

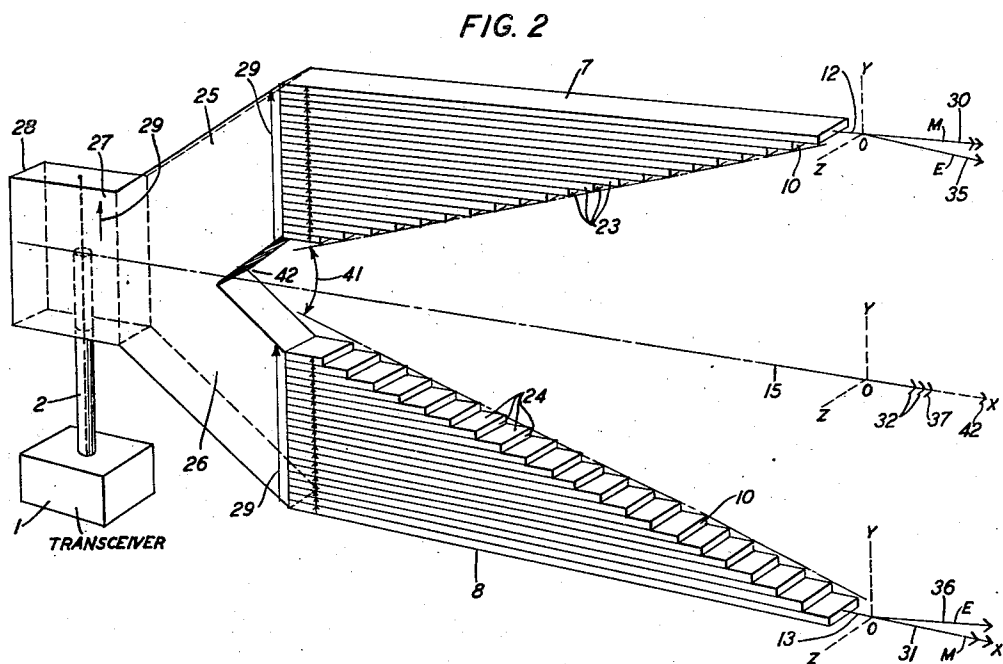
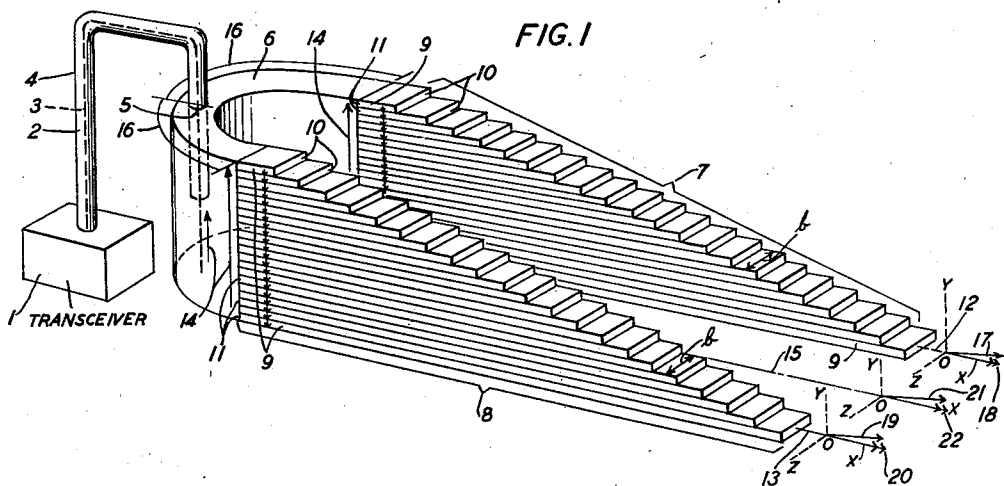
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MICROWAVE ANTENNA

