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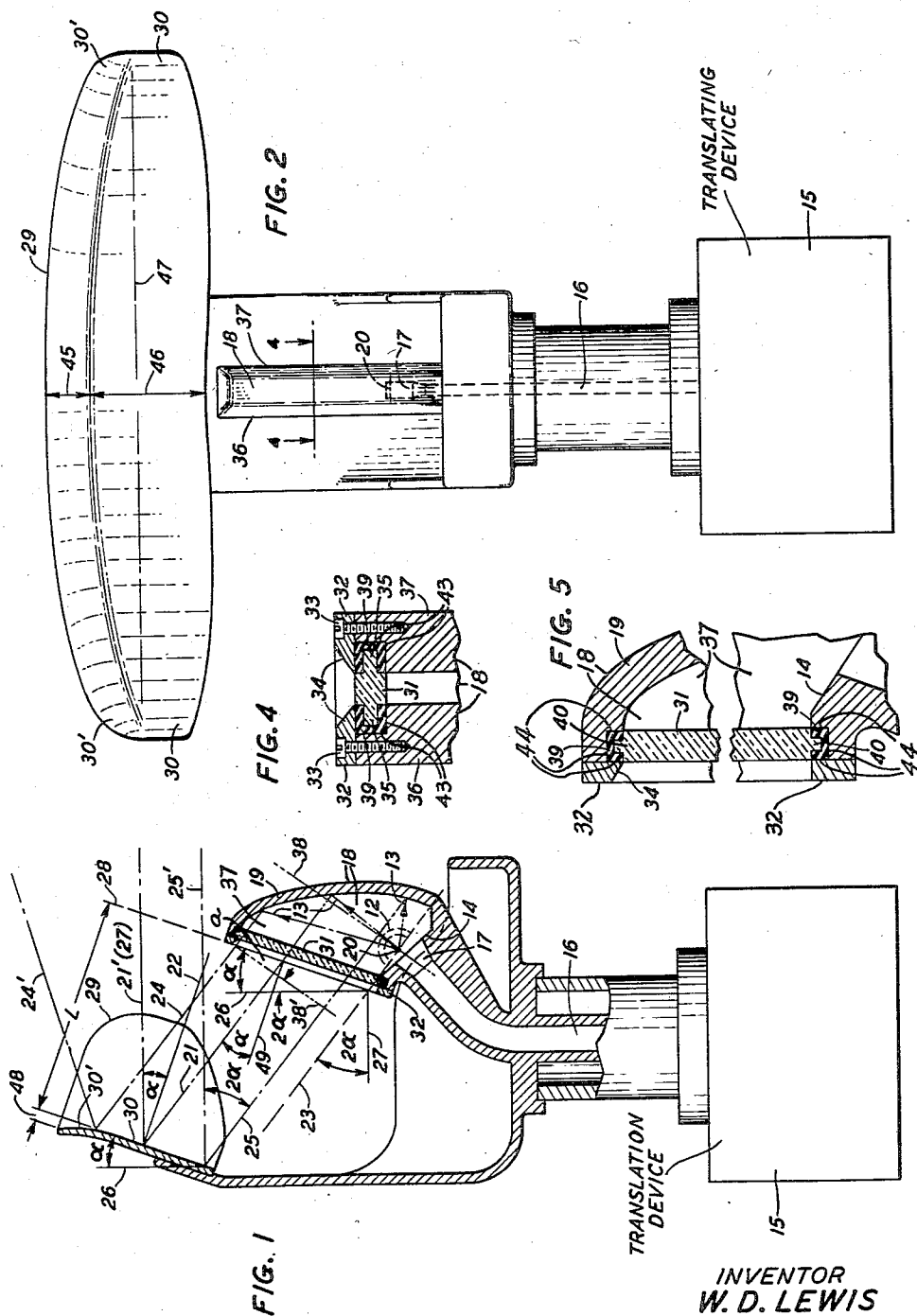
W. D. LEWIS

