

Oct. 4, 1949.

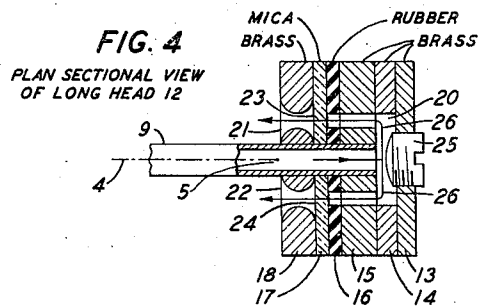
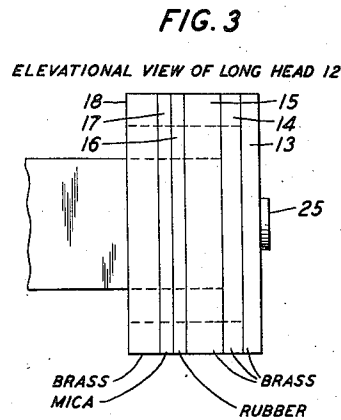
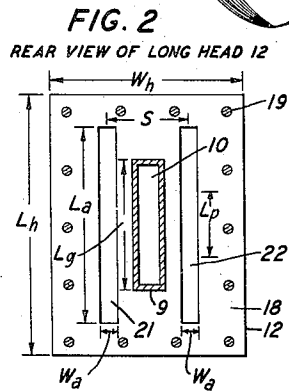
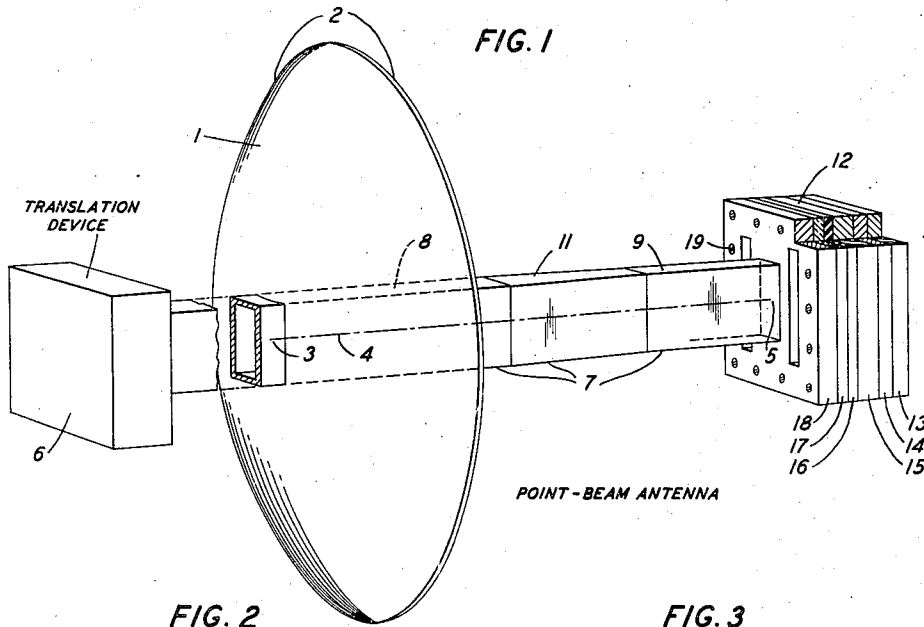
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2,483,575

DIRECTIONAL MICROWAVE ANTENNA

Filed July 26, 1944

6 Sheets-Sheet 1



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DIRECTIONAL MICROWAVE ANTENNA

