Jan. 24, 1950 A. C. BECK 2,495,219

DIRECTIONAL ANTENNA SYSTEM

Filed Jan. 24, 1945 3 Sheets-Sheet 1

FIG. 2

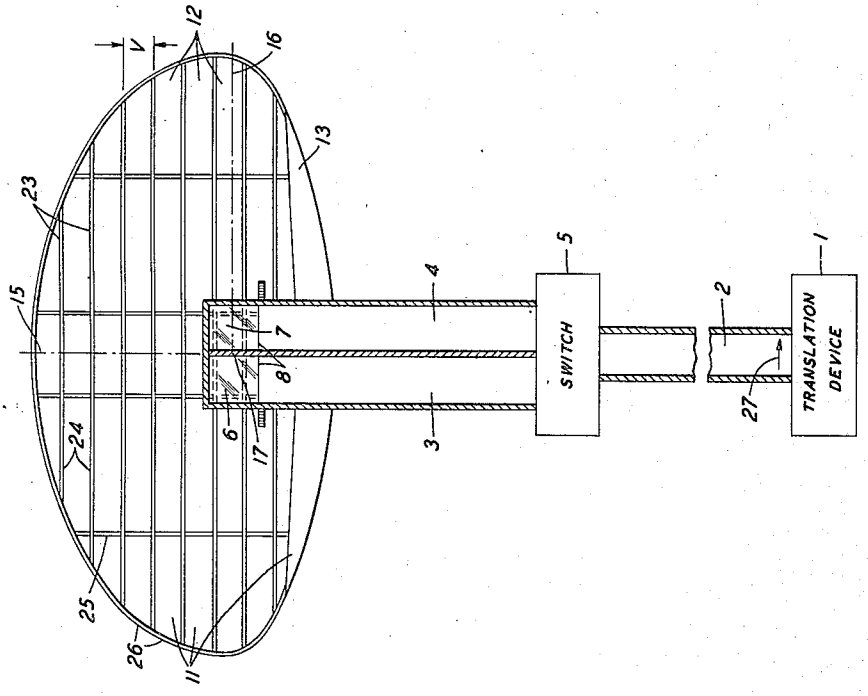
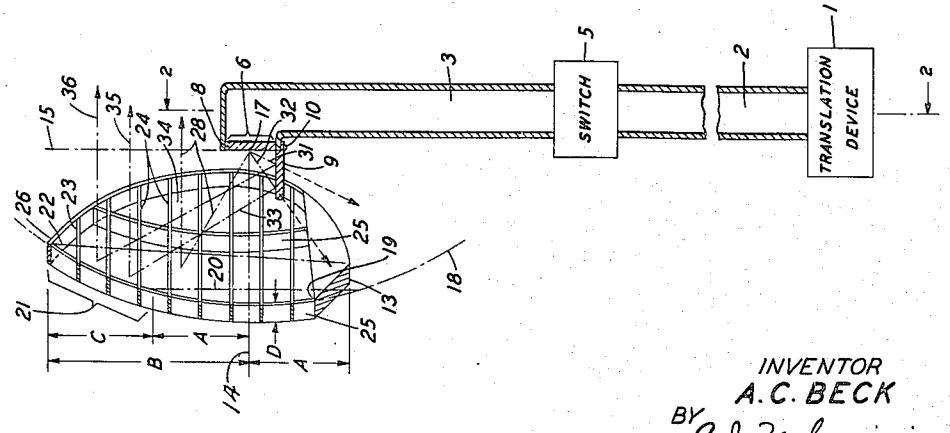