2,846,680

DIRECTIVE ANTENNAS

Filed June 29, 1946

2 Sheets-Sheet 1



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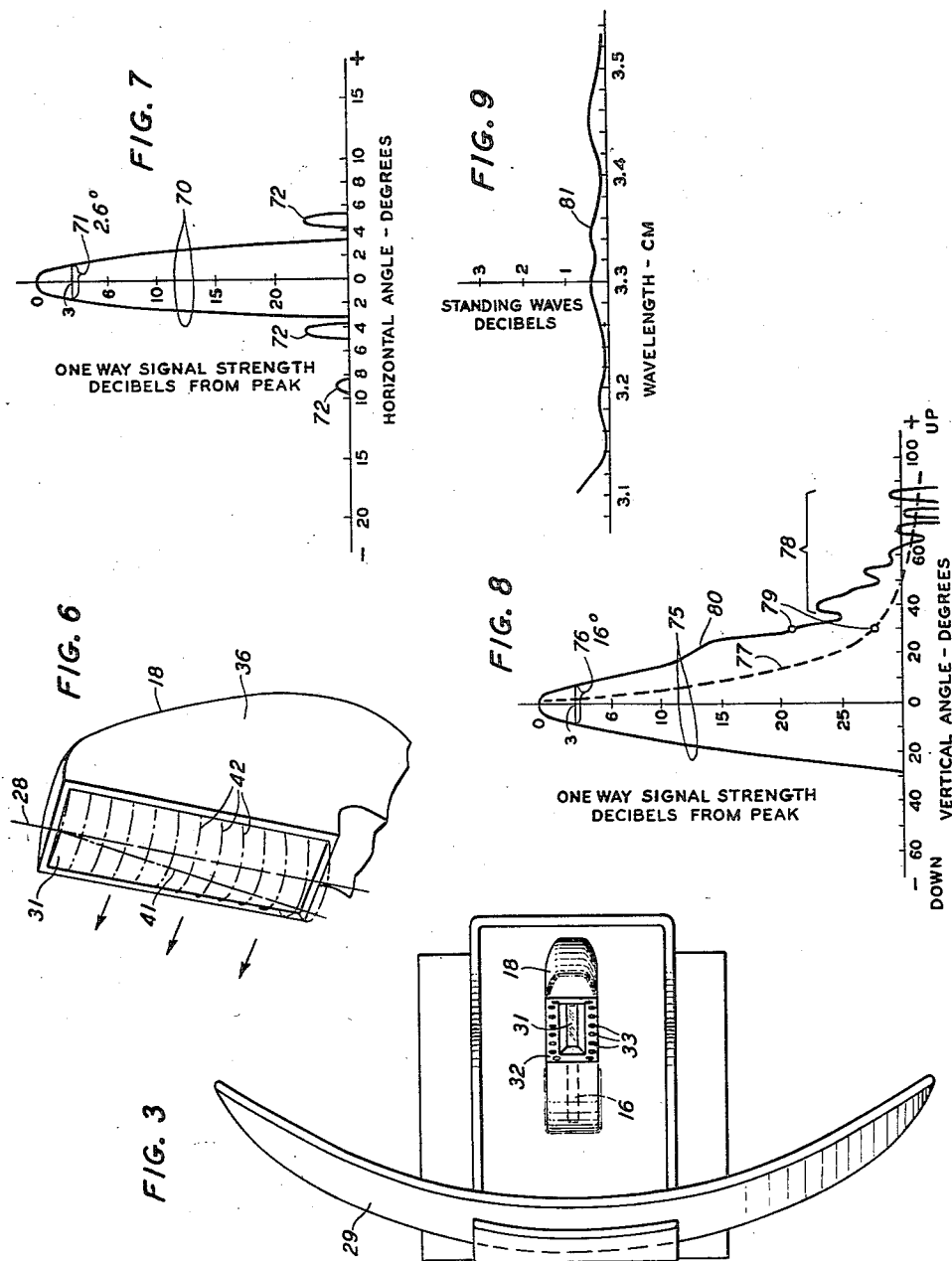
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DIRECTIVE ANTENNAS

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Application June 29, 1946, Serial No. 680,361

13 Claims. (Cl. 343—838)

This invention relates to antenna systems and more particularly to antenna systems for use with directive radio devices.

In general, antenna systems for use with directive radio energy reflection devices have employed a primary antenna element and one or more reflecting elements which present curved surfaces to secure concentration of the energy distribution. Because surfaces having a cylindrical parabolic curve are more easily and economically manufactured than paraboloidally curved surfaces certain advantages accrue to the use of the former surface. Patents 2,434,253 granted on January 13, 1948 to A. C. Beck and 2,482,162 granted on September 20, 1949 to C. B. H. Feldman each disclose an antenna system comprising a cylindrical parabolic reflector and a wave guide or primary antenna. Certain compensating desirable features have been found to be attendant upon the use of paraboloidally shaped reflectors. In the copending application of C. C. Cutler, Serial No. 547,399, filed July 31, 1944 an antenna system is disclosed for securing uniform illumination, or so-called cosecant coverage, of a plane area. This application matured into Patent 2,489,865 granted November 29, 1949. Patent 2,427,005 granted on September 9, 1947 to A. P. King discloses an antenna system, comprising a concave or paraboloidally shaped reflector and a wave guide or primary antenna, for avoiding the undesirable effects attendant upon interposing a structure of substantial size in the field of the reflector. My copending application, Serial No. 574,334, filed January 24, 1945, which matured into Patent 2,705,754 granted April 5, 1955, discloses an easily manufactured cylindrical parabolic reflector system for securing an exceedingly high gain antenna possessing a wide band characteristic and a very sharp major lobe. The system provides a beam possessing adequate cosecant distribution for an "early warning" or long range searching system.

