

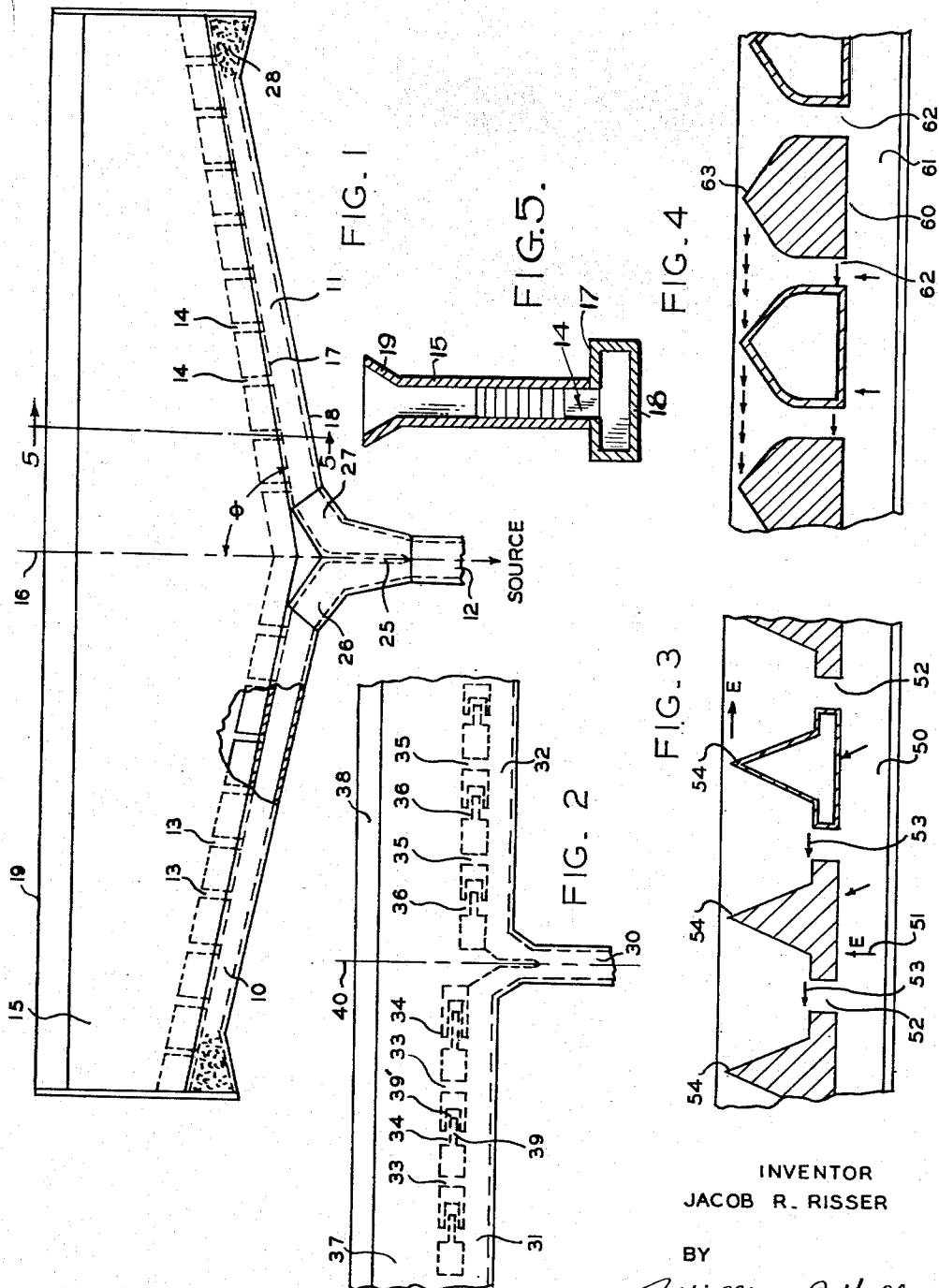
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ANTENNA ARRAY

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ANTENNA ARRAY

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

It is frequently desirable in electrical apparatus to employ an antenna which will provide a directed beam of electromagnetic energy. One method often found suitable to accomplish this result is to utilize what is known as a wave guide array, which usually consists of a wave guide fed from a source of electromagnetic energy and having multiple radiating elements fed from the wave guide.

Among the difficulties encountered with wave guide arrays are the obtaining of a simulated line source of radiation, the impedance matching of the elements to the wave guide from which they draw energy, and the reduction of the frequency sensitivity of the array.