FIG. 1



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FIG. 3

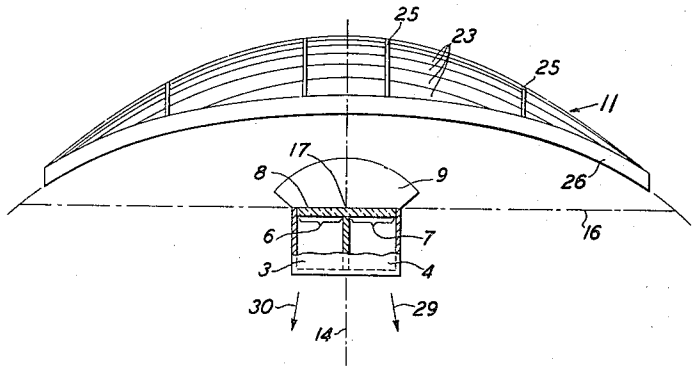
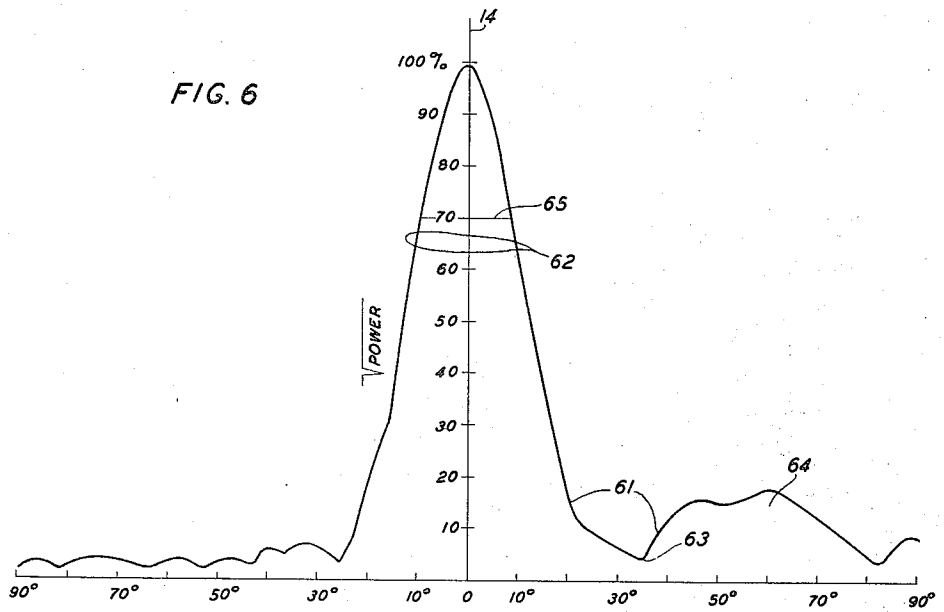


FIG. 6



H-PLANE DIRECTIVE PATTERN- SYSTEM OF INVENTION

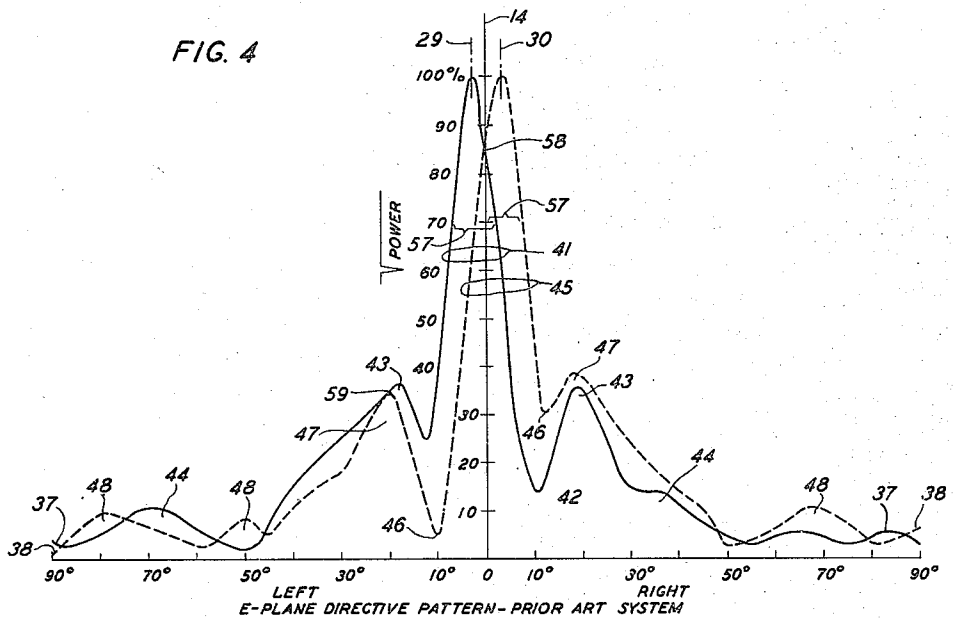
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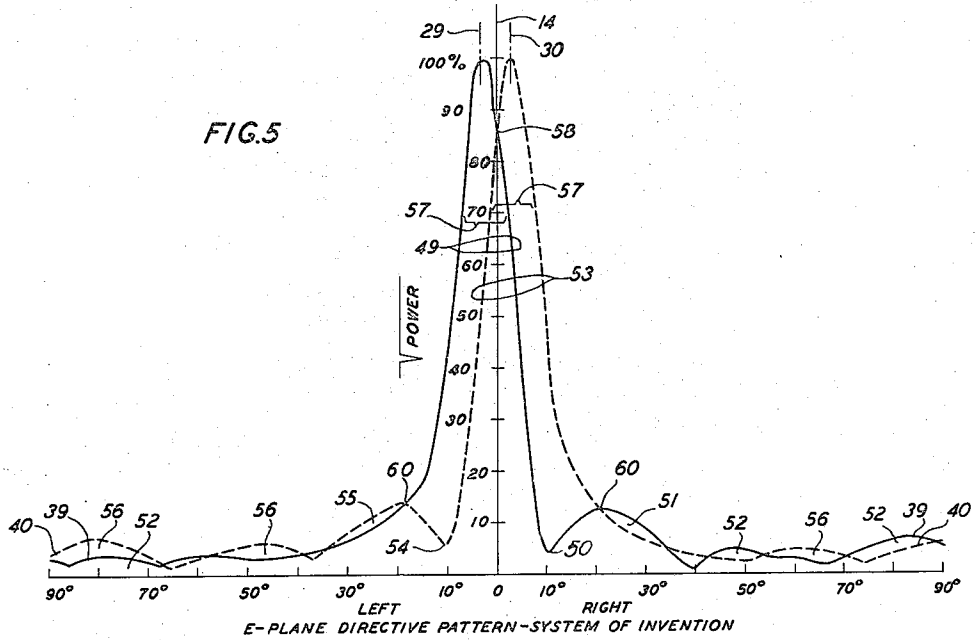
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FIG. 4