In addition to the foregoing considerations, as exemplified by the above cited applications, most prior art antenna systems employing a wave guide primary antenna interposed in or adjacent to the axis of the antenna field are subject to detrimental results arising from outgoing energy being reflected back into the wave guide, or feed line, to cause a frequency sensitive impedance mismatch.

Accordingly, it appears advantageous to secure an antenna system that lends itself to simple economical manufacturing processes, is capable of a high degree of definition in two perpendicular planes, possesses a beam with so-called cosecant coverage suitable for detection of nearby objects at considerable elevational angle, and while being of sufficient size to possess mechanical ruggedness does not introduce secondary reflection or "shadow" effects and is not susceptible to frequency sensitive mismatches.

It is one object of the invention to secure a mechanically rugged antenna system possessing a lobe or beam in which the half power point lobe width in one plane is at least five times the half power point width in a perpendicular plane.

It is also an object to make possible an asymmetrical

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energy distribution whereby the energy in one-half of the major lobe in one plane is distributed along a curve approximating the curve for a cosecant function.

It is a further object to secure in an antenna system the radiation of or receipt of energy at high angles of elevation such as would be necessary for the detection of a nearby object in a plane perpendicular to the scanning plane.

It is also an object to make possible in antenna systems possessing considerable mechanical ruggedness the radiation and receipt of radio energy without experiencing secondary reflection effects or without distorting the fields of the antenna.

A still further object of the invention is to make possible the directive radiation of radio energy while at the same time substantially eliminating the reflection of radiated energy back into the primary antenna.

A still further object is to make possible watertight, pressure proof housing of the primary antenna element of an antenna system without introducing objectionable reflection effects.

One embodiment of the invention comprises a relatively large cylindrical parabolic main reflector slightly inclined from the vertical in which the upper portion is distorted from its cylindrical contour to a slightly convex contour so that the reflector presents a cylindrical parabolic surface for more than one-half of its transverse dimension and a convex parabolic surface for the remainder. A line type antenna element, or so-called half pill-box, comprising a relatively small cylindrical parabolic auxiliary reflector and two parallel end plates attached thereto so as to form therewith a rectangular antenna aperture, faces the main reflector and is so positioned that the short focal line, not greater than one-half wavelength, of the auxiliary reflector is perpendicular to but spaced from the relatively long focal line of the cylindrical parabolic section of the large reflector. A substantially transparent dielectric window is positioned in the aforesaid antenna aperture. The plane of the antenna aperture mentioned above is substantially parallel to and coincident with the focal line of the large reflector; however, this plane is at an acute angle to the axial plane of the secondary reflector. A horn is slightly offset from the focal line of the secondary or auxiliary reflector in such fashion that no part of the horn is interposed in the useful field of the secondary reflector.

In operation, waves emanating from the horn appear to originate along the focal line of the auxiliary reflector whereby it is uniformly illuminated. The half pill-box antenna produces a plane wave front extending perpendicular to the axis or axial plane of the auxiliary reflector, by reason of the parabolic contour of the auxiliary reflector and the very small spacing, not greater than a half wavelength, between the parallel end plates. After passing beyond the confines of the reflector and end plates, that is, through the rectangular antenna aperture, the wave tends to take on a circular front in the transverse plane parallel to the short dimension of the rectangular aperture and to the axial plane. In the longitudinal plane parallel to the long dimension of the rectangular aperture, the wave front is linear and, as the plane of the aperture is at an acute angle to the secondary reflector's axial plane, the wave has a conically shaped wave front originating along the focal line of the large reflector. The main and secondary reflectors are so disposed with respect to the horizontal and vertical planes that the wave from the secondary reflector describes an acute angle with a perpendicular to the plane of the aperture. As the angle of reflection, or the summation of the re-radiated wavelets, is equal to the angle of incidence and the large reflector is inclined from the vertical at an angle equal to the angle of incidence it is possible to locate

the secondary reflector beneath the main scanning plane of the system. Because the secondary reflector is substantially removed from the scanning plane of the large reflector and because the directive horn is substantially removed from the axial field of the secondary reflector the amount of outgoing energy that is reflected into the wave guide antenna is comparatively small.

The departure of the upper part of the large reflector from a cylindrical to a convex contour provides a reflecting surface along the upper longitudinal dimension of that reflector for high angle radiation and receipt of energy. This makes possible a cosecant distribution pattern for close-in detection of objects at relatively large elevational angles to the horizontal scanning plane. In reception, the system performs in reverse order.