2,447,768

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2 Sheets-Sheet 1



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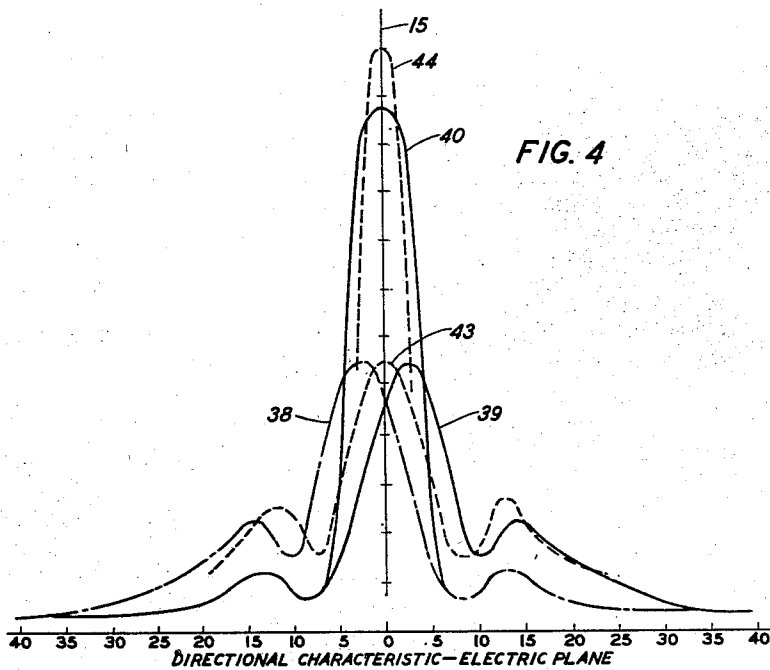
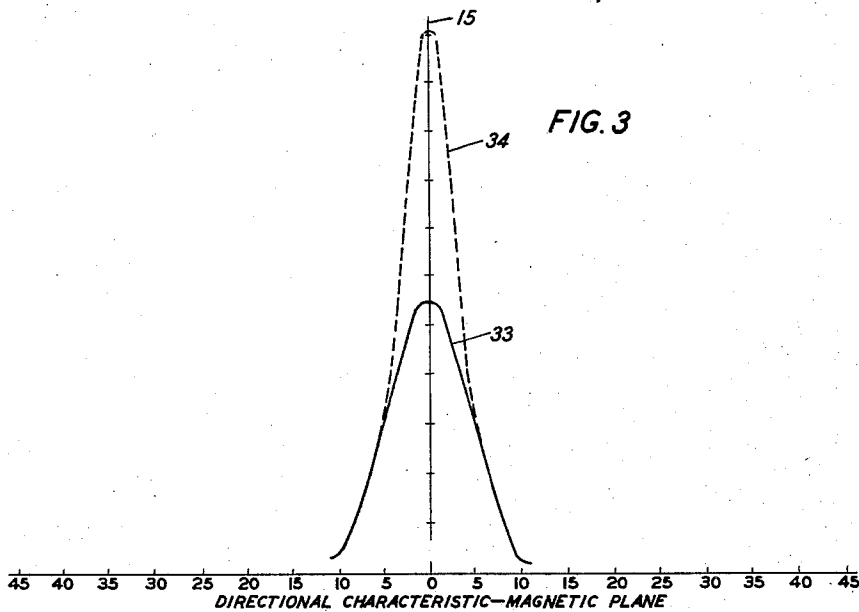
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MICROWAVE ANTENNA

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This invention relates to directive antenna systems and particularly to directive microwave antenna systems.

As disclosed in Patent 2,411,872 granted on December 3, 1946, to C. B. H. Feldman and G. E. Mueller, highly directive radio action and a large gain may be obtained by utilizing a plurality of microwave open-ended wave guides in an end-on "organ pipe" array. In this arrangement, the widths and lengths of the pipes or guides are selected so that the wavelets emitted in the end-on direction are in phase agreement, substantially. As stated in the above-mentioned application, it has been found in practice that, while the direction of maximum action in the magnetic plane is aligned with the longitudinal axis of the organ pipe antenna, the direction of maximum action in the plane of polarization, that is, the electric plane, is not exactly aligned with the aforementioned axis because of mutual coupling between the apertures or elemental antenna and because of other effects. It now appears desirable exactly to align, in end-on antenna systems of the high gain organ pipe type, the electric plane direction of maximum action, as well as the magnetic plane direction of action, with the longitudinal axis of the system. More particularly, it appears advantageous in radio scanning systems, to have the principal radius or axis of the maximum directive lobe, considered in the solid, rather than a minor axis of the aforementioned lobe, aligned with the longitudinal axis of the system or array in order to facilitate the direction determination.

It is one object of this invention to obtain a microwave array having an exceedingly high gain.

It is another object of this invention to obtain a microwave antenna having a highly directive characteristic.

It is still another object of this invention to collect or project, from both sides or legs of a microwave V antenna, wavelets having the same polarity.

It is an additional object of this invention to align, in a microwave antenna array having a high gain, the magnetic plane and electric plane directions of maximum action.

It is a further object of the invention to compensate for aperture coupling effects in an organ pipe wave guide array.