E-PLANE DIRECTIVE PATTERN-PRIOR ART SYSTEM

FIG.5



E-PLANE DIRECTIVE PATTERN-SYSTEM OF INVENTION

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UNITED STATES PATENT OFFICE

2,495,219

DIRECTIONAL ANTENNA SYSTEM

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Application January 24, 1945, Serial No. 574,335

5 Claims. (Cl. 250—33.65)

1

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

My Patent 2,409,183 granted on October 15, 1946, discloses a lobe switching radar antenna system comprising a paraboloidal reflector having a horizontal axis, and a pair of vertical dielectric guides extending partly across the reflector. Each guide has a primary antenna aperture facing the reflector and positioned near, and in the horizontal plane of, the reflector focus. The two guides are connected through a dielectric guide switch to a transceiver. In practice, it has been found that, by reason of the passive or shadow effect of the double guide feed, the directive pattern taken in the horizontal lobe switching plane contains fairly large minor lobes which produce false indications on the cathode ray tube indicator associated with the transceiver. Accordingly, it appears desirable to provide means for eliminating or reducing these undesired minor lobes. While various arrangements have been suggested heretofore for reducing undesired minor lobes as, for example, the depressed or off-focus feed disclosed in Patent 2,427,005 granted to A. P. King on September 9, 1947, the prior art arrangements are not entirely suitable for use in the lobe switching system mentioned above and, moreover, may cause a decrease in the antenna gain. Accordingly, it appears advantageous to accomplish the minor lobe reduction, in applicant's lobe switching system, without depressing the feed and in a manner such as to increase, or at least not change materially, the antenna gain.

It is one object of the invention to secure, in an antenna system, a directive pattern having negligible minor lobes.

It is another object of this invention to reduce, in an antenna system comprising a parabolic reflector and a vertical front dielectric guide feed, the minor lobes in the horizontal plane directive pattern, without decreasing the antenna gain.

It is another object of this invention to eliminate, in a lobe-switching antenna system having a double directive pattern, overlapping of the major lobe of one pattern with a minor lobe of the other pattern, or so-called false cross-overs, during the lobe switching operation.