In order to provide a watertight pressure-proof housing for the primary antenna element the antenna aperture of the secondary reflector is equipped with a dielectric window one-half wavelength in thickness. The window thickness is determined by the operating frequency and the dielectric constant of the substance forming the window, the optimum thickness being substantially equivalent to one-half wavelength, as measured in the aforesaid dielectric substance. The window is mechanically supported on dielectric flanges fitting into slots in the side plates and end members of the reflector. For optimum conditions the slots have a depth in the side plates equal to one-half the wavelength in the dielectric used and in the end members equal to one-quarter wavelength in the dielectric. In general, the thickness of the flange section should be maintained at a minimum consistent with providing adequate mechanical strength to meet the expected stress or pressure to which the window is likely to be exposed.

The invention will be more readily understood from a study of the following detailed explanation with reference to the accompanying drawing in which like reference characters denote elements of similar function and in which:

Figs. 1, 2 and 3 are respectively side, front and top views of one embodiment of the invention;

Fig. 4 is a top cross-sectional view at the line 4—4 of Fig. 2;

Fig. 5 is a detail partial sectional view of the line antenna element included in the embodiment of Figs. 1, 2 and 3;

Fig. 6 is a perspective view showing the conically shaped contour the wave assumes after it emerges from the line antenna element;

Figs. 7, 8 and 9 are explanatory graphs referred to in the following explanation.

Referring to Figs. 1, 2 and 3 reference numeral 15 denotes a translation device, such as a radar transceiver, and numeral 16 denotes a wave guide attached thereto. Numeral 17 denotes a horn extending through the bottom 14 of a cylindrical parabolic reflector 19 which has a short focal line 20 of a length equal to one-half wavelength or less, an axis or axial plane 23 and a focal plane 38. Numerals 36 and 37 denote metallic end plates attached to each end of the parabolic reflector 19 and forming therewith a line antenna element 18, or so-called half pill-box, having a rectangular opening containing the dielectric window 31. Numeral 29 denotes a larger cylindrical parabolic reflector hereinafter referred to as the main or primary reflector. This reflector has a complex shape comprising the cylindrical parabolic surface 30 having a transverse dimension 46 and a longitudinal dimension 47 and a convex parabolic surface 30' having the same longitudinal dimension 47 and the transverse dimension 45. Section 30' is formed by causing the section comprising the dimensions 45, 47 to depart from the straight line of the cylindrical section essentially along a square law curve, as shown, so that the top longitudinal edge of the reflector is set back a distance 48 from its position in the cylindrical portion of the reflector. Refer-

ence numerals 26 and 27 denote vertical and horizontal planes respectively. Reference letter α denotes the angle by which the cylindrical axis of the main reflector 29, the focal line 23 of this reflector and the plane of the aperture window 31 are inclined from the vertical plane 26. It also represents the angle formed by the plane of the aperture window 31 and the plane 38' parallel to the latus rectum plane 38 as well as the angle formed by the axial plane 23 and the plane 49 perpendicular to the plane of the window 31.

Referring to Figs. 4 and 5, which illustrate the mounting details for the dielectric window 31, numeral 32 denotes a clamping device secured to the outer edge of the side walls 36 and 37 and the two ends of the auxiliary reflector 19 by the machine screws 33. Numerals 34 denote three inside surfaces of the metallic clamping device 32, the three surfaces being beveled or flared so as to form impedance improving flanges and to provide proper illumination of the main reflector 29 by the line antenna element 18. The side walls 36 and 37 and the end members 14 and 19 are grooved or "stepped" so that, with the clamping device 32 in place, receptacles 43 along the longitudinal sides and receptacles 44 along the ends 14 and 19 are formed. These receptacles are adapted to receive the flange-like sections 35 and 40 which form the mechanical support for the window 31. Numeral 39 designates a rubber gasket that may be used to secure a watertight pressure-proof fitting about the window 31 if that is desired. If this gasket is used it should be of a material having a dielectric constant the same as or closely approaching that of the material composing the dielectric window 31 and the flange portions 35 and 40.

The window construction is such that its length and breadth correspond to the respective aperture dimensions. It has a thickness substantially equal to one-half wavelength in the dielectric material at the operating frequency. The grooved recesses 43 have a depth equal to the window thickness and the grooved recesses 44 along the end sections have a depth of one-quarter wavelength in the dielectric at the operating frequency. These grooved sections 43, when filled with the flange-like dielectric sections 35 having a one-half wavelength dimension, appear as shorted half wave sections and present apparent low impedance surfaces at the junction of the window 31 and the flange sections 35. Insofar as the radio waves approaching the window 31 are concerned it appears substantially as if the side walls 36 and 37 continued outwardly to meet the flared surfaces 34. The grooved sections 44 having a quarter wavelength depth, when filled with the flange-like sections 40 having a quarter wave dimension, appear as shorted quarter wave sections and present apparent high impedance surfaces at the junction of the window 31 and the flange sections 40 and effectively reduce the spillover or leak of radio energy around the end surfaces.