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6 Sheets-Sheet 2

FIG. 5

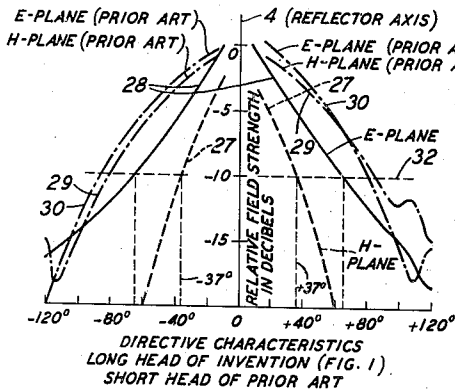


FIG. 6

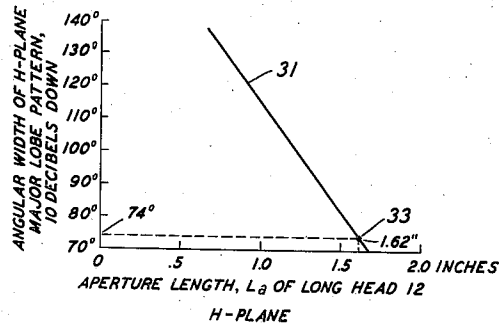


FIG. 7

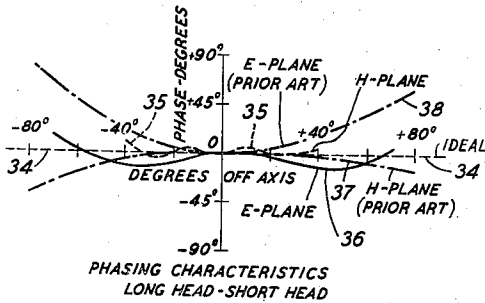


FIG. 8

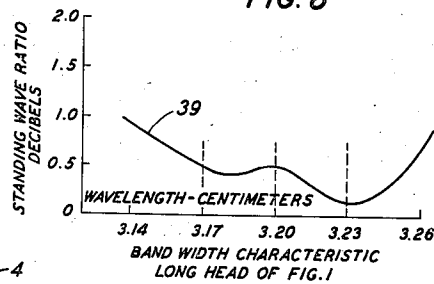
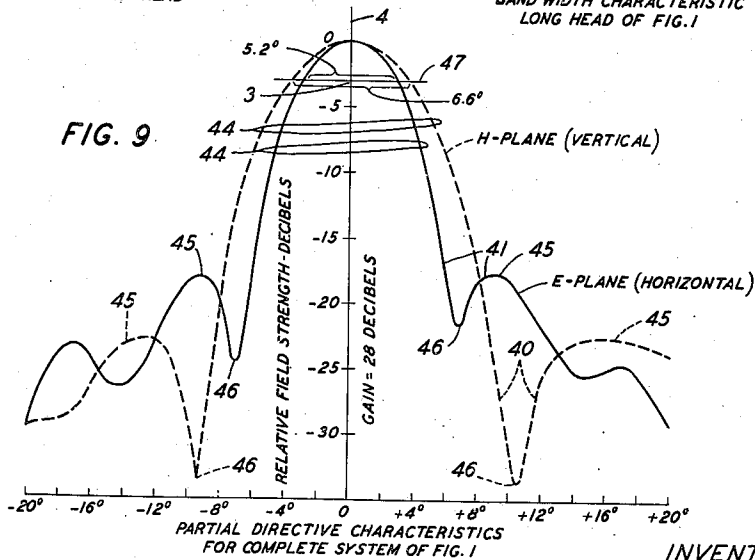


FIG. 9



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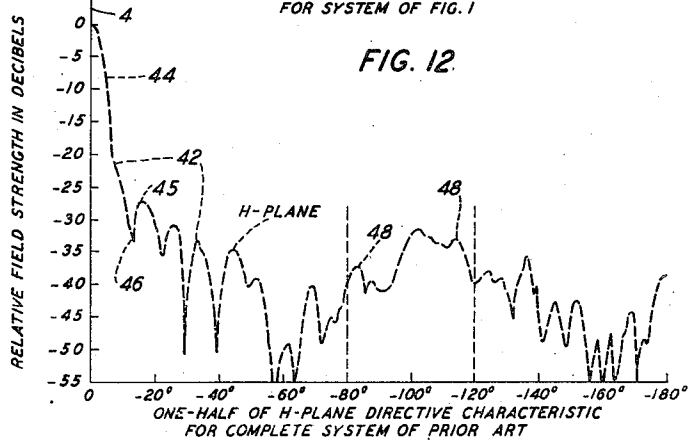
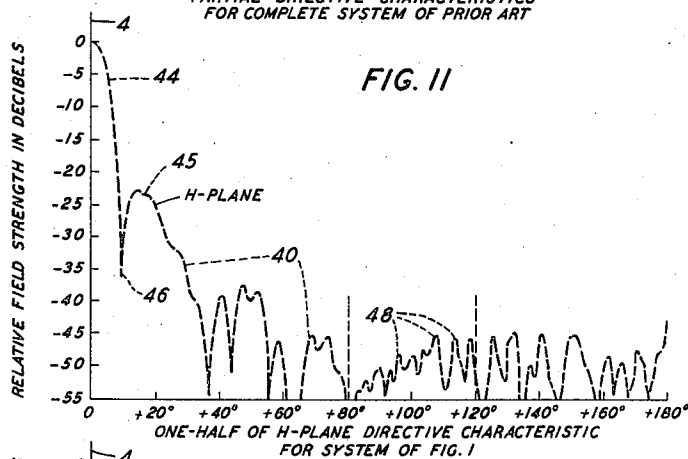
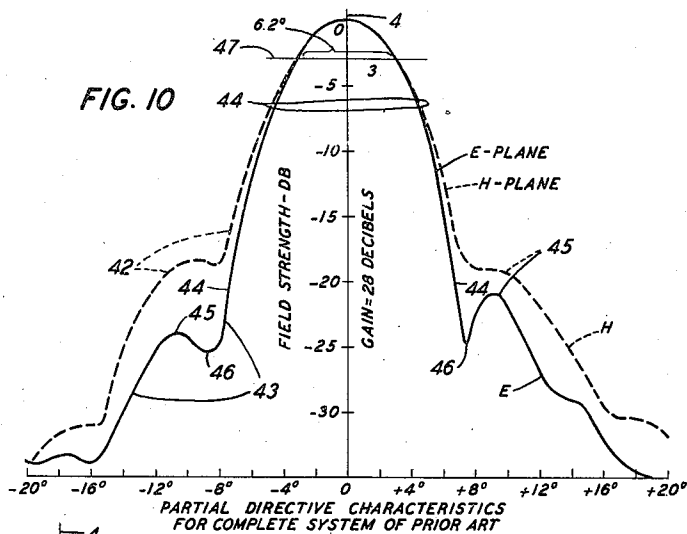
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6 Sheets-Sheet 3