Therefore, it is among the objects of this invention to provide a wave guide fed array which closely simulates a line source of electromagnetic radiation.

It is another object of this invention to provide a wave guide fed array with radiating elements or means which aid in the simulation of a line source of electromagnetic radiation.

It is a further object of this invention to provide a wave guide fed array which is comparatively insensitive to frequency variations.

Other and further objects, advantages and novel features of my invention will become apparent from the following description and the accompanying drawing wherein:

Fig. 1 is a top view of one preferred embodiment of the invention;

Fig. 2 is a top view of another preferred embodiment of the present invention; and

Fig. 3 is a cross-sectional view of an alternative embodiment of the invention particularly illustrating a variation in the wave guide fed elements;

Fig. 4 is a cross-sectional view of another embodiment of my invention illustrating a variation of the wave guide fed elements and employing the same principles of operation as the elements of Fig. 3; and

Fig. 5 is a sectional view taken along line 5—5 of Fig. 1.

In brief, my invention contemplates the use of a wave guide fed array, usually center fed

to assist in the reduction of frequency sensitivity, and employing apertures as radiating elements.

Referring now to Fig. 1, there is illustrated in top view a center fed wave guide array. Feed wave guides 10 and 11 of the array are supplied with energy by a wave guide 12 from a source (not shown). The energy is caused to divide in substantially equal amounts in wave guides 10 and 11 from whence small amounts pass through each of apertures 13 and 14 from where it is directed between a pair of parallel metallic surfaced plates 15 into outer space. The array is symmetrical along a median plane 16, and consequently, it will be sufficient to describe the structure on one side of the plane. Wave guides 11 and 12 are viewed in the E-plane, that is, electric vectors, when the guides are excited, are in the plane of the drawing. Wave guide 11 is formed so that the wall 17 thereof from which energy escapes through apertures 14 makes an angle θ with median plane 16 which is less than 90° . Elements or apertures 14 are substantially equally spaced and of the same size and shape. Walls 17 and 18 of wave guide 11 are tapered in the direction away from the source so that each element 14 will receive approximately the same amount of power. Apertures 14 are slots which constitute small wave guides communicating with wave guide 11. They may be cut in the broad wave guide wall 17 and are so calculated in cross-sectional dimension that they can be excited only in the fundamental mode having an electric vector oriented parallel to the plane of the view of Fig. 1. Where parallel plates 15 join walls 17 they enclose slots 14, which may not extend entirely from top to bottom of wall 17. By decreasing the space between the parallel plates 15, which may be considered as forming a parallel plate wave guide, and decreasing the angle θ , the spacing between wave guide apertures 14 may be increased substantially beyond a wavelength as measured in wave guide 11. Consequently, the slots 14 are preferably spaced greater than a wave guide wavelength so that energy from each one lags slightly in phase the energy from the preceding aperture (moving outwardly from median line 16), and energy arriving at aperture 19 of the plates 15 will be substantially in phase. Thus aperture 19 simulates a line source of electromagnetic radiation. The aper-

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ture 19 may be suitably flared to reduce reflections due to mismatch with outer space.

In order to secure a substantially equal division of power between wave guides 10 and 11, a tapered septum 25 is introduced centrally in wave guide 12 extending from the top and bottom walls thereof and the resulting divided wave guide leads into two branch guides 26 and 27 which respectively communicate directly with wave guides 10 and 11. Wave guides 26 and 27 are gradually widened to the proper width. Wave guides 10 and 11 are tapered, as mentioned above, so that substantially equal amounts of energy are withdrawn therefrom by each of slots 13 and 14.

Wave guide 11 is suitably terminated with a matched absorptive load 28 (diagrammatically illustrated) to reduce the reflection of any power not radiated by elements 14 to a negligible amount.

The reduction of the angle θ to a value less than 90° , which is not customary to the art, together with corresponding increase of spacing between slots 14, provides a reduction in frequency sensitivity, and further, the close spacing of parallel plates 15 contribute to reduce diffraction effects. The frequency may be altered over a substantial band without causing the direction of the electromagnetic energy radiated from aperture 19 to depart from the direction of line 16.