Again referring to Figs. 1, 2 and 3, in operation the waves supplied by the translation device 15 are conveyed by the wave guide 16 to the directive horn 17 where they are radiated. The opening of the horn 17 is substantially aligned with the short focal line 20 but is depressed slightly below the line so that it is removed from the useful field of the reflector 18 while at the same time it energizes the focal line 20. Because of the small spacing between the plates 36 and 37, the wave emitted by the horn 17, and propagated in the half pill-box between the plates 36, 37 and toward reflector 19, has a linear front in any plane parallel to, or containing, the short focal line 20. In the vertical plane perpendicular to the focal line 20, the aforesaid propagated wave has a circular front, as indicated by the curved dotted lines 12. Hence, the wave propagated toward the reflector 19 has a conical wave front. This wave impinges upon the parabolic surface of the curved member 19, as indicated by the direction arrows 13, and by this

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surface the circular front mentioned above is converted to a linear front. The wave reflected by the reflector 19 and having a substantially linear front in the vertical plane mentioned above and any plane perpendicular thereto, and hence having a plane front extending parallel to the reference plane 38' and perpendicular to the axis 23, moves toward the main reflector 29 in a direction perpendicular to the latus rectum plane 38, and parallel to the axis 23, until it reaches the outside of the window 31. After leaving the window 31 the wave front in the axial plane assumes a circular contour as indicated by the dot-dash lines 42 of Fig. 6. The wave front in the vertical plane containing the focal line 28 and perpendicular to the short focal line 20 remains linear, as indicated in perspective by line 41 of Fig. 6. Because the plane of the aperture containing the window 31 is at an angle α to the reference plane 38', that is, because the lengths of the diverse propagation paths extending between the window 31 and the reference plane 38' vary linearly, the wave front established by the half pill-box 18 is conical, as shown in Fig. 6, the slope of the conical wave front being inclined at an angle of 2α to the vertical plane 26 and at an angle α to the plane of the window 31. The window 31 and the longitudinal axis of the conical wave front are substantially coincident with the focal line 28. It should be remembered that this wave had a linear front parallel to the line 41 (Fig. 6) initially and this condition is retained as it progresses toward the main reflector 29, notwithstanding its circular front in the axial plane 23. The portion of the main reflector having the surface 30 is a parabolic cylinder having a vertical focal line parallel to dimension 45, and considering the vertical plane, it functions as a plane reflector for the linear component or portion of the conical wave front established by the line antenna element 18. Reflector 30 having a parabolic contour in its longitudinal plane transforms the circular wave front, shown by the dot-dash lines 42 (Fig. 6) to a linear front. The final outgoing wave therefore has a flat front since it has linear characteristics in perpendicular planes and assumes the character of a point beam with the attendant high gain. Because the impinging wave front 41 (Fig. 6) strikes the cylindrical parabolic surface 30, which acts as a plane reflector in the vertical plane, at an angle of 2α to the horizontal plane, and because the optical or mathematical axis 22 of this reflector is inclined at an angle α from the horizontal plane, the effective angle of incidence is α , as is the angle of reflection, which places the plane of maximum energy distribution in the horizontal plane with the flat wave front perpendicular to this plane. Because of the foregoing angular relations, the system is ideally suited for azimuthal scanning.

From the foregoing it will be noted that the shape of the horizontal plane characteristic of the beam is controlled by the parabolic contour of the main reflector 29 since the auxiliary reflector 18 acts as a plane reflector in this plane. Similarly the shape of the vertical plane characteristic of the beam is essentially controlled by the parabolic contour of the reflector 18 since the main reflector 29 acts as a plane reflector in this plane over its surface 30. By properly correlating the dimensions of the two reflectors a wide choice of lobe patterns are available. In one tested embodiment wherein the longitudinal dimension of the window 31 was slightly greater than the length of the focal line 28 and the longitudinal dimension 47 of the main reflector was about 60 times as great as the length of the focal line 20, a beam was obtained in which the width at the half power point in the vertical plane was 5 times that of the width in the horizontal plane at the same power point.

