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ANTENNAS FOR MONOPULSE RADAR SYSTEMS HAVING PLANAR SLOT ARRAY AND COUPLING MEANS FOR PROVIDING SUM AND DIFFERENCE SIGNALS

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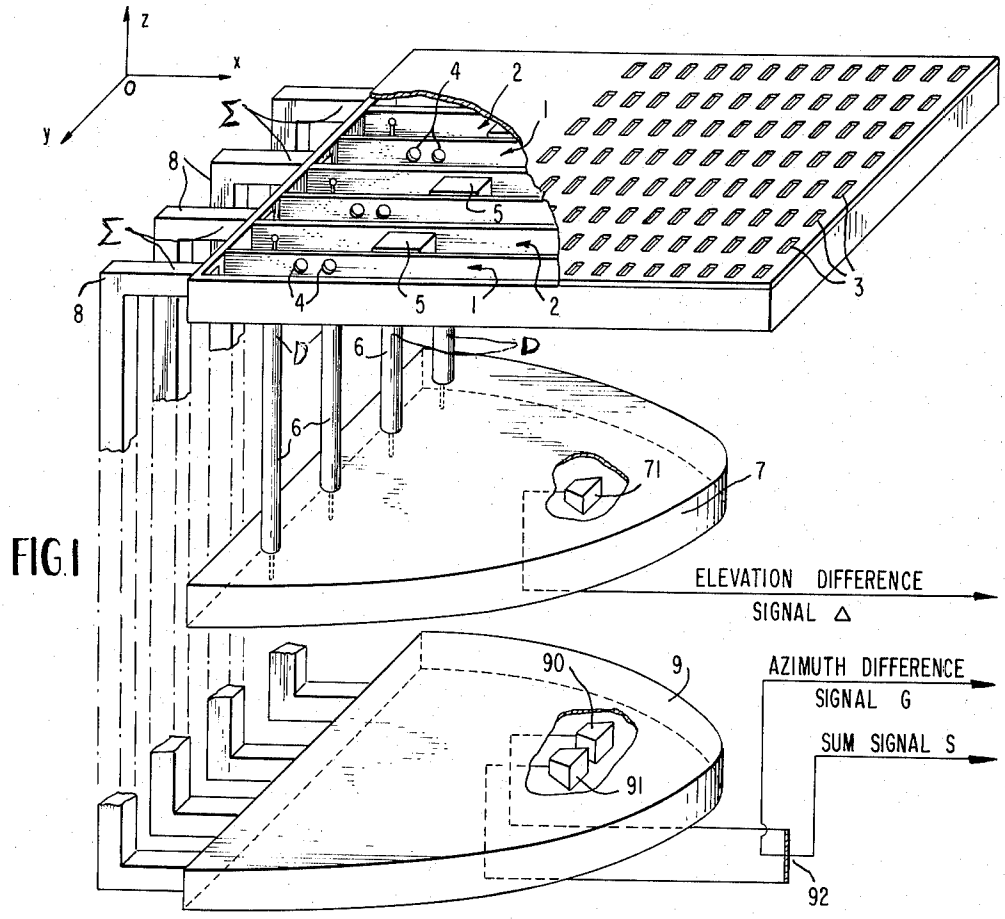


FIG. 1

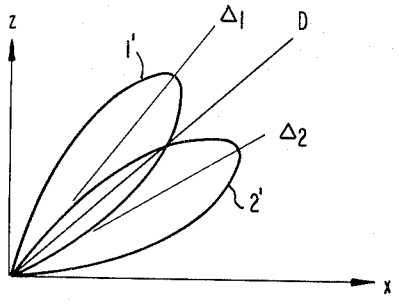


FIG. 2

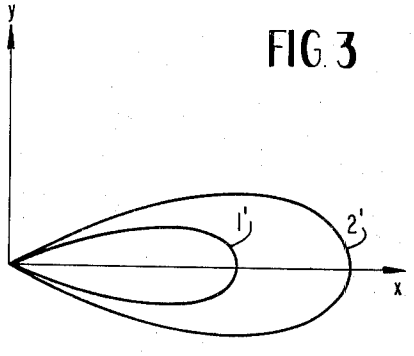


FIG. 3

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ANTENNAS FOR MONOPULSE RADAR SYSTEMS HAVING PLANAR SLOT ARRAY AND COUPLING MEANS FOR PROVIDING SUM AND DIFFERENCE SIGNALS

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6 Claims. (Cl. 343—771)

The present invention relates to radar antennas. More particularly, it is an object of the invention to provide an antenna adapted to radiate a plurality of electromagnetic-wave beams.