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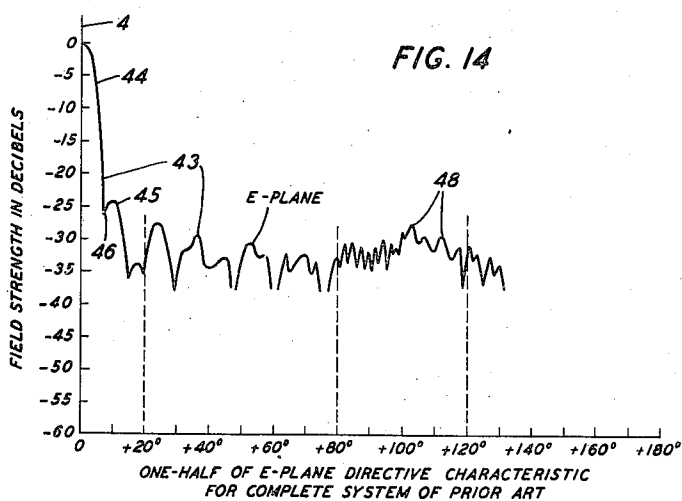
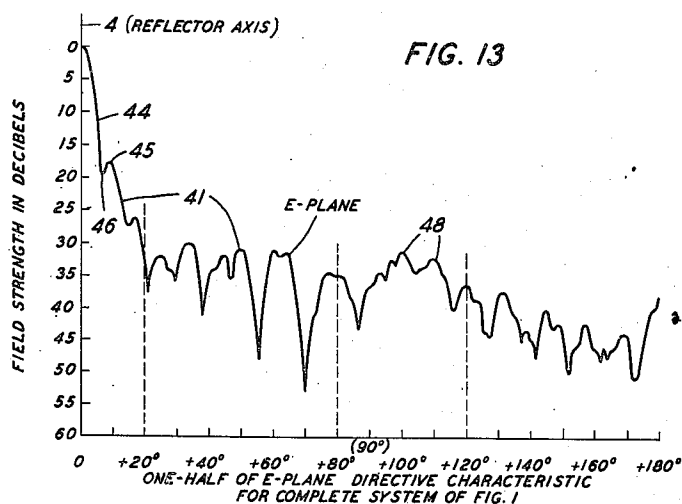
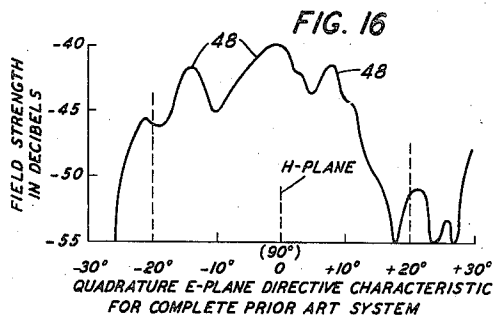
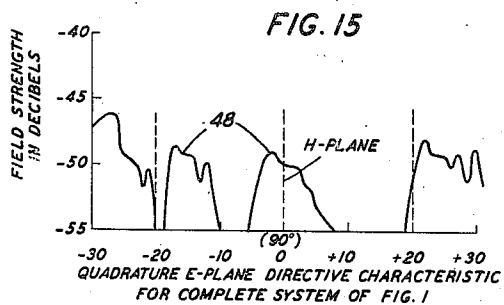
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DIRECTIONAL MICROWAVE ANTENNA

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6 Sheets-Sheet 4



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DIRECTIONAL MICROWAVE ANTENNA

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6 Sheets-Sheet 5

FIG. 17

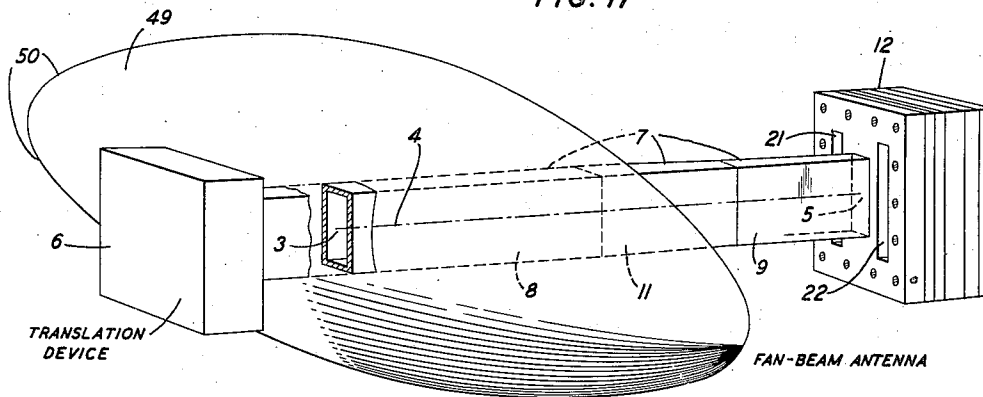
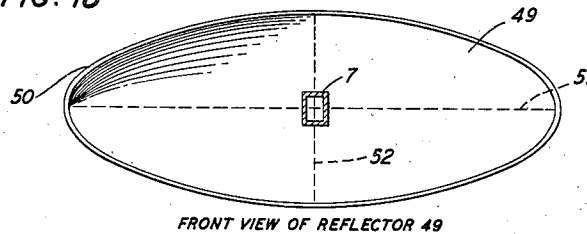


FIG. 18



FRONT VIEW OF REFLECTOR 49

FIG. 19

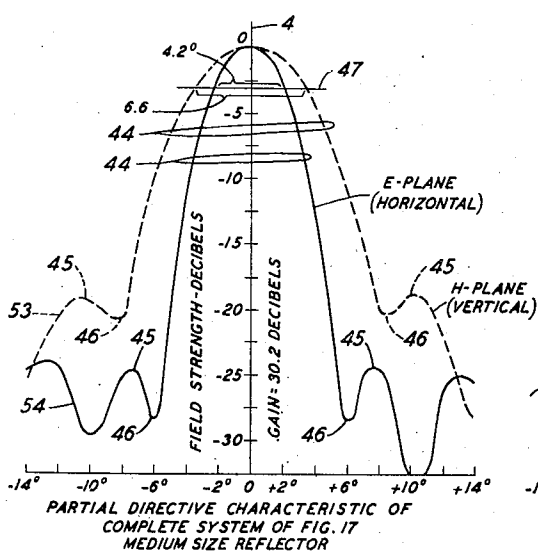
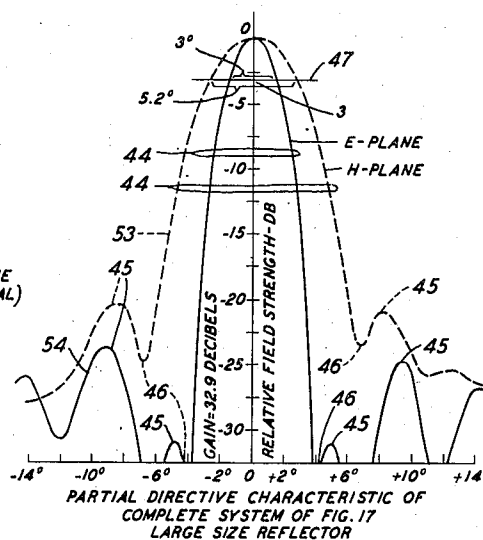