It was previously stated, the lobe pattern in the vertical plane is essentially controlled by the parabolic contour of reflector 18 and its relation to the length of the focal

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line 28 and this is true for low elevational angles. However, some of the wave energy from the auxiliary reflector 18 strikes the convex parabolic surface 30' and as the transverse axis of this section departs from the straight line axis of the cylindrical section 30 substantially as a square law function it is evident that this section does not act as a plane reflector along its transverse axis 45 and therefore the energy is reflected at an angle greater than α and is accordingly directed above the horizontal plane. The exact contour of this section is selected by trial to produce the desired energy distribution. As will be noted in the discussion of Fig. 8 in one embodiment this surface was shaped so that its effect when combined with the beam above referred to produced an asymmetrical lobe pattern in which the upper half approximated a desired theoretical distributional pattern in accordance with the cosecant curve for uniform illumination of a certain desired target plane. From the foregoing it is evident that this system, in addition to being admirably suited for azimuthal searching produces a beam with cosecant coverage to exceptional high elevational angles and, therefore, is also admirably suited for searching in a vertical plane perpendicular to the main search plane. This result is accomplished through the use of relatively easily manufactured reflectors and by so placing the primary antenna 17 and the auxiliary reflector 18 in a depressed position such that they do not impair the antenna distributional pattern through reflective or "shadow" effects and substantially eliminate frequency sensitive mismatches since a negligible amount of the radiated energy is reflected back into the feed line 16.

Figs. 7, 8 and 9 indicate some measured results obtained on a particular antenna system employing one embodiment of the invention and having a design frequency corresponding to a wavelength of 3.3 centimeters. Some representative physical dimensions were as follows. Focal line 20 and spacing between side plates 36 and 37 one-half inch. Window aperture 31 one-half inch wide by 6.84 inches high. Focal length "L" of the main reflector 29 ten inches. Longitudinal axis 47 thirty inches. Transverse axes 45 and 46 respectively two and five and one-half inches. Angle α approximately nine degrees. "Set back" 43 of the surface 30' as compared to the surface 30 was one-half inch.

Referring to Fig. 7 the main lobe 70 and the minor lobes 72 are shown for the horizontal plane. The main lobe is symmetrically disposed about its axis and has a width of substantially 2.6 degrees at its half power point 71 corresponding to a decrease of 3 decibels from its peak value. It will be noted that the most closely associated minor lobes 72 are at least 22 decibels below the peak of the major lobe 70. Although not here shown the actual measurements indicated the next occurrence of minor lobes of sizable magnitude was at plus 25 degrees and minus 30 degrees where lobes 27 decibels and 28 decibels, respectively, below the peak value, were noted. All other measured lobes were below these levels. The antenna gain of this system was found to be 27.7 decibels above that for a theoretical spherical antenna.

Fig. 8 indicates the energy distribution in a vertical plane for the described system. The main lobe 75 has a width of approximately 16 degrees at the half power point 76 corresponding to a decrease of 3 decibels from its peak value. This width when compared to the 2.6 degrees at a similar point in the horizontal plane indicates a beam having an aspect ratio greater than 6 to 1. That portion of the curve that would normally show as minor lobes has been here grouped under reference numeral 73 since they now form a part of the major lobe 75 by virtue of the reflective effect of the convex parabolic section 30' of the main reflector 29. In this connection, it is interesting to note that this changed contour 30' of the main reflector 29 gives the first indication of its effect in this embodiment at about 17 degrees elevation as designated by the numeral 80 and has no appreciable effect on the lower half or

"down" half of the pattern. Because of this action the major lobe 75 is vertically asymmetrical about its axis in a horizontal plane and approximates and lies above the curve 77 for all angles up to about 64 degrees from the horizontal. Curve 77 represents the idealized curve of energy distribution sufficient to provide uniform scanning illumination of a target plane such as would encompass a target first noted at 15,000 yards range and 1,000 feet elevation and which approaches the antenna at constant altitude until it is overhead. This is the so-called cosecant curve or cosecant pattern. As the upper half of curve 75 closely approximates the curve 77 and remains constantly above that curve for all angles up to about 64 degrees of elevation above the horizontal it follows that this system provides a beam with cosecant pattern suitable for sky searching when mounted for azimuthal scanning.

Fig. 9 shows the extremely wide band characteristic of a system such as described. Curve 81 indicates the level of standing waves as measured in the wave guide 16 adjacent to the directive horn 17 for various frequencies corresponding to wave-lengths from 3.1 centimeters to 3.5 centimeters. The impedance match of this system remains substantially unchanged over this wide band because of the substantial elimination of the reflection of radiated energy back into the feed line 16. This result was achieved through the double depression of the energizing sources beneath the main fields of radiation as was done in aligning the directive horn 17 with, but slightly beneath, the focal line 29 of reflector 19 and also by depressing the line antenna 18 beneath the scanning plane of the main reflector 29. It should be noted that the half pill-box or parallel plate line element 18 constitutes a wave guide and since the dielectric window 31 is at an acute angle to the wave propagation direction 23 or 24 in the half pill-box 18, wave components reflected by the inner or outer surface of the window toward reflector 19 are not directed into the horn 17, that is, the window angle is such that the reflected or feedback wavelets just mentioned are not focussed on horn 17, whereby standing waves are not established in guide 16. In addition to the elimination of frequency sensitive impedance mismatches the depression of the reflector 18 makes possible the production of energy distribution patterns having minor lobes suppressed to a considerably greater extent than most prior art systems.