In accordance with the preferred embodiment of the invention, a transceiver of the type employed in conventional radars, range finding and radio scanning systems, is connected by a main wave guide to a wave guide antenna array comprising two organ pipe arrays of the type disclosed

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in the above-mentioned copending application. The stepped *b* sides containing the spaced elemental antenna apertures face each other, and the longitudinal axes of the two organ pipe arrays, hereinafter called subarrays, extend parallel, or at a slight angle, to the desired direction of maximum action. The individual directions of maximum action in the electric plane for the two subarrays are aligned with the longitudinal axis of the array, or are angularly related thereto, so that the direction of maximum action in this plane for the entire array coincides with the bisector of the angle formed by the apertured or stepped sides. Since the magnetic plane direction of action for each subarray coincides with the longitudinal subarray axis as in the structure of the copending application, the electric and magnetic plane directions of maximum action coincide. Stated differently, the direction of maximum action, considered in the solid, for the system is along a single path which is aligned with the longitudinal axis of the array.

The invention will be more fully understood from a perusal of the following specification taken in connection with the drawing on which like reference characters denote elements of similar function, and on which:

Fig. 1 illustrates a perspective view of one embodiment of the invention comprising a U-shaped broadside array of two end-on organ pipe subarrays;

Fig. 2 illustrates a perspective view of the preferred embodiment of the invention comprising a V-shaped broadside array of two organ pipe subarrays; and

Figs. 3 and 4 are curves illustrating the directional characteristics of the preferred embodiment of Fig. 2.

Referring to Fig. 1, reference numeral 1 denotes a translation device such as a pulse transceiver commonly used in radio scanning systems and numeral 2 designates a coaxial line comprising an inner conductor 3 and an outer conductor 4, and coupled to the mid-point 5 of a curved rectangular wave guide 6. Numerals 7 and 8 denote organ pipe subarrays of the type disclosed in the aforementioned patent. Each subarray comprises a plurality of open-ended air-filled rectangular wave guides 9 having end apertures or elemental antennas 10 and graded lengths. The guides or pipes 9 have, in general, different "b" or wide transverse dimensions, and therefore different phase velocities, so that in operation, as explained in the aforesaid Patent 2,411,872, the waves supplied to the adjacent open input ends 11 of pipes

9 and radiated from the apertures 10 in the direction parallel to the longitudinal axes 12 and 13 of subarrays 7 and 8 are in phase, substantially. At the mid-point 5 the inner conductor 3 of coaxial line 2 extends into guide 6 in a direction parallel to the narrow transverse "a" wall and, assuming the flat rectangular guides 9 which have corresponding lengths are in the same horizontal plane, the wavelets emitted by apertures 10 of both subarrays are vertically polarized as shown by arrow 14. Preferably, the axes 12 and 13 extend parallel to the array axis 15.

In operation, waves are supplied by device 1 over line 2 to the mid-point 5 of guide 6, through the two equal length sections 16 of guide 6 to the input openings 11 of pipes 9 in sub-arrays 7 and 8, and are radiated from elemental antenna apertures 10. As previously explained, the radiated wavelets combine cophasally in the general propagation directions 13 and 15. More accurately, considering subarray 7, the wavelets add to produce, in the plane of polarization, herein-after called the electric plane (XY plane, Fig. 1), a direction of maximum action angularly related to axis 12, as represented by the single-headed arrow 17. In the horizontal or magnetic plane (XZ plane, Fig. 1) the wavelets combine in a manner such that the maximum action for the subarray is in a direction aligned with the longitudinal axis 12, as shown by the double-headed arrow 18. Similarly, considering subarray 8, the electric plane direction 19 and the magnetic plane direction 20 of maximum action are angularly related and aligned, respectively, with the axis 13. For the entire array, the two electric plane directions 17 and 19 of maximum action coincide, as illustrated by the single-headed arrow 21, and the two magnetic plane directions 18 and 20 likewise coincide, as indicated by double-headed arrow 22. As a result, the array has a considerably greater gain than the single pipe organ array disclosed in the aforesaid Patent 2,411,872 and a greater gain for a given area perpendicular to the direction of radiation than realized with the so-called panel antennas, for example, a parabolic reflector system, commonly used in the microwave field. If desired, the electric plane directions 17 and 19 may be aligned, respectively, with directions 18 and 20, by tilting the entire array.

Referring to Fig. 2 the subarrays 7 and 8 have their stepped or apertured sides 23 and 24 facing each other, the longitudinal axes 12 and 13 being parallel or angularly related as explained below. Numerals 25 and 26 denote two guides of equal length which are connected through the main guide 27 to the coaxial line 2 and device 1. The coaxial line 2 is connected to guide 27 at a distance a quarter wave-length from the closed guide end 28, the closed end being a reflector similar to the antenna reflector employed in conventional short wave unidirectional systems. As in the structure of Fig. 1, the portion of the inner conductor 3 extending into the associated guide is parallel to the narrow transverse or electric plane guide wall, so that the wave components supplied to the pipes in subarrays 7 and 8 are polarized vertically as indicated by arrow 29.