FIG. 20



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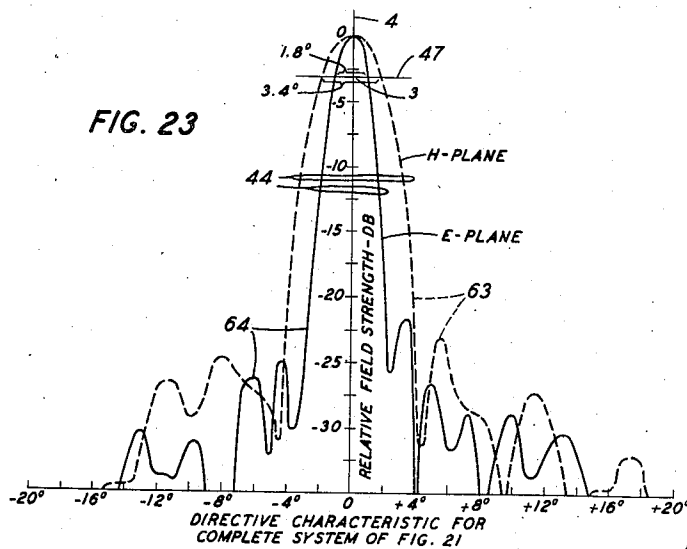
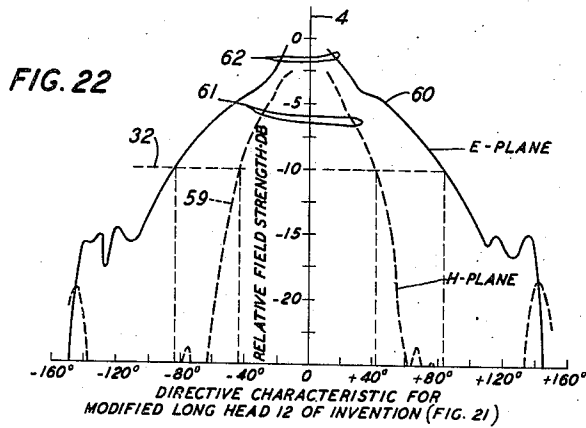
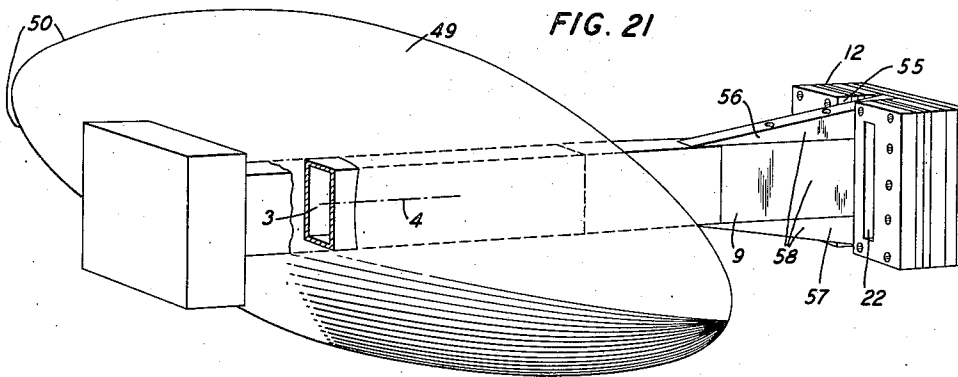
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DIRECTIONAL MICROWAVE ANTENNA

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UNITED STATES PATENT OFFICE

2,483,575

DIRECTIONAL MICROWAVE ANTENNA

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Application July 26, 1944, Serial No. 546,687

7 Claims. (Cl. 250—33.63)

1

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

Patent 2,422,184 granted on June 17, 1947, to applicant discloses and claims a highly directive antenna system comprising a paraboloidal reflector having a circular periphery, a rectangular wave guide extending through the reflector vertex and along the reflector axis to a point slightly beyond the reflector focus, and a "head" or resonant chamber connected to the end of the wave guide and having a pair of spaced rectangular apertures or slots facing the reflector. The long transverse dimensions of the apertures and guide are parallel, the long transverse dimension of each aperture being in the order of 0.59 to 1.0 wavelength and smaller than that of the guide. In transmission, each aperture in effect energizes or illuminates a different half of the reflector. The wave front produced by the primary antenna comprising the two apertures is nearly spherical, that is, the so-called "phasing" characteristic in the plane of electric polarization and the phasing characteristic in the plane of magnetic polarization are fairly flat. The major lobe patterns of the primary antenna are sufficiently wide to illuminate properly the reflector and are substantially the same. The axis of the major lobe pattern in each plane of the complete rear-feed antenna system is aligned with the reflector axis and the half power widths of the major lobe patterns of the system in the two planes are relatively small and also substantially the same. Stated differently, the system has a "point" beam. Ordinarily, in azimuthal scanning airborne radar systems utilizing the above described antenna, the electric and magnetic planes of polarization are horizontal and vertical, respectively.

While the point-beam antenna described above is highly satisfactory and has been successfully used, it has been found in practice that the so-called quadrature minor lobes extending at right angles to the reflector axis are often quite pronounced. Hence when the antenna is used in an airborne azimuthal scanning radar system, strong echo signals may be received from the earth's surface beneath the aircraft, whereby ambiguous target indications are obtained. Accordingly, it appears desirable to improve the point-beam antenna system described above for the purpose of reducing or eliminating the so-called quadrature minor lobes. Also, it appears advantageous to use, in a point-beam system comprising a paraboloidal reflector having a circular periphery, a primary antenna or head having a very wide band characteristic and more nearly flat phasing characteristic.