Although the invention has been explained in connection with certain embodiments it should be understood that it is not to be so limited thereto since other apparatus may be employed in successfully practicing the invention.

What is claimed is:

1. In combination, a cylindrical parabolic reflector having a focal line included in a vertical plane and extending at an acute angle to a horizontal plane containing the desired direction of maximum radio action, a line antenna element substantially coincident with said focal line, said element being spaced from said horizontal plane.

2. In combination, a first cylindrical parabolic reflector having an axial plane, a second cylindrical parabolic reflector having an axial plane perpendicular to the axial plane of said first reflector, a pair of parallel end plates attached to said second reflector and forming therewith a rectangular aperture, the plane of said aperture forming an acute dihedral angle with the axial plane of said second reflector.

3. In an antenna system, a reflector positioned at an acute angle with the vertical plane and having a focal line, said line forming an acute angle with a horizontal plane, a second reflector having an axial plane, a focal line, a pair of parallel end plates attached to said second reflector and forming therewith a rectangular antenna aperture, the longitudinal dimension of said aperture being substantially coincident with the focal line of said first reflector, the plane of said aperture and the axial plane of said second reflector forming an acute dihedral

angle, the angle between the horizontal plane and the axial plane of said second reflector being twice the dihedral angle formed by the intersection of the plane of the aperture and the vertical plane, whereby the directive pattern of said antenna system is not distorted by said second reflector.

4. A directive antenna system having in a given plane of action a directive pattern including one major lobe and at least one minor lobe, said system comprising a first and a second cylindrical parabolic reflector facing each other and having their axial planes at right angles, the second reflector being spaced from said plane of action, the plane bisecting the dihedral angle formed by the intersection of said plane of action and the axial plane of said second reflector including a mathematical axis of a parabolic segment of said first reflector, whereby the directive pattern of said antenna system is not distorted and the intensity of said minor lobe is maintained at a minimum with respect to the major lobe intensity.

5. In combination, a first reflector comprising a complex surface, the upper portion of which is a convex surface such as would be described by passing an arc along a parabolic curve, the lower portion of which has a substantially cylindrical parabolic shape and a focal line, said lower portion constituting more than one half of the total reflector, a second reflector having a substantially cylindrical parabolic shape, an axial plane, and a focal line perpendicular to the focal line of said first reflector, a pair of parallel end plates attached to said second reflector and forming therewith a rectangular aperture facing said first reflector, the plane of said aperture being at an acute angle to the axial plane of said second reflector and being located at substantially the focal line of said first reflector, whereby an asymmetrical directive pattern having an aspect ratio of at least five to one is secured.

6. In combination, a cylindrical parabolic small reflector having a short focal line and an axial plane, a large reflector the greater portion of which has a focal line of greater length than said first mentioned focal line and the lesser portion of which presents a convex parabolic surface, a pair of parallel end plates attached to said small reflector and forming therewith an antenna aperture located substantially coincident with the focal line of said large reflector whereby said small reflector illuminates said large reflector and the directive pattern, in a plane containing the focal line of the large reflector and extending perpendicular to the short focal line of the small reflector, has a contour substantially in accordance with a cosecant curve.

7. A directive scanning radio system having an energy distribution pattern at the half power point at least five times as wide in one plane as is its energy distribution pattern at the half power point in a perpendicularly related plane, said system comprising a main reflector having a substantially convex parabolic surface in its upper portion and a cylindrical parabolic surface in its lower portion said lower portion exceeding said upper portion and having a focal line inclined at an acute angle with the vertical, a second cylindrical parabolic antenna having a short focal line and an axial plane perpendicular to the focal line of said first reflector, a pair of parallel end plates attached to said second reflector and forming therewith a rectangular aperture, said aperture being located substantially coincident with the focal line of said first-mentioned reflector, a directive wave guide antenna located at substantially the focal line of said second cylindrical parabolic antenna, and a translation device connected to said directive antenna, whereby in transmission the wave emitted by the primary antenna is converted to a conically shaped wave front coincident with the focal line of said first-mentioned reflector, and said first reflector converts said conically shaped wave front to a plane wave front having its energy distribution at least five times as concentrated in one plane as it is in a per-

pendicularly related plane, and whereby in reception the converse operation obtains.