In operation, referring to Figs. 2, 3 and 4, the wavelets supplied by device 1 to subarrays 7 and 8 are radiated from the apertures 10, and considering the magnetic plane, the phases of the wavelets are such as to produce maximum action in the directions 30 and 31 coinciding

with, or parallel to, the array axis 15, as in the system of Fig. 1. The double-headed arrow 32 represents the direction of the maximum action in the magnetic plane for the entire array. In Fig. 3, the curve 33 illustrates the directive lobe in the magnetic plane for each of subarrays 7 and 8 and curve 34 illustrates the combined or resultant array lobe. In the electric plane, assuming the axes 12 and 13 are parallel and in a vertical plane, the direction of maximum action for subarray 7 is downward and toward the axis 14 and for subarray 8 it is upward and toward axis 14, as shown in Fig. 2 by arrows 35 and 36, respectively. The resultant lobe has its principal axis aligned with the direction represented by the single-headed arrow 37. In Fig. 4, curves 38 and 39 denote the lobes, in the electric plane, respectively, for subarrays 7 and 8, and curve 40 illustrates the combined or resultant lobe. Preferably, the angle 41, Fig. 2, between the apertured surfaces 23 and 24 is initially chosen or adjusted, so that electric plane directions 35 and 36, Fig. 2, coincide respectively with magnetic plane directions 30 and 31, whereby the radio action in the electric plane direction 37 is enhanced, and maximum gain, in the direction 37 of maximum action, is obtained as illustrated by arrow 42. In other words, preferably, angle 41 is such that lobes 38 and 39, Fig. 4, are superimposed and symmetrically disposed relative to axis 15 as illustrated by curve 43 of Fig. 4 and instead of the blunt relatively short lobe 40, the highly desirable sharp and relatively long lobe 44 is obtained. As in the system of Fig. 1, the gain over a standard antenna is considerably greater than that achieved by a single organ pipe antenna or a panel type antenna. Thus, in accordance with the invention, a microwave array having an exceedingly high gain and electric and magnetic plane directions of maximum action aligned with the array axis is obtained.

Although the invention has been explained in connection with certain embodiments, it should be understood that it is not to be limited to the embodiments described inasmuch as other apparatus may be successively employed in practicing the invention.

What is claimed is:

1. A microwave antenna comprising a plurality of subarrays each comprising a plurality of parallel wave guides having different lengths and end-antenna apertures.
2. A microwave V antenna comprising two subarrays each comprising at least two parallel wave guides of different length and having end apertures, the corresponding apertures of said subarrays being equally spaced in the desired end-on direction of maximum action.
3. A microwave V antenna array comprising two organ pipe subarrays having their apertured sides facing each other, the angle between said sides being a function of the spacing and mutual coupling between the adjacent apertures in each subarray.
4. A broadside microwave antenna array of parallel end-on subarrays, said subarrays having superimposed directions of maximum action in a plane including the axes of the subarrays, and angularly related directions of action in a plane perpendicular to said plane and including said axes, the bisector of the angle formed by said angularly related directions being aligned with said axes, whereby the directions of maximum action

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in said plane for the broadside array are superimposed.

5. A microwave V antenna comprising two sets of open-ended parallel wave guides connected to a translation device, the adjacent guides in each set having a given difference in length, the end openings of the two longer guides being farther apart than the openings of the two shorter guides.

6. A microwave antenna array comprising two subarrays of parallel open-ended wave guides, the guides in each subarray having wide transverse dimensions of different widths and a difference in length dependent upon the difference in width, means for supplying similarly polarized wavelets to all of said guides, the direction of maximum action in the plane of wave polarization of each subarray being at an angle to the longitudinal axis of the subarray, and the said directions being in effect superimposed.

7. A V antenna comprising two organ pipe subarrays each comprising a plurality of parallel wave guides having graded lengths, one set of corresponding ends of said guides being connected through dielectric paths of equal lengths to a translation device, and the other set of corresponding ends having apertures included in the same wave front plane.

8. A microwave antenna array comprising two subarrays each comprising a plurality of open-ended wave guides of different length, the electric plane directions of maximum action of said subarrays making equal angles with the desired end-

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on direction of action coinciding with the longitudinal axis of said subarrays.

9. A microwave V antenna array comprising two subarrays each comprising two parallel wave guides of different lengths, the guides in each subarray having one set of corresponding ends adjacent and connected to a translation device and apertures at their other ends, the apertures of one subarray being spaced along one side and the apertures of the other subarray being spaced along the other side of an angle having its bisector aligned with the desired direction of action, the angle having a value related to the length difference between the guides of each subarray.

10. An antenna system comprising a pair of similar subarrays each comprising a plurality of dielectric channels having antenna apertures spaced along the path of desired maximum action, the apertures of one subarray being spaced in a direction perpendicular to said path and the apertures of the other subarray in a direction opposite said mentioned direction, and a translation device connected to said subarrays.

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