In addition, for certain radar uses, a "fan-beam" antenna, that is, one having a directive

2

characteristic in which the half power widths of the major lobe patterns in the electric and magnetic planes are substantially different, is preferred over a point-beam antenna. In accordance with the present invention, a paraboloidal reflector having an ellipsoid or quasi-elliptical periphery, is employed to secure a fan-beam and the improved primary antenna or head mentioned above, slightly modified as explained below or not, is utilized to secure optimum energization or illumination of the undulous ellipsoid reflector.

As used herein the term "feed" generically applies to a transmitting or receiving primary antenna used in front of a reflector such as a paraboloidal reflector. Also the terms "horizontal fan-beam" and "vertical fan-beam" refer to fan-beams wherein the major lobe patterns of greater width are included, respectively, in the horizontal plane and the vertical plane. The term "aperture" is used in its physical or mechanical sense and not in its optical or electro-optical sense; that is, as used herein, it signifies a passage or a hole, and not the width or diametral dimension taken at the periphery of the paraboloidal reflector.

It is an object of this invention to obtain highly unidirectional radiant action.

It is another object of this invention to reduce or eliminate, in an airborne radar system, echo signals from the earth's surface beneath the aircraft.

It is another object of this invention to obtain, in a point-beam antenna system, narrow major lobe patterns in the electric and magnetic planes and negligible minor lobes, particularly negligible quadrature minor lobes, in said planes.

It is another object of this invention to obtain, for use with a paraboloidal reflector, a feed or primary antenna which emits or receives a spherical wave front.

It is another object of this invention to obtain a highly efficient, high gain fan-beam antenna system.

It is another object of this invention to energize a paraboloidal reflector having a non-circular periphery in an optimum manner and without substantial energy loss.

In accordance with one embodiment of the invention, in a point-beam antenna system, such as the prior art system disclosed in my patent mentioned above, the long transverse dimension of each of the two rectangular apertures is in the order of 1.28 wavelength and therefore considerably greater than the corresponding aperture dimension of the above-described prior art head. Also, by way of comparison, the long aperture dimension is greater

3

than the long transverse dimension of the guide. As compared, respectively, to the major lobe magnetic and electric plane patterns for the point-beam head included in the prior art system and hereinafter termed the "short" head, the major lobe magnetic plane pattern is considerably more narrow, and the major lobe electric plane pattern is to a less extent more narrow. In other words, the head included in the system of the present invention hereinafter termed the "long" head, has a horizontal fan-beam. As a result, the illumination or energization of the central or vertex portion of the reflector and the energization of the peripheral portion of the reflector are greater and smaller respectively, than those produced by the prior art head; and the quadrature minor lobes, which are established primarily by the peripheral portion of the reflector, are relatively small. Consequently, the echo signals from the earth's surface beneath the aircraft are minimized. At the same time, the half power widths of the major lobe patterns in the electric and magnetic planes are not changed materially.

In accordance with another embodiment, a rear-fed paraboloidal reflector having an ellipsoid periphery and symmetrically disposed relative to the reflector axis, is associated with a dual-aperture head or primary antenna. More particularly, the projection of the reflector periphery on a plane perpendicular to the reflector axis, such as the plane containing the latus rectum of the reflector, is an ellipse; and the actual curvature, considered in the solid or in three dimensions, of the periphery is undulous and almost elliptical, that is, quasi-elliptical or ellipsoid. The major axis and the minor axis of the ellipsoid periphery are substantially horizontal and vertical, respectively, whereby a fan-beam having a small half power width in the horizontal plane and a much larger width in the vertical plane, that is a "vertical" fan-beam, is secured. While the dual aperture head may be of the prior art short type or of the long type described above, the long type is preferred inasmuch as the "horizontal" fan-beam of the long head produces, as is desired, a sharply tapered or optimum illumination of the quasi-elliptical reflector in the magnetic plane and, in the electric plane, a less sharply graded illumination which is optimum for the wider reflector. In this connection it will be noted that the fan-beam directive characteristics, considered in the solid, of the long head and of the quasi-elliptical reflector, are the inverse of each other. In a modification, the optimum illumination taper in the electric plane, for a quasi-elliptical reflector, is secured by attaching a vertical wedge or triangular reflective member to the top wall of the guide and a similar vertical member to the bottom guide wall. By reason of the wide vertical reflecting surface formed by the wide wall of the guide and the two wedge members, the right and left halves of the quasi-elliptical reflector are each energized by only one of the dual slots, substantially. In more detail, each reflector half is illuminated by wavelets propagated directly from the associated rectangular aperture and, in addition, the illumination of the peripheral reflector portion farthest removed from the slot is enhanced by wavelets propagated indirectly via the wide reflecting surface, or image slot, whereby optimum illumination of the quasi-elliptical reflector obtains.

The invention will be more fully understood

4

from a perusal of the following specification taken in conjunction with the drawings on which like reference characters denote elements of similar function and on which:

Fig. 1 is a perspective view of a point-beam antenna system constructed in accordance with the invention; and Figs. 2, 3 and 4 are respectively rear, elevational and sectional plan views of the long head included in the embodiment of Fig. 1;

Fig. 5 illustrates the magnetic or H-plane and the electric or E-plane directive curves for the long head used in the system of Fig. 1 and for a prior art short head such as disclosed in my patent mentioned above;

Fig. 6 is a curve showing the relation between the width of the H-plane major lobe for the long head and the length of each aperture in the head; and Figs. 7 and 8 illustrate respectively, the phasing characteristic and the bandwidth characteristic of the long head of Fig. 1;

Fig. 9 illustrates the H-plane and the E-plane directive characteristics taken for a scanning sector centered on the reflector axis of the complete system of Fig. 1; and Fig. 10 illustrates the companion curves for a prior system comprising the prior art short head;

Figs. 11, 13 and 15 illustrate the directive characteristics, taken for a sector centered on a line perpendicular to the reflector axis, of the complete system of Fig. 1; and Figs. 12, 14 and 16 illustrate the corresponding companion curves for the aforementioned prior art system;

Fig. 17 is a perspective view of a fan-beam antenna system constructed in accordance with the invention; and Fig. 18 is a front view of the reflector included in the system of Fig. 17;

Figs. 19 and 20 are directive curves for a system constructed in accordance with Fig. 17 and comprising, respectively, a medium size reflector and a large reflector;

Fig. 21 is a perspective view of a fan-beam antenna system constructed in accordance with the invention and comprising a modified long head or primary antenna;

Fig. 22 illustrates the directive characteristic for the modified long head of Fig. 21; and

Fig. 23 illustrates the directive characteristic for the complete system of Fig. 21.