In accordance with one embodiment of the invention a small horizontal flat metallic deflector is attached to the double guide feed of the lobe switching antenna referred to above at a point immediately below the two guide apertures. The deflector or "window sill" is below, and parallel to, the optical axis of the paraboloidal reflector and extends a short distance towards the reflector. The paraboloidal reflector extends approximately twice as far above its horizontal optical axis as below. In transmission, most of the wave components emitted alternately by the two apertures and propagated towards the portion of the reflector adjacent the lower edge, and most of the components propagated in downwardly pointing directions which avoid the reflector, are redirected by the deflector upwards towards the overhanging upper portion of the parabolic reflector, and are thence radiated in a general horizontal direction. Hence the radiation from the lower reflector portion mentioned above, which portion faces the dual guide feed, is relatively small and, as compared to that produced by the lower reflector section in the original system, greatly decreased; and most of the energy is reflected or radiated by the upper portion, including the overhanging section, of the reflector. As a result, the shadow effect of the guide feed is minimized and the minor lobes in the directive pattern, taken in the horizontal lobe-switching plane, are substantially reduced. In reception, the converse operation is obtained by virtue of the reciprocity theorem.

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

Figs. 1, 2 and 3 illustrate, respectively, a sectional side view, a sectional front view and a top view of the preferred embodiment of the invention;

Fig. 4 illustrates, for purpose of explanation, the directive pattern taken in the E or horizontal lobe-switching plane, of a prior art system constructed in accordance with my copending application mentioned above;

Fig. 5 illustrates the E-plane lobe-switching directive pattern of the system of Figs. 1, 2 and 3; and

Fig. 6 illustrates the H or vertical plane pattern of the system of Figs. 1, 2 and 3.

Referring to Figs. 1, 2 and 3, reference numeral 1 denotes a translation device, such as a radar transceiver, and numeral 2 designates a main metallic air-filled vertical dielectric guide connected thereto. The main guide 2 is connected to a pair of metallic feed guides 3 and 4 through a guide switch 5 of the "finger" type disclosed in my copending application mentioned above, or of a different type, such as, for example, the so-called "fin" type. At the top, each of the feed guides is bent ninety degrees and contains an

antenna aperture, the two apertures being included in the same vertical plane. The antenna aperture in the left feed guide 3 and the antenna aperture in the right feed guide 4 are denoted, respectively, by the reference numerals 6 and 7. Numeral 8 denotes a double polystyrene window which covers both apertures and permits passage of radio waves. Numeral 9 denotes a metallic horizontal deflector or window sill which is attached to the dual feed guides, by means of screws 10, at a point immediately below the apertures 6 and 7, or window 8. The deflector 9 has a circular front edge, Fig. 3, and at its widest portion extends outwardly from the dual guides 6, 7, a distance of approximately a half wavelength.

Reference numeral 11 denotes a concave reflector comprising a paraboloidal section 12 having an ellipsoid opening and a conical underhanging section 13. The section 12 has a horizontal optical or principal geometrical axis 14 extending above deflector 3, the two latus rectums 15 and 16 and a point-focus 17. The focus 17 is positioned in the plane of, and approximately midway between, apertures 6 and 7, and the optical axis 14 passes through the point focus 17 and the vertex of the reflector 11. In Fig. 1, the dot-dash curve 18 illustrates the parabola which is revolved about axis 14 to secure the paraboloidal contour of section 12. If desired, the underhanging section, instead of being coniform, may be barrel-shape, which shape is obtained by revolving the bottom edge 19 of the paraboloidal reflector section 12 counter-clockwise, Fig. 1, through a small angle and about the latus rectum 16. The conical or barrel feature forms no part of the present invention, and, if desired, the underhanging section 13 may comprise merely an extension of the paraboloidal section 12.

Considering the vertical plane, Fig. 1, containing axis 14 and the point-focus 17, the line 20 perpendicular to axis 14 represents, for purpose of explanation and comparison, the diameter or opening of a conventinal paraboloidal reflector similar to that included in the system of my above-mentioned patent. The conventional reflector just mentioned extends the same distance above and below the axis 14. In contrast, the concave reflector 11 of the present invention extends about twice as far above as below axis 14. In Fig. 1, the vertical heights of the portions of reflector 11 above and below the axis 14 are designated by the reference letters B and A, respectively. In one embodiment tested at a design wavelength of about 9.8 centimeters, B and A are 11 and 5 inches, respectively, and in another embodiment tested at the same wavelength, B and A are 2 feet and 1 foot, respectively. In the last-mentioned embodiment, the horizontal width of the reflector 11, taken along the latus rectum 16, is 5 feet. Hence, the concave reflector 11 of the present invention comprises an overhanging or canopied portion 21 having a vertical dimension C, and, in the vertical plane containing axis 14 and point-focus 17, the reflector aperture 22 is tilted forward and forms an acute angle with the axis 14. As will be explained in detail below, the reflective canopy 21 and the reflective window sill 9 mutually cooperate and function to eliminate the shadow effect of the dual guides 3, 4, and, consequently, to reduce the undesired minor lobes.