An antenna according to the invention comprises an arrangement of slotted waveguides extending in parallel relationship in the same plane and arranged in successive pairs. The waveguides of each one of said pairs radiate, respectively, along two predetermined directions.

Means are associated with said pairs of waveguides, for receiving the sum of the signals collected by each pair and the difference of these signals.

The difference signals produced by each pair feed in phase a first reflector, in the focus of which is placed a horn collecting the sum of these signals and providing the elevation error signal.

The sum signals produced by each pair feed in phase a second reflector, in the focus of which are two horns connected to a magic-T, the sum-channel of which provides the reference signal while the difference-channel provides the bearing error signal.

The invention will be best understood from the following description and appended drawings, wherein:

FIG. 1 is a perspective view of an antenna according to the invention;

FIGS. 2 and 3 are respectively cross-sections through the plane of symmetry and the plane comprising the waveguides assembly of the radiating pattern of the antenna.

The antenna according to the invention shown in FIG. 1 comprises an assembly of slotted waveguides 1 and 2, in parallel relationship, guides 1 and 2 contacting one another along their small sides.

These waveguides are formed with transversal slots 3. Of course, other types of slots or other radiating sources may be used, without departing from the scope of the invention. The guides of each pair are connected by a two hole directional coupler 4, provided in their common wall, and, in addition, guide 2 comprises a phase-shifter 5 adapted to provide a $\pi/2$ phase-shift. Accordingly, the vector-sum and the vector-difference of the signals picked up by guides 1 and 2 are respectively collected at points Σ and D of said guides.

The slots having the same position in guides 1 and 2 are fed in phase by the collected signal, the spacing between the slots being the same in all the guides.

Taking the trihedral $Oxyz$ as the reference trihedral, with Oz perpendicular to the plane Oxy comprising guides 1 and 2, and Ox coinciding with the direction of energy propagation in the guides, the assembly of guides 1 and the assembly of guides 2 have radiation patterns 1' and 2' which are symmetrical with respect to Ox, as shown in FIG. 4.

Means known per se are provided to cause the phase velocity in guides 1 and 2 to be different. This results in guides 1 having a maximum radiation in a direction Δ_1 of plane zOx, whereas guides 2 have a maximum radiation in a direction Δ_2 of the same plane.

Transition elements 6 connect the outputs D of guides

2 to a first reflector 7, for example of the parabolic type. Points Σ are connected by transition elements 8 to a second reflector 9. Reflectors 7 and 9 may, for example, be located below the plane of guides, in parallel relationship thereto. The operation is as follows. The energy coming from guide 2, FIGURE 2, is phaseshifted by $\pi/2$ by phaseshifter 5, and divided in two equal parts; one flowing directly to D, the other, through coupler 4, to Σ; this latter part is phaseshifted by said coupler and has consequently a total phaseshift or π.

As to the energy coming from guide 1, the part flowing directly to Σ has no phaseshift and is algebraically added to the energy coming from guide 2. Since this latter has been phaseshifted by π in passing through coupler 4, this algebraical addition is in fact arithmetical subtraction. The other part flowing from guide 1 to point D, through coupler 4, is in turn phaseshifted by $\pi/2$, and consequently at point D, is in phase with the energy coming from guide 2. Consequently there is a summation at point D.

In the focus of reflector 7, there is located a first horn 71 which sums up the vectorial difference to provide signals I.

FIGS. 2 and 3 show that the assembly operates as a "monopulse" antenna, the pointing direction of which is contained in the plane zOx and is the bisectrix D of the angle formed by directions Δ_1 and Δ_2. When the target leaves this axis, while remaining in the plane zOx (error in elevation), the difference signals will appear and are summed up in reflector 7 by horn 71 which receives the sum of all these signals. This provides, after detection, an elevation error signal Δ, this signal being equal to zero, when the target is in the pointing direction and appearing, when the target leaves this direction, while remaining in the zOx plane, is in fact the elevation error signal.

Signals Σ are summed up by means of reflector 9 in the focal plane of which there are horns 90 and 91, as shown in FIGS. 5 and 6. These two horns are coupled to the two input branches of a magic-T 92.