8. A directive reflector for the propagation of radio waves comprising a cylindrical parabolic reflector having an axial plane and a short focal line, a pair of parallel end plates attached to said reflector and forming there- with an antenna aperture having given longitudinal and transverse dimensions in a plane at an acute angle to said axial plane, a dielectric member for closing said aperture without substantially impairing the radiating efficiency of said reflector, a clamping member having suitable means for attachment to the reflector structure so as to form therewith a grooved recess for fastening said dielectric member over said aperture, said grooved recesses having a depth of substantially one half the length of the radio wave in the dielectric material along the longitudinal sides and a depth of one fourth the aforesaid wavelength along the transverse ends of said aperture, said dielectric member having a shape such that it extends one half of said aforesaid wavelength beyond each longitudinal edge of said aperture and one fourth the aforesaid wavelength beyond each transverse end of said aperture, each edge of said dielectric member being short-circuited by said clamping member, said dielectric member having a thickness of substantially one half of said aforesaid wavelength throughout the area of said member continuous to said aperture and having elsewhere a thickness of less than one half of the aforesaid wavelength, whereby said dielectric member is apparently supported by low impedance elements along the longitudinal sides and high impedance elements along said transverse ends of said antenna aperture.

9. A dielectric member for transmitting radio waves through an antenna aperture having given transverse and longitudinal dimensions, said member comprising a block of dielectric material having a main conducting body portion and a secondary contiguous circumscribing portion in the shape of flange surfaces projecting from the sides and ends of said main portion, said main body portion having substantially the same coincident transverse and longitudinal dimensions as said aperture and in a plane perpendicular to the plane containing said transverse and longitudinal dimensions a thickness dimension substantially equal to one half the length of the radio wave in said dielectric at the operating frequency, said secondary circumscribing contiguous portion having a thickness dimension less than the thickness of said main portion and extending outwardly from each longitudinal side of said main body for a distance equal to substantially one half the length of the wave in the dielectric at the operating frequency, whereby said conducting main portion may be supported along its longitudinal sides by apparent low impedance surfaces.

10. A dielectric member according to claim 9, said secondary contiguous circumscribing portion extending outwardly from said main body along each transverse end section for a distance equal to substantially one fourth the length of the wave in the dielectric at the operating frequency, whereby said conducting main portion may be supported along its transverse end sections by apparent high impedance surfaces.

11. A terminating member for a radio wave propagating antenna aperture, said member being composed of a dielectric material of complex shape, said member comprising a block section of suitable length and breadth dimensions for fitting contiguously inside of said aperture and having a thickness substantially equal to one half of the wavelength of said radio wave in said dielectric, and two flange-like sections each having a thickness equal to less than one half of said wavelength and of the same length as said block section, each of said flange sections extending outwardly from a side of said block section for a distance equal to one half of said wavelength measured along a line substantially normal

to said side, whereby a minimum impedance change is presented to the propagated radio wave in the desired plane of propagation and an apparent low impedance surface is presented to said wave in the plane of the juncture of said block section and flange sections when said flange sections are substantially everywhere in contact with the metallic surface of said antenna member.

12. A terminating member for a radio wave propagating antenna aperture, said member being composed of a dielectric material and having a complex shape, said member comprising a block section having a thickness equal to one half the length of the operating radio wave in said dielectric material and a length and breadth suitable for fitting contiguously inside of said aperture, two flange-like sections each having a thickness of less than one half of said wavelength and having another dimension equal to the width of said block section, each of said flange sections extending outwardly from an end of said block section for a distance equal to one fourth of said wavelength along a line substantially normal to said end, whereby a minimum impedance change is presented to the propagated radio wave in the desired plane of propagation and an apparent high impedance surface in the plane of the juncture of said block and flange sections is presented to said radio wave when the lateral faces of said flange sections are substantially everywhere in contact with a metallic surface.

13. A terminating member for a radio wave propagating antenna aperture, said member being composed of a dielectric material of complex shape, said member comprising a first section having a substantially uniform thickness equal to one half of the length of the operating radio wave in the dielectric material and having suitable length and breadth for contiguous fit inside of said aperture, and a second section of a thickness equal to less than one half of the length of said wave in said dielectric, said second section bounding the two ends and two sides of said first section and extending outwardly from said sides a distance equal to one half of said wavelength and extending outwardly from said ends a distance equal to one fourth of said wavelength when measured along lines substantially normal to said sides and ends of said first section, whereby a minimum impedance change is presented to said propagated radio wave in the desired plane of propagation, apparent low impedance surfaces are presented to said radio wave in the planes of juncture of said first and second sections along the lengthwise dimensions and apparent high impedance surfaces are presented to said radio wave in the planes of juncture of said first and second sections parallel to said end sections when the lateral faces of said second section are substantially everywhere in contact with a metallic surface.

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