

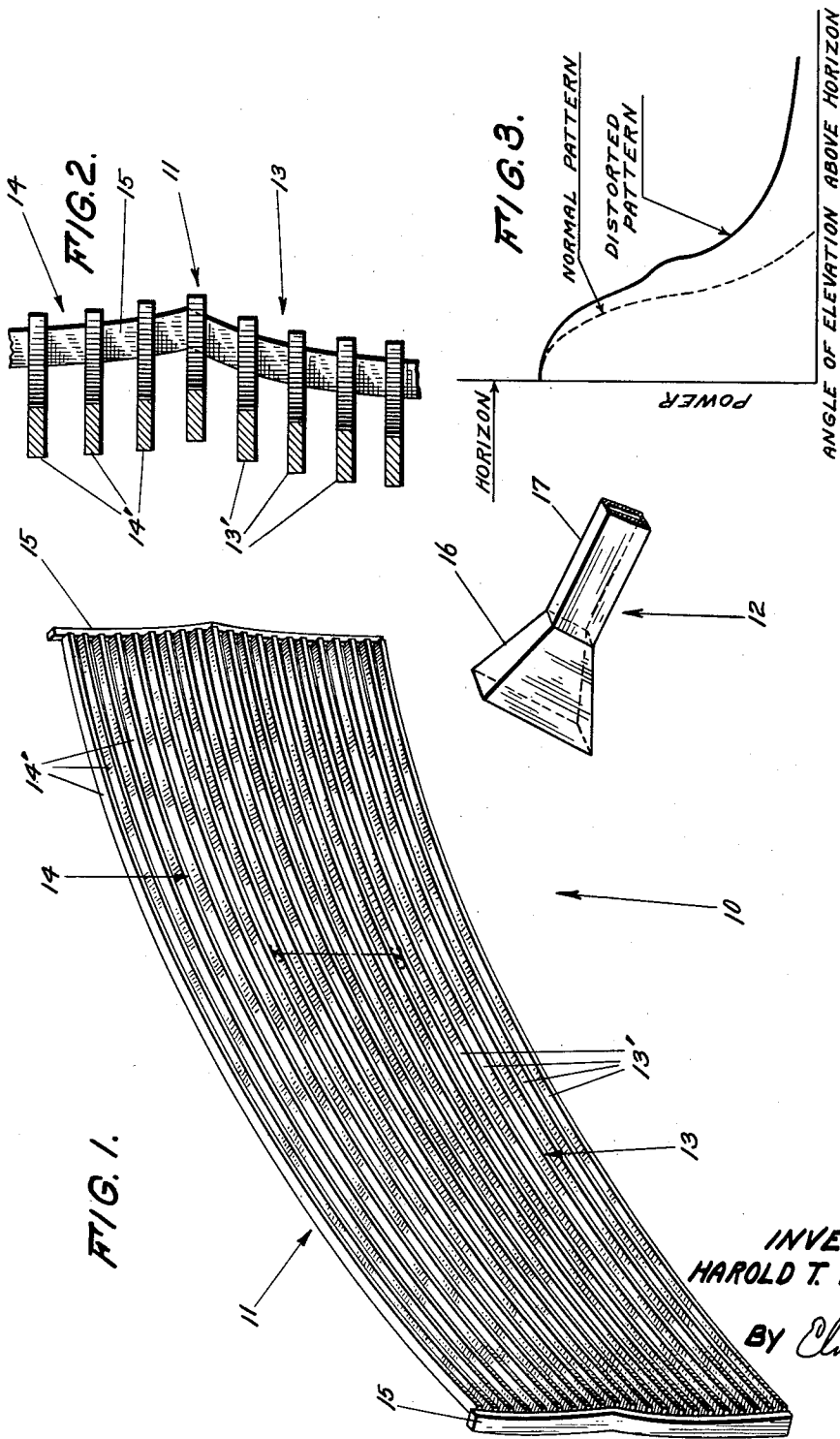
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ANTENNA SYSTEM

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ANTENNA SYSTEM

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This invention relates to antenna systems, and more particularly to antenna systems for use with radar apparatus operating in the hyper-frequency region of the electromagnetic spectrum.

Such antenna systems generally comprise a reflecting element, for example, a paraboloid, and a radiating element located at the focal point of said paraboloid and so disposed with respect thereto as to illuminate the same, whereby the energy directed by said radiating element toward said paraboloid is projected into space substantially in the form of a highly-directional, cylindrical beam.

In certain situations, for example, where it is required that the antenna system of a radar installation be limited in size, be located relatively close to the ground, and yet enable detection of targets at a substantial elevation above the ground, it has been found that the arrangement above described is inadequate. Heretofore, attempts, consistent with the limitations mentioned, to broaden the radiation pattern of such a system, so that its useful portion would include a substantial elevation above the ground, have not been successful.

It is, therefore, the main object of the present invention to provide an antenna system of the type described which is limited in size, which can be located relatively close to the ground, and which, nevertheless, enables detection of targets at substantial elevations above the ground.

