles to members 9 and 10 and afford plane conductive surfaces 22 and 23 extending substantially normal to surfaces 11 and 12. Parallel plate wave guide 4 thus communicates with parallel plate wave guide 5 with their energy guiding conductive surfaces at right angles.

A series of reflecting teeth 26 extend downwardly from member 10 into wave guide 5. The teeth are formed of conductive or conductively surfaced material. Each of teeth 26 has a reflecting edge 27 inclined at a substantially 45° angle to the surfaces defining wave guide 5, and effectively form a continuation of surface 23 into the wave guide 5. Edges 27 of teeth 26 lie substantially along a common plane and act as a reflecting surface, as will appear more fully hereinafter.

The adjacent sides of teeth 26 are separated by a distance less than the cut-off separation at the highest contemplated frequency of operation. The teeth 26 do not contact surface 15, although extending to within a close and uniform distance therefrom. A quarter wavelength slot 30 in each tooth, facing surface 15, is at a distance substantially one-quarter wavelength from the edges 27. Thus, slots 30 communicate, through quarter-wavelength guides having closely adjacent surfaces, with that portion of wave guide 5 which joins wave guide 4, and function to prevent leakage of energy through the space between surface 15 and teeth 26 as will appear.

Secured to walls 13 and 18, and in part defining the aperture 7 between wave guides 5 and 6, are reflecting members 32 comprising teeth 33 and 34 which extend into wave guides 5 and 6, respectively, as shown. The teeth of reflecting members 32 have the same basic structure as teeth 26, in that they are provided with quarter-wavelength choke slots spaced a quarter-wavelength from the reflecting edges 35 and 36 of teeth 33 and 34 respectively. Members 32 are spaced in such a manner as to permit the passage of teeth 33 between teeth 26, so that wave guide 6 including the members 32 is freely movable with respect to walls 9 and 10. Reflecting edges 35 are inclined substantially parallel to reflecting edges 27, and reflecting edges 36 are oriented substantially at right angles to edges 35, for reasons which will become more apparent hereinafter.

A better understanding of the operation and utility of the structure, here shown and described in part, with which the reflecting teeth of the present invention are associated, may be had by reference to the above mentioned patent of Walter O. Gordy, from which it will be seen that members 9 and 10, 13 and 8, and 18 of Fig. 1 herein may be considered as a portion of a structure forming two coaxial conical shell wave guides, or forming a conical shell wave guide 5 having an aperture 7 in its inner wall for introducing energy thereto. The walls of the several wave guides may be considered as joined by side plates (not shown) in such manner that relative movement between wave guides 5 and 6 may take place. Thus, the structure of Fig. 1 is similar to that illustrated in the patent of Walter O. Gordy, and may be regarded as a transformation of the conical shell wave guide.

The apparatus as shown might be useful in laboratory and testing work, or in phase shifting structures with members 9, 10, 20, 21 and 26 stationary relative to the remaining structure.

Referring now to Figs. 2 and 3 which illustrate in perspective and face views, respectively, another embodiment of the invention, wave guides 40 and 41, having a common wall 42, communicate with wave guides 43 and 44, respectively. The wave guides 43 and 44 are perpendicular to wave guides 40 and 41, and are defined by a common partition 45, and by walls 46 and 47 respectively. Partition 45 bears a series of members 48 having a series of teeth 49 which effectively provide a reflecting surface for directing energy between wave guides 40 and 43, and a series of teeth 50 which similarly provide a reflecting surface for directing energy between wave guides 41 and 44. The wall 42 may be movable with respect to the remaining structure, and may bear reflecting teeth (not shown) suitably spaced to pass between the teeth 49, 50 in a manner similar to teeth 27 in Fig. 1. Wave guide 40 is formed by the wall 42 and a wall 51, walls 42 and 51 having substantially plane, parallel, and conductive inner surfaces. Wave guide 41 is similarly formed by the wall 42 and a parallel wall 52. The inner walls of wave guides 43 and 44 are similarly substantially plane, parallel, and conductive, and are perpendicular to the inner surfaces of wave guides 40 and 41, being joined thereto by walls 53 and 54 having inner conductive surfaces 55 and 56, respectively. The surfaces 55 and 56 are inclined at substantially 45° to the walls of the interconnected wave guides as shown. Members 48 are also constructed of conductively surfaced material. Members 48 may be formed integrally with partition 45, or constructed separately and secured in slots in partition 45 as shown. The conductive surfaces of partition 45 and the teeth 49 and 50 are directly connected electrically.

The entire structure thus far described may be better understood by reference to the previously mentioned patent of Walter O. Gordy, in particular to Fig. 2 showing a conical shell wave guide in cross-section, and the description thereof. The wave guides 40 and 41 here shown may thus be regarded as forming a part of the conical guide portion of a conical shell wave guide, having wave guides 43 and 44 communicating therewith.

The teeth 49 and 50 have reflecting edges 57 and 58 respectively. These reflecting edges are disposed perpendicularly to each other, and at a 45° angle to the surfaces of parallel plate wave guides 40, 41, 43 and 44. Thus, reflecting edges 57 and 58 extend from the surfaces of partition 45 into wave guides 40 and 41, respectively.