Referring to Figs. 1, 2, 3 and 4 reference numeral 1 denotes a paraboloidal reflector having a substantially circular periphery 2, a vertex 3, an axis 4 and a focal point 5. Numeral 6 denotes a translation device which may be a transmitter, a receiver or a radar transmitter, and numeral 7 designates a rectangular air-filled wave guide which passes through the vertex 3 of reflector 1 and extends along the axis 4 to a point slightly beyond the focus 5. The guide 7 comprises a main section 8 which is connected to device 6, an end section 9 having an end opening 10 and a tapered impedance-matching section 11 connecting sections 8 and 9. Reference numeral 12 denotes a dual aperture long head horn which encloses the open end of guide section 9 and comprises the three brass plates 13, 14 and 15, the rubber gasket 16, the dielectric plate 17 and the brass plate 18, all held securely by brass screws 19. Numeral 20, Fig. 4, designates a resonant chamber or cavity in plate 14 and numerals 21 and 22 denote two antenna apertures which extend through the plates 15, 16 and 18. Portions 23 and 24 of the dielectric plate 17 extend across the antenna apertures 21 and 22, respectively, and constitute dielectric windows. Numeral 25 denotes a threaded plug for tuning the cavity 20.

5

Each of apertures 21 and 22 has a long transverse dimension L_a which is greater than the long transverse dimension L_g of guide section 9 and in one specific embodiment is in the order of 1.62 inches, as indicated in Fig. 6, corresponding to 4.12 centimeters and 1.285 wavelengths at the mean or design operating wavelength of 3.2 centimeters. The width W_a of each of the apertures in the aforementioned specific embodiment is in the order of 0.1 wavelength and the spacing S between the centers of the apertures is in the order of 0.5 wavelength. Also the length L_h and width W_h of head 12 in the specific embodiment are, respectively, 2 and 1.5 inches. For comparison the length L_p , representing the long transverse dimension of the apertures in the prior art short head, is shown.

In operation, assuming device 6 is a transmitter or transceiver, microwaves supplied by device 6 are conveyed by guide 7 to the resonant cavity 20 and the antenna apertures 21 and 22, as indicated by the arrows 26, Fig. 4, and wavelets are emitted by the apertures. For purpose of explanation, it is assumed that the waves are horizontally polarized, that is, the E-plane and H-plane are horizontal and vertical, respectively. The wavelets impinge upon reflector 1 and are reflected or redirected along the general direction of the reflector axis 4. In reception, the converse operation obtains by reason of the reciprocity theorem.

In more detail, and as explained below in connection with Figs. 5, 6, 7 and 8, the wavelets emitted by the apertures are cophasal and these wavelets combine to produce a nearly spherical wave front having, by virtue of the critically selected aperture length L_a , a sharply tapered intensity variation, whereby the taper of the reflector illumination is relatively great or sharp as compared to the illumination taper realized in the prior art system of my copending application. As explained in my above-mentioned patent, a highly satisfactory over-all directive characteristic, taken over a scanning sector of say, 40 degrees, is obtained when the illumination of the reflector decreases uniformly from a maximum at the vertex to a value of about ten decibels below the maximum at the reflector periphery. In other words, the effective portion of the E-plane or H-plane major lobe pattern for that head may be considered to be the central portion which is centered on the lobe axis and extends between the plus and minus directions or angles having intensities ten decibels below the maximum, approximately.

Referring to Figs. 5 and 6, reference numerals 27 and 28 designate respectively the H-plane and E-plane major lobe patterns for the long head 12 of Fig. 1; and numerals 29 and 30 denote the H-plane and E-plane patterns for the prior art short head. In Fig. 6, the curve 31 illustrates the relation between the H-plane dimension or length L_a of apertures 21 and 22 and the effective angle of illumination, that is, the width taken at a point ten decibels below the peak of the H-plane major lobe pattern for the long head 12. In Fig. 5, the width of the H-plane lobe 27 for the long head 12 at the ten-decibel point, represented by line 32, is considerably less than the corresponding width of the H-plane lobe 29 for the prior art short head. In the H-plane, the illumination produced by the long head 12 is effective primarily over the central or vertex portion of the reflector 1 or, more accurately, over the 74-degree sector included between the plus 37-degree and

6

the minus 37-degree directions; and the illumination of the peripheral portions of the reflector and at angles beyond the periphery is negligible whereby, as discussed below in connection with Figs. 11 and 12, the quadrature minor lobes in the vertical plane are of relatively low intensity and ground reflection is reduced. As indicated by point 33 on curve 31, Fig. 6, the optimum length L_a corresponding to the optimum major lobe 27, Fig. 5, having at the ten-decibel point 32 an effective illumination angle of 74 degrees is 1.62 inches. Considering the E-plane, Fig. 5, the width at point 32 of the lobe 28 for the head 12 is less than the corresponding width of the E-plane lobe 30 for the short head, but somewhat greater than the effective width of the H-plane lobe 27 for the long head 12. Since the E-plane is horizontal, ground reflections do not occur in this plane. Hence, the somewhat larger angle of illumination produced by head 12 in the E-plane, as compared to that produced in the H-plane, is not detrimental in an airborne azimuthal scanning radar.