It is a further object of the present invention to provide an antenna system, having the foregoing desirable characteristics, which is simple in construction, and which is easy to fabricate and assemble.

These and other objects of the present invention, which will become more apparent as the detailed description thereof progresses, are attained, briefly, in the following manner:

The reflecting element of the antenna system of the present invention incorporates at least two reflecting surfaces, angularly disposed with respect to each other, whereby their respective focal points are displaced with respect to each other. Preferably, said reflecting surfaces, especially in the vertical direction, are of parabolic cross-section, and, together, constitute contiguous portions of a single parabola. It is to be understood, of course, that said reflecting surfaces are not necessarily parabolic; nor do they necessarily have to constitute contiguous portions of a single parabola. Their shapes depend, in each case, on the nature of the space coverage desired of the particular antenna system.

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A radiating element, preferably, in the form of an electromagnetic horn, is disposed in the vicinity of the focal point of one of said reflecting surfaces, whereby the energy illuminating that particular reflecting surface is projected into space substantially as an elliptical beam. The angle at which said electromagnetic horn is placed is such that said last-named reflecting surface is strongly illuminated, while another reflecting surface is relatively weakly illuminated; in other words, the radiation pattern of said horn overlaps but unequally illuminates said reflecting surfaces. By so disposing said electromagnetic horn, the energy reflected by the weakly illuminated reflecting surface so adds to the energy of the main beam that an approximately cosecant-squared pattern results, thus increasing the vertical angle of space illuminated by the system.

While all of the above referred to reflecting surfaces may be solid, it is preferred that they comprise spaced parallel slats.

In the accompanying specification there shall be described, and in the annexed drawing shown, an illustrative embodiment of the antenna system of the present invention. It is, however, to be clearly understood that the present invention is not to be limited to the details herein shown and described for purposes of illustration only, inasmuch as changes therein may be made without the exercise of invention, and within the true spirit and scope of the claims hereto appended.

In said drawing,

Fig. 1 is a perspective view of an antenna system assembled in accordance with the principles of the present invention;

Fig. 2 is an enlarged, fragmentary, vertical sectional view taken along line $x-x$ of Fig. 1; and

Fig. 3 is a graph of the radiation pattern of a conventional antenna system of the parabolic-reflector type as compared with the pattern of the antenna system of the present invention.

Referring now more in detail to the aforesaid illustrative embodiment of the present invention, with particular reference to Figs. 1 and 2 of the drawing, the numeral 10 generally designates an antenna system including a reflecting element 11 and a radiating element 12.

The reflecting element 11 comprises a plurality, here shown as two, of reflecting surfaces 13 and 14, which are slightly angularly disposed with respect to each other, whereby the radiation patterns of the energy reflected thereby, as will be hereinafter described, overlap, but have their major axes extending at slightly different angles of elevation. While not necessarily so, it is pre-

ferred that said reflecting surfaces 13 and 14 be of parabolic cross-section both in the vertical and horizontal directions, and that, in the vertical direction, the cross-sections of said reflecting surfaces constitute contiguous portions of a single parabola.

Preferably, the reflecting surfaces 13 and 14 comprise a plurality of spaced, parallel slats 13' and 14', all of said slats being horizontally disposed in their length, and, as will hereinafter become more apparent, tipped slightly downwardly in their width in the forward direction. As most clearly shown in Fig. 2 of the drawing, in the case where the reflecting surfaces are of parabolic cross-section, the slats 14' of the upper surface 14 are stepped rearwardly in ascending order, and the slats 13' of the lower surface 13 are stepped rearwardly in descending order. The slats 13' and 14' may be supported at their outer ends by any suitable members 15.

Because of the angular relationship between the reflecting surfaces 13 and 14, their respective focal points are obviously displaced with respect to each other in the vertical direction. The radiating element 12 is located in the vicinity of the focal point of one of said surfaces, for example, the surface 13. Preferably, said radiating element 12 comprises an electromagnetic horn 16 terminating a wave guide 17, which is adapted to convey electromagnetic energy from any suitable hyper-frequency oscillation generator (not shown) to said horn.

Said horn 16 has its mouth disposed at such angles with respect to the planes of the apertures of the parabolic surfaces 13 and 14 that the radiation pattern of said horn overlaps said surfaces 13 and 14, but the surface 13 is more strongly illuminated than is the surface 14. Because said horn 16 is located in the vicinity of the focal point of the surface 13, and said surface is relatively strongly illuminated, the main beam of the radiation pattern of the entire reflecting element 11 is substantially in the form of an elliptical column. However, the relatively weakly illuminated surface 14, with respect to whose focal point the horn 16 is displaced, adds to the main beam an auxiliary beam giving a resultant approximation of a cosecant-squared pattern. The combination of the two beams extends the vertical coverage of the reflecting element considerably beyond what it would be in the absence of the angularly-disposed, reflecting surface 14. It has been found that the major axis of the combined beam is shifted upwardly as a result of the presence of the auxiliary portion thereof, and where it is desired that said major axis intersect the horizon, this shift may be compensated for by tilting the entire antenna assembly slightly forwardly.