Preferably, but not necessarily, the paraboloidal section 12 is of the so-called dielectric guide grid or grille type, as illustrated, instead of the solid type; and the underhanging section 13 is of the solid type. The grid reflector 12 comprises horizontal metallic strips 23, which form the guide openings 24 and are spaced, on centers and vertically, a distance V of about one inch, corresponding to less than a half wavelength. The strips have a depth D, Fig. 1, of about one inch and are supported by the transverse members 25 and the rim member 26, the members 25 and 26 being made of conductive or non-conductive material. The reflector is designed for use with waves polarized horizontally, as shown by arrow 27, Fig. 2. Hence, the transverse members 25, which appear to be vertical as seen from the dual feed apertures 6, 7, do not affect the operation of the reflector. Moreover, since the dimension V of the openings 24 is less than a half wavelength, at the mean or design frequency, waves of the operating frequencies arriving at the grille reflector 12 from the feed or projector apertures 6, 7, or from a remote reflective target, do not pass through the openings 23, but are rejected or reflected thereby.

The general transceiving and lobe-switching operation of the system of Figs. 1, 2, and 3, is basically the same as that of the system of my above-mentioned patent. Briefly, in transmission, horizontally polarized waves are supplied by device 1 to main guide 2 and through the guide switch 5, alternately, to the dual feed guides 3 and 4. The waves are alternately emitted by the antenna apertures 6, 7, and are reflected primarily in a horizontal direction by the concave reflector 11. In Fig. 1, reference numeral 28 denotes a representative direction or path followed by a wave component emitted from one of apertures 6 or 7, towards the upper portion of reflector 11 and redirected thereby. When the waves are emitted by the left-hand antenna aperture 6, maximum action in the horizontal plane occurs in the direction 29, Fig. 3, lying on the right side of, and making an acute angle with, the optical axis 14; and when the waves are emitted by the right antenna aperture 7, the direction 30 of maximum action is on the left side of optical axis 14 and forms therewith an acute angle. The directions 29 and 30 of maximum action correspond to the principal axes of the left and right lobe-switching main beams or major lobe patterns taken in the horizontal or E-plane. In reception, the converse operation is obtained.

In more detail, the E-plane pattern of the left or right main beam is relatively narrow by reason of the parabolic contour in this plane of the concave reflector; and the H-plane pattern of the main beam is somewhat wider, so that a fan-beam is secured. Assuming, for the moment, that the deflector 9 is omitted, the underhanging reflector section 13 functions to increase the radio action at the high or sky angles included in the 50–70 degree vertical sector. With deflector 9 in place, in accordance with the invention, some of the waves propagated from aperture 6 or 7 in downwardly pointing directions, such as direction 31 which avoids the reflector 11 altogether, or direction 32 which is intercepted by the bottom portion of the underhanging reflector section 13, are redirected by the deflector 9 towards the upper part, particularly the overhanging part 21, of the concave reflector 11, as shown by arrows 33 and 34. The deflected waves are then propagated horizontally as shown by arrows 35 and 36. Consequently, as compared to the prior art system of my above-mentioned patent, the intensity of the radiation from the bottom reflector portion facing the vertical dual feed guide is decreased and the waves, which without deflector 9 would

be radiated from this reflector portion, are in a sense transferred to and reflected by the overhanging reflector portion 21. As a result, the passive action or shadow effect of the dual guide structure 3, 4, which causes the beam to split into minor lobes, is reduced. Also, the horizontal or E-plane of maximum action is, in effect, no longer coincident with the horizontal plane containing the optical axis 14 of the concave reflector, and an E-plane directive pattern with reduced or negligible minor lobes is secured. In the vertical or H-plane, the deflector renders the high angle or sky radiation less than that obtained in the above-mentioned prior art system.