On one of the output branches of the T, there is collected the signal S, or the reference sum signal of the monopulse radar.

The second output branch provides the difference of the signals respectively received by horns 90 and 91. This difference is nil when the target is in the direction Ox. Accordingly, this signal is the signal indicating the error in bearing of the monopulse radar.

Of course the invention is not limited to the one embodiment described and shown which has been given solely by way of example.

What is claimed is:

1. An antenna for ultra-high frequency energy comprising: a plurality of waveguides extending in the same plane in parallel relationship to one another and arranged in successive pairs, each guide having radiating discontinuities equispaced along said guide; means associated with each pair of said guides for receiving the sum of the signals collected by the two guides of said pair and the difference of said signals; and parabolic reflector means for summing the respective sum signals of said pairs and the respective difference signals thereof.

2. An antenna for ultra-high frequency energy comprising: a plurality of rectangular waveguides extending in the same plane in parallel relationship to one another having respective large and small walls and arranged in successive pairs, the guides of each pair contacting one another along their respective small walls; each of said guides having equispaced radiating slots in their large walls, said guides being arranged to form a continuous flat assembly; means associated with each pair of said

guides for receiving the sum of the signals collected by the two guides of said pair and the difference of said signals; and parabolic reflector means for summing the respective sum signals of said pairs and the respective difference signals thereof.

3. An antenna for ultra-high frequency energy comprising: a plurality of rectangular waveguides extending in the same plane in parallel relationship to one another and having respective large and small walls, said large walls forming a continuous flat surface, said guides being arranged in successive pairs, each of said guides having radiating equidistant slots in one of their large walls; the respective guides of each pair radiating respectively along two predetermined directions; means associated with each pair of guides for obtaining the sum of the signals collected by the guides of said pair and the difference of said signals; parabolic reflector means for summing up the respective sum signals and the respective difference signals of said pairs for providing a reference signal, an elevation error signal and a bearing error signal.

4. An antenna for ultra-high frequency energy comprising: a plurality of rectangular waveguides extending in the same plane in parallel relationship to one another and having respective large and small walls, said large walls forming a continuous flat surface, said guides being arranged in successive pairs, each of said guides having radiating equidistant slots in one of their large walls; the guides of each pair radiating respectively along two predetermined directions; means associated with each pair of guides for obtaining the sum of the signals collected by the guides of said pair and the difference of said signals; a first and a second parabolic reflector respectively coupled to said guides, for respectively summing up the respective sum signals and the respective difference signals from said pairs for providing a reference signal, an elevation error signal and a bearing error signal.

5. An antenna for ultra-high frequency energy comprising: a plurality of rectangular waveguides extending in the same plane in parallel relationship to one another and having respective large and small walls, said large walls forming a continuous flat surface, said guides being arranged in successive pairs, each of said guides having radiating equidistant slots in one of their large walls; the guides of each pair radiating respectively along two predetermined directions; means associated with each pair of guides for obtaining the sum of the signals collected by the guides of said pair and the difference of said signals; a first and a second parabolic reflector respectively coupled to said guides; a first horn in the focal plane of said first reflector for summing up the respective sum signals of said pairs and providing a reference signal; a second and a third horn in the focal plane of said second reflector, and coupling means between said horns, said means having two outputs, for respectively providing an elevation error signal and a bearing error signal.

6. An antenna for ultra-high frequency energy comprising: a plurality of rectangular waveguides extending in the same plane in parallel relationship to one another and having respective large and small walls, said large walls forming a continuous flat surface, said guides being arranged in successive pairs, each of said guides having radiating equidistant slots in one of their large walls; the guides of each pair radiating respectively along two predetermined directions; means associated with each pair of guides for obtaining the sum of the signals collected by the guides of said pair and the difference of said signals; a first and a second parabolic reflector respectively coupled to said guides; a first horn in the focal plane of said first reflector for summing up the respective sum signals of said pairs and providing a reference signal; a second and a third horn in the focal plane of said second reflector, a coupler having two inputs respectively connected to said second and said third horns and two outputs for respectively providing an elevation error signal and a bearing error signal.

References Cited by the Examiner

UNITED STATES PATENTS

2,567,197	9/1951	Fox	343—16
2,810,908	10/1957	Crawford	343—786
2,940,075	6/1960	Stavis	343—777
2,967,301	1/1961	Rearwin	343—777
2,981,948	4/1961	Kurtz	343—16.1

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