Referring to Fig. 7, the vertical scale represents the phase angle in degrees of the wavelets arriving at the circumference of a reference circle having its center at the focus or head and included in the H-plane or E-plane, zero phase being on the circumference of the reference circle. The horizontal scale represents angular directions as measured in degrees, the zero direction being coincident with the reflector axis 4. Reference numeral 34 denotes the ideal flat phasing characteristic, and numerals 35 and 36 designate, respectively, the H-plane and E-plane phasing characteristics for the head 12. Numerals 37 and 38 denote the H-plane and the E-plane phasing curves for the prior art short head. It will be noted that the H-plane characteristic for the long head almost coincides with the ideal characteristic 34 and is greatly superior to the H-plane curve 37 for the short head. Stated differently, in the H-plane, the wave front produced by the long head 12 is, as is desired, circular; or stated still differently, the wavelets arriving at the circumference of the reference circle are almost in complete phase agreement. Also, the E-plane characteristic 36 is relatively flat and superior to the E-plane characteristic 38 for the short head.

Referring to Fig. 8, reference numeral 39 denotes the measured standing wave band-width characteristic for the long head 12 of Fig. 1. As shown, the impedance of the head 12 and guide section 9 is substantially matched at wavelengths included in the band extending from 3.14 to 3.26 centimeters. For a normal radar wavelength band, centered on a design wavelength of 3.20 centimeters and extending from 3.17 to 3.23 centimeters, the characteristic is relatively flat.

Referring to Figs. 9 and 10, reference numerals 40 and 41, Fig. 9, designate respectively, the measured H-plane and E-plane partial directive patterns for a system constructed in accordance with Fig. 1 and comprising a reflector having a substantially circular opening, the long and short dimensions of the opening being $13\frac{1}{8}$ and $14\frac{1}{8}$ inches respectively, and the focal length being 6.3 inches. The patterns were taken for the central 40 (± 20) degree sector. Numerals 42 and 43, Fig. 10, denote respectively, the measured H-plane and E-plane partial directive patterns for the prior art system comprising a short head. In each pattern numeral 44 denotes the major lobe, numerals 45 denote the two minor

lobes adjacent the major lobe 44, and numerals 46 denote the nulls between the major lobe 44 and the adjacent minor lobes 46. The half power widths, taken at a point 47 three decibels down from the peak lobe value of the H-plane and E-plane major lobes 44 of patterns 40 and 41, Fig. 9, are substantially the same, the widths being 6.6 degrees and 5.2 degrees respectively. In a comparable embodiment of the prior art system, the H-plane and E-plane half power major lobes are each exactly 6.2 degrees. Hence the system of Fig. 1 produces a "point" beam which is only slightly different from the point beam of the prior art system. As is desired, the H-plane minor lobes, 45, Fig. 9, are of less intensity than the minor lobes 45, Fig. 10; and the H-plane nulls, 46, Fig. 9, are deeper than the H-plane nulls 46, Fig. 10.

The H-plane directive pattern 40, Fig. 11, and the E-plane directive pattern 41, Fig. 13, are more complete measured patterns for the system of Fig. 1. These patterns constitute in a sense extensions of the patterns 40 and 41 of Fig. 9 respectively, and are taken over a 180-degree side sector including one-half the central sector. Similarly, the measured companion H-plane directive pattern 42, Fig. 12, and the measured companion E-plane directive pattern 43, Fig. 14, correspond respectively to the H-plane and E-plane patterns, 42 and 43, Fig. 10, for the system of the prior art. In the patterns of Figs. 11, 12, 13 and 14, numerals 48 denote the quadrature minor lobes, these lobes being included in the 80 to 120-degree sector centered on the 90-degree direction. Generally considered, the H-plane quadrature minor lobes 48, Fig. 11, for the embodiment of the invention illustrated by Fig. 1 are, as is desired, more than 45 decibels below the major lobe peak, whereas in the prior art system the corresponding lobes 48, Fig. 12, are only about 30 decibels down. Hence, as already discussed, the long head 12 functions as compared to the prior art short head to suppress or eliminate more completely the undesired ground echoes. In addition, the E-plane quadrature minor lobes 48, Fig. 13, for the system of Fig. 1 are of less intensity than the corresponding quadrature lobes 48, Fig. 14, for the prior art system.

Fig. 15 illustrates a measured partial or quadrature E-plane pattern for the system of Fig. 1, the pattern being centered on the H-plane. Fig. 16 illustrates the companion partial E-plane pattern for the prior art system. These patterns were taken with the reflector axis 4, Fig. 1, vertical, for the purpose of avoiding ground effects; and they are therefore more truly indicative of the action in the E-plane than the curves of Figs. 13 and 14. As shown by the curves of Figs. 15 and 16, the E-plane quadrature minor lobes 48, Fig. 15, for the system of Fig. 1, are of considerable less intensity, as is desired, than the corresponding quadrature lobes 48, Fig. 16, for the prior art system.

Referring to Figs. 17 and 18, reference numeral 49 denotes a paraboloidal reflector having an undulous elliptoid or quasi-elliptical periphery 50, the horizontal major axis and the vertical minor axis of the periphery being denoted, respectively, by the reference numerals 51 and 52. The axes 51 and 52 are each parallel to the latus rectum plane which plane, as in all conventional parabolic reflectors, contains the focal point 5 and extends perpendicular to the axis 4. The remaining portion of the system comprising the

device 6, guide 7 and head 12 is the same as the system of Fig. 1. In operation, the quasi-elliptical reflector 49 is energized in an optimum manner, since the head 12 has a horizontal fan-beam. Note that the effective width at point 32, Fig. 5, of the E-plane lobe 28 for the long head is greater than the effective width of the H-plane lobe 27 for this head. The quasi-elliptical reflector, taken alone, has a vertical fan-beam characteristic since the reflected beam is more sharply focussed in the horizontal plane than in the vertical plane.