Referring to Figs. 4 and 5, reference numerals 37 and 38 denote, respectively, the alternate left and right measured E-plane directive patterns obtained for the lobe-switching prior art antenna system of my patent; and numerals 39 and 40 designate, respectively, the alternate left and right measured E-plane directive patterns obtained for the lobe-switching antenna system of Figs. 1, 2, and 3. In Fig. 4, the left pattern 37 includes a major lobe 41, first dips or nulls 42, first minor lobes 43, and higher order minor lobes 44; and the right pattern 38 includes a major lobe 45, dips 46, first minor lobes 47, and high order minor lobes 48. In Fig. 5, the left pattern 39 includes a major lobe 49, the right first null 50, the right first minor lobe 51, and the higher order minor lobes 52; and the right pattern 40 includes the major lobe 53, the left dip 54, the left first minor lobe 55, and the higher order minor lobes 56. The half power width of each major lobe 41, 45, 49, and 53, is denoted by the reference numeral 57 and the real or desired cross-over points of patterns 37 and 38, and patterns 39 and 40, are denoted by numeral 58.

As shown in Fig. 5, the half power width 57 of each of major lobes 49 and 53 is relatively small. The first minor lobes 51 and 55, Fig. 5, are only about 12 to 15 per cent of the major lobes 49 and 53, respectively, and therefore negligible. By way of contrast, the first minor lobes 43 and 47, Fig. 4, are about 35 per cent of the major lobes 41 and 45, respectively. Also, the higher order minor lobes 52 and 56, for the system of the invention, are considerably lower than the corresponding higher order minor lobes 44 and 48, for the prior art system. It will be noted that the left first minor lobes 43 and 47, Fig. 4, of the two patterns 37 and 38 touch or cross at about the 35 per cent power point denoted by reference numeral 59. Hence, an indication resulting from this false cross-over is fairly strong. On the other hand, the false cross-over points 60 of patterns 39 and 40, Fig. 5, are at about the 12 per cent power-point and the indications produced thereby are therefore negligible.

Referring to Fig. 6, reference numeral 61 denotes the vertical plane directive pattern for the system of Figs. 1, 2, and 3. The pattern includes the major lobe 62, the dip 63, and the higher angle or "sky" minor lobe 64. The half power width 65 of the major lobe 62, it will be noted, is greater than the corresponding width 57, of the major lobes 49 or 53, for the system of Figs. 1, 2, and 3. If deflector 9 were omitted, the minor lobe 64 would be considerably higher.

Thus, in accordance with the invention, the minor lobes produced in a lobe switching system are reduced. The gain of a system constructed in accordance with the invention and comparable in size to a system constructed in accordance with

my patent is 19.8 decibels, whereas the gain of the comparable system of my copending application is about 19 decibels so that the lobe reduction is secured with a slight increase in gain.

Although the invention has been described in connection with a specific embodiment, it is not to be limited to the embodiment described, inasmuch as other apparatus may be employed in successfully practicing the invention.

What is claimed is:

1. In combination, a reflector having an optical or principal geometrical axis and a focus said reflector having a concave surface on one side of said axis, a primary antenna at said focus and a flat deflector extending parallel to and lying on the opposite side of said axis, said deflector being spaced from said reflector and positioned substantially between said reflector and said primary antenna.

2. A combination in accordance with claim 1, said axis being substantially horizontal, said reflector extending approximately twice as far above as below said axis and said deflector being positioned below said axis.

3. In combination, a paraboloidal reflector having a substantially horizontal optical axis, said reflector extending farther above than below said axis, a vertical dielectric guide extending across the lower part of said reflector and having an antenna aperture facing said reflector, and a plane deflector attached to said guide, said deector being positioned entirely below said axis and extending towards said reflector.

4. In combination, a concave reflector having a focus and a substantially horizontal optical or principal geometrical axis, said reflector extending farther above than below said axis, a pair of vertical wave guides positioned in front of said reflector and each having an aperture facing said reflector, the reflector focus being midway between said apertures, a horizontal plane deflector attached to said guides and extending below said axis and towards said reflector, a wave guide switch, a radar transceiver, said guides being connected through said switch to said radar transceiver.

5. A combination in accordance with claim 4, said reflector comprising a plurality of wave guide openings dimensioned to reject or reflect wave components, the upper and greater portion of said reflector having a paraboloidal contour and the smaller and lower portion having a conical contour.

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