As shown in Fig. 3 of the drawing the solid-line curve labelled Distorted pattern indicates the increased elevational coverage obtained by means of the present invention over the coverage heretofore obtained, which, in said figure, is indicated by the broken-line curve labelled Normal pattern.

In a typical case, wherein it was desired to cover a sector of space extending through about 2.8° in azimuth, and through about 20° in elevation, a reflecting element was used having a total height of 13.6' and a total width of 48'. The dividing line between the two reflecting surfaces was about 7' from the lower edge of the lower reflecting surface, with the vertex of said lower reflecting surface about 2.4' from said lower edge. The vertical cross-sections of the upper and lower reflecting surfaces constituted con-

tiguous portions of a single parabola having a focal length of 14'', with said upper reflecting surface tipped back at an angle of about 9° with respect to said lower reflecting surface. The entire antenna assembly was tipped forwardly about 5° from the vertical.

The slats followed a parabola, tipped 5°, having a focal length of 12''. Each slat was about .4' wide, and about .062' thick, with the center-to-center spacing between slats .4''. The center of one slat passed through the vertex of the lower reflecting surface and coincided with the plane containing the axis of said lower reflecting surface. All of the slats were parallel, with 6 slats below the vertex slat and 28 slats thereabove. The leading or reflecting edges of the slats extended about .125' beyond the supporting end members.

The electromagnetic horn was uniformly flared in both planes, and was designed to radiate horizontally-polarized energy. Said horn was 4.062' in length, having a mouth 1.140' x 4.768'. The center of the mouth was 12.062' from the vertex of the lower reflecting surface, with its vertical axis inclined at an angle of 23° to the horizontal.

The above-described specific embodiment of the present invention was utilized for radiating energy having a wave length of 4.80 centimeters.

This completes the description of the aforesaid illustrative embodiment of the present invention. It will be noted from all of the foregoing that the present invention provides an antenna system permitting considerably extended vertical space coverage notwithstanding its being restricted as to size and elevation above the ground. It will be understood, of course, that the same principles can be utilized to obtain increased coverage in azimuth. Another advantage of the present invention is that the reflector is made up of uniformly shaped slats, which permits practical commercial production of slatted reflectors without requiring many special dies.

Other objects and advantages of the present invention will readily occur to those skilled in the art to which the same relates.

What is claimed is:

1. In an antenna system: a reflecting element having a plurality of relatively angularly-disposed, parabolic reflecting surfaces the cross-sections of which, together, and in the absence of said angular disposition, define a single parabola; said reflecting surfaces having focal points which are displaced with respect to each other; and a directional radiating element disposed relatively closer to a selected one of said focal points than to the others, and having its radiation pattern overlapping said reflecting surfaces and illuminating one more intensely than the others.

2. In an antenna system: a reflecting element having a plurality of relatively angularly-disposed reflecting surfaces; said reflecting surfaces having relatively displaced focal points and each of said reflecting surfaces including a plurality of spaced slats, with the slats of all of said reflecting surfaces parallel to each other; and a directional radiating element disposed relatively closer to a selected one of said focal points than to the others, and having its radiation pattern overlapping but unequally illuminating said reflecting surfaces.

3. In an antenna system: a reflecting element having a plurality of relatively angularly-disposed parabolic reflecting surfaces the cross-sections of which, together, and in the absence of said angular disposition, define a single parabola;

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said reflecting surfaces having focal points which are displaced with respect to each other; each of said reflecting surfaces including a plurality of spaced slats, with the slats of all of said reflecting surfaces parallel; and a directional radiating element disposed relatively closer to a selected one of said focal points than to the others, and having its radiation pattern overlapping but unequally illuminating said reflecting surfaces.

4. In an antenna system: a reflecting element having a plurality of relatively angularly-disposed, parabolic reflecting surfaces the cross-sections of which, together, and in the absence of said angular disposition, define a single parabola; said reflecting surfaces having focal points which are displaced with respect to each other; and an electromagnetic horn, having a mouth of extended area, disposed relatively closer to a selected one of said focal points than to the others, and having its radiation pattern overlapping said reflecting surfaces and illuminating one more intensely than the others.

5. In an antenna system: a reflecting element having a plurality of relatively angularly-disposed, parabolic reflecting surfaces the cross-sections of which, together, and in the absence of said angular disposition, define a single parabola; said reflecting surfaces having focal points which are displaced with respect to each other; each of

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said reflecting surfaces including a plurality of spaced slats, with the slats of all of said reflecting surfaces parallel to each other; and an electromagnetic horn, having a mouth of extended area, disposed relatively closer to a selected one of said focal points than to the others, and having its radiation pattern overlapping but unequally illuminating said reflecting surfaces.

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