Referring now to Fig. 2, there is illustrated a top view of another embodiment of the invention which includes a wave guide 30 which carries energy from a source (not shown) to feed wave guides 31 and 32 in substantially equal amounts. Energy is fed through slots or radiating elements 33 and 34 of wave guide 31 and 35 and 36 of wave guide 32. These slots feed energy between parallel plates 37 which have a suitably flared aperture 38. Slots 33 and 35 are rectangular slots in the side walls of 31 and 32 respectively, whereas adjacent slots 34 and 36 respectively may be formed by inserting a tongue member 39 in a grooved space 39'. There is thereby provided a wave guide of small dimensions having a longer path for the energy to traverse than the simple straight slots. As a result, the additional path length is calculated, for example, to be a half wavelength longer than the path length through the straight slots so that energy leaking into the slots from the feed wave guides is radiated in phase as it leaves the slots spaced a half guide wavelength apart. Unwanted diffraction lobes are thereby eliminated.

A further improvement is provided by causing the energy to divide between wave guides 31 and 32 but increasing the total distance traveled by energy to corresponding slots in wave guide 31 and in wave guide 32 by a quarter wave length. The distance between adjacent slots 33—33 and 34—34 of wave guide 31 is equal to the distance between adjacent slots 35—35 and 36—36 of wave guide 32, but the initial distance traversed by the energy in reaching from wave guide 30 to the tongued slot 34 closest to median plane 40 in wave guide 31 is a quarter wavelength longer than the initial distance traversed by the energy in reaching from wave guide 30 to the tongued slot 36 in wave guide 32 closest to median plane 40. However, the entire slot structure of wave guide 32 is displaced a quarter wavelength farther from aperture 38 in a direction parallel to median line 40, so that compensation is made for the extra travel to cause the energy to be

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in phase as it leaves aperture 38. The advantage in this type of structure lies in the cancellation of reflections caused by corresponding slots, as energy reflected from the slots travels a half wavelength longer in its total journey from the source into the wave guide 31 and return than does similar reflected energy traveling from the source into wave guide 32 and return. Thus, the half wavelength differential secures an improved impedance characteristic insofar as the source of energy is concerned.

Referring now to Fig. 3, there is illustrated in top view an alternative structure for the slots. It will be understood that for purposes of clarity the proportions of the structure are somewhat different than may be encountered in actual practice. There is shown in Fig. 3 a section of a feed wave guide 50 of a wave guide feed array which may be similar to those hereinbefore discussed. The E vector within the guide is oriented as illustrated by the arrow 51 and a small percentage of the energy in guide 50 is radiated through each small aperture or opening 52. The apertures permit the passage of energy having its E vector oriented as illustrated by arrows 53, and metallic surfaces forming the slot side walls are then triangulated to gradually reach a point. The effect of such construction is to reduce the difficulties of small discrete radiating elements, the latter tending to result in a diffraction pattern having lobes. With this invention the tapering causes the energy to be gradually distributed over the entire area between the points 54 of the material through which the slots are cut or formed so that rather than a series of discrete radiating elements, there is presented a substantially uniform radiating line.

Referring now to Fig. 4, there is again illustrated an alternative construction for radiating slots in a wave guide feed array wherein the slots are provided in side wall 60 of feed wave guide 61. In this instance the arrows again illustrate orientation of the electric vector within the guides and again there is provided a short space of substantially rectangular slot 62 followed by a widening so that the structure between each of slots 62 approaches a point 63. In either Figs. 3 or 4 the side walls may be solid and the desired space cut therein, or constructed of adjacent solid members, or hollow tubing or metallic coated substance may be used. The alternative construction employing a hollow member is illustrated in each instance by one member as shown in the figures.

Having thus described my invention, I wish it understood that I do not desire to be bound only to the specific embodiments herein disclosed, but I intend by the accompanying claims, to claim all such modifications, variations and equivalents as fairly fall within the scope and spirit of my invention.

What is claimed is:

1. An antenna array with a radiation pattern broad in one plane and highly directional in a plane perpendicular thereto for radiation of a broad frequency band of electromagnetic energy polarized in said one plane comprising a source wave guide, two feed wave guides branching therefrom, each of said feed wave guides having a first broad wall facing in the general direction of energy radiation, said first walls of said feed wave guides being at an angle less than 180° and greater than 90° with respect to one another, said first walls being provided with energy radiation slots, and a pair of parallel plates form-

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ing a single wave guide about the space to be fed by all of said slots, one pair of edges of said plates providing therebetween a plane aperture for energy radiation, the spacing between said slots being greater than a wavelength at the mid-frequency of said frequency band for providing in-phase radiation in the plane of said aperture.

2. An antenna array according to claim 1 wherein means are mounted adjacent each of said slots outside said wave guides providing energy propagation paths of increasing width to minimize side lobes in the radiation pattern of the array.

3. An array according to claim 1, in which the space between said parallel plates is less than the

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width of said broad walls for minimizing the necessary number of slots.

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