Teeth 49 and 50 also have surfaces 59 and 60, respectively, which are substantially parallel to and closely spaced from the inner surface of wall 42. The space between teeth 49 and 50 is in part defined by surfaces 62 which are spaced from the inner surface of wall 42 a considerable distance as compared to the spacing of surfaces 59 and 60 therefrom. The space between surfaces 59 and the inner surface of wall 42, and similarly between surfaces 60 and wall 42, may be considered as defining wave guides 65 and 66 respectively, with extremely small separation of surfaces. Surfaces 62 and wall 42 may be considered as defining a wave guide 67 communicating directly with wave guides 65 and 66.

Referring again to Fig. 1, the operation of the embodiment there shown may be best understood by considering an incident wave of electromagnetic energy, approaching teeth 26 through wave guide 4, and polarized normal to the wave guide surfaces.

The reflection of electromagnetic energy substantially obeys the comparable law of reflection in optics, that is, the angle of incidence and the angle of reflection are equal. Although the reflecting surface provided by teeth 26 is mechanically discontinuous between surface 23 of wall 21 and surface 15 of wall 8, the effect of the spacing of the teeth and of their slotted structure is to provide an

electrically continuous surface. Since teeth 26 are spaced at less than cut-off distance for the frequency of the incident energy, the energy cannot pass through the spaces between the teeth, so that electrically there appear no gaps between teeth. The space between surface 15 of wall 8 and the opposed undersurfaces of the teeth forms a quarter-wavelength wave guide, which communicates with the quarter-wavelength slots 30. Thus there is an equivalent half-wavelength shorted wave guide extending from the points of teeth 26 to the ends of slots 30, resulting in an equivalent short circuit impedance between surface 13 and the points of teeth 26. Electrically, then, a continuous reflecting surface exists between surface 15 of wall 8 and surface 23 of wall 21, while free mechanical movement of waveguide 6 with respect to walls 9 and 10 of wave guide 5 is obtainable.

The teeth 33 and 34 similarly provide electrical reflecting surfaces for high frequency energy impinging upon the members 32. The incident wave is reflected from edges 35 of teeth 33, passes through aperture 7 toward teeth 34, and is reflected from edges 36 into wave guide 6. These changes of direction take place without substantial reflection towards the direction from which the incident wave is progressing, because there are no obstructions to the direction of travel pointed out above. Thus, of the incident energy which approaches teeth 26 through wave guide 4, substantially all is reflected into wave guide 6. The reflecting teeth direct the incident energy into unobstructed impedance matching wave guides at each step.

The operation or effect of the members 48 of Figs. 2 and 3 may be readily understood by considering an incident wave of electromagnetic energy travelling toward the right in wave guide 40 and approaching teeth 49. As the wave impinges on the teeth 49, substantially none of the energy passes between the teeth because of their spacing at less than cut-off. The direction of reflection is determined largely by the orientation of edges 57, which lie substantially along a plane surface oriented at a forty-five degree angle to the surfaces of wave guide 40. The major portion of the wave is therefore reflected into wave guide 43, with substantially no reflection of energy back toward the direction from which the incident energy approaches. Each of the wave guides 65 is substantially a quarter-wavelength long, as are directly communicating wave guides 67 and 66. The resultant three-quarter-wavelength wave guide is open circuited at its far end, that is, the end farthest from the approaching incident wave under consideration. Thus, a transformer effect is provided which causes a short-circuit impedance from the points of teeth 49 to wall 42 to appear to the incident energy. The effect of the relatively deep wave guide 67 is to provide a broad band transformer, that is, to make the structure effective over a wide range of operating frequencies and relatively insensitive to frequency shifts. Thus, the electrical effect of the structure is substantially the same as though the teeth 49 extended into actual electrical contact with each other and with wall 42. Similar action takes place with regard to an incident wave approaching edges 58 of teeth 50 from wave guide 41.

It will be apparent to those skilled in the art that the reflecting teeth will operate quite as well to reflect energy in the reverse directions from those here described, since the device is linear and reversible in operation. Further, that the hypothetical reflecting surface along which the reflecting edges lie need not be a plane surface.

Having thus described preferred embodiments of the invention, it will be understood that it is the purpose of the appended claim to include all variations, modifications, and equivalents within the scope and spirit of the invention.

What is claimed is:

A wave transmission structure comprising first and second spaced walls, a third wall intermediate said first and second walls and forming with said first wall a first

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wave guide and with said second wall a second wave guide, a first slot in said intermediate wall for transfer of energy from one wave guide into the other, a second slot in said first wall for transmission of energy into said first wave guide, a first reflecting barrier fixed in said first slot and having spaced teeth extending toward, but out of contact with, said said first and second walls, opposite ends of said teeth having oppositely diverging edges having an angle of substantially 90° therebetween, whereby energy directed toward them from said second slot will be deflected through said first slot into said second wave guide, a second reflecting barrier fixed at one edge of said second slot and having spaced reflecting teeth extending from said one wall toward, but out of contact with, said inter-

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mediate wall, the teeth of said first barrier being staggered with respect to the teeth of said second barrier, whereby upon motion of one slot relative to the other to vary the distance between said barriers, one set of teeth will move past the other set of teeth.

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