Referring to Figs. 19 and 20, numerals 53 and 54 denote respectively, the measured H-plane and E-plane patterns for two systems constructed in accordance with Fig. 17 and having reflectors of different size. In the system corresponding to Fig. 19 the paraboloidal reflector has a focal length of 8 inches; and the major and minor axes of the quasi-elliptical periphery are 21 and 12 inches respectively. In the system corresponding to Fig. 20 the reflector has a focal length of 10.5 inches and the major and minor axes of the quasi-elliptical periphery are 29 and 16 inches, respectively. For optimum operation with the head 12 the ratio of the major and minor axes of the periphery should be in the order of 2.0; and the ratio of the major axis of the quasi-elliptical periphery to the focal length should be in the neighborhood of 2.6.

As shown by the curves of Figs. 19 and 20 the system of Fig. 17 produces a fan-beam. In Fig. 19, the H-plane major lobe pattern has a half-power width, taken at line 47, of 6.6 degrees and the E-plane major lobe pattern has a half-power width of 4.2 degrees. The fan-beam of Fig. 20 is more pronounced, the H-plane and E-plane half-power widths of the major lobe patterns being respectively 5.2 and 3.0 degrees. Since, in a fan-beam radar, the target direction is usually determined only in the plane of the sharper or more narrow major lobe pattern, that is, the E-plane, the E-plane minor lobes 45, Figs. 19 and 20, are highly satisfactory, since they are small, and the somewhat larger H-plane minor lobes 45 and relatively shallow H-plane nulls 46 are not especially detrimental. Note that the first E-plane minor lobes 45, Fig. 20, adjacent the major lobe 44, are extremely low. In addition, the gain of the system of Fig. 17 over a standard comparison antenna, as measured on the common axis 4 of the reflector and the major lobe, is very high. Specifically, the gain of the system comprising the smaller reflector, Fig. 19, is 30.2 decibels and the gain of the system using the larger reflector, Fig. 20, is 32.9 decibels.

Referring to Fig. 21, the system is the same as that illustrated by Fig. 17, except that the head 12 contains a slot 55 and triangular reflective members or wedges 56 and 57 positioned in slot 55 and attached, respectively, to the top and bottom walls of guide section 9. Considering either aperture, 21 or 22, the vertical wall of guide 9 and the wedges 56 and 57 constitute a vertical reflective surface 58 which functions to direct the wavelets proceeding from the aperture towards the outermost peripheral portion of the left or right half of the reflector, whereby as explained below optimum illumination of the reflector 49 is obtained. In other words, each right or left half of the reflector sees a different vertical real slot and, in the vertical reflecting surface, the image of the real slot. The surface 58 also in a sense shields the two apertures 21 and 22 from each other.

Referring to Fig. 22, reference numerals 59 and 60 denote, respectively, the H-plane and E-plane major lobe patterns for the wedge or modified head 12 of Fig. 21. The widths of the H-plane lobe 61 and the E-plane lobe 62, taken at the effective illumination point 32, ten decibels down, are greater respectively than the corresponding widths, Fig. 5, for the long head without the wedges. Thus the H-plane and E-plane effective lobe widths, Fig. 22, for the modified head are, respectively, 83 and 164 degrees, whereas the H-plane and E-plane effective widths for the head of Fig. 5 are 73 and 130 degrees, respectively. By reason of the increase in the effective lobe widths, especially in the E-plane, the illumination is suitable for a quasi-elliptical reflector of greater depth, as measured by the ratio of the major axis dimension to the focal length. In certain installations it is advantageous to use a focal length which is as short as practicable; and because the E-plane major lobe is wider for the modified head of Fig. 21, than for the unmodified head of Fig. 17, the modified head is preferred on these installations.

As shown by the H-plane and E-plane patterns 63 and 64, Fig. 23, for the complete system of Fig. 21, with the modified head a highly satisfactory fan-beam is secured. More specifically, the half-power widths at line 47 of the H-plane and E-plane lobes 44 of patterns 63 and 64 are respectively 3.4 and 1.8 degrees, the ratio of the H-plane and E-plane half power widths being approximately 2 to 1. Note that all minor lobes 45 of the H-plane and E-plane patterns 63 and 64 are below 22 decibels and are, therefore, negligible.

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

What is claimed is:

1. A concave antenna reflector having a varying peripheral diameter extending perpendicular to its axis, the projection of the reflector periphery on the latus rectum plane of the reflector being an ellipse, the maximum axial depth of the reflector being less than its focal length.

2. In a directive radio system, means for transmitting an approximately spherical wave front comprising a rectangular wave guide, a translation device connected thereto, said guide comprising a first metallic wall having a pair of antenna apertures spaced in a given plane for emitting or collecting wave components, a second metallic wall connected to said first wall between said apertures and shielding said apertures from each other, the long transverse dimension of each aperture being greater than 1.25 wave lengths and the short transverse dimension of each aperture being 0.1 wavelength.

3. A system in accordance with claim 2, the long transverse dimension of each aperture being 1.62 wavelengths and the short transverse dimension of each aperture being 0.098 wavelength.

4. In an antenna system, a secondary passive member having an axis and an ellipsoid periphery symmetrically disposed relative to said axis, a primary member facing said secondary member and having a pair of rectangular apertures, the long dimension of each aperture being greater than 1.25 wave lengths, the longest diameter of said ellipsoid periphery being perpendicular to said axis and to the long dimensions of said aper-

tures, and a translation device connected to the primary antenna.

5. In an antenna system, a concave reflector having a focus, a rectangular wave guide connected to a translation device, said guide extending through said reflector and having an end opening near said focus, a wave guide chamber or cavity comprising a first metallic wall for receiving the end of said guide and a second metallic wall facing said opening, said first wall being included between said reflector and said opening and having a rectangular aperture facing said reflector, the long transverse dimensions of said guide and aperture being parallel and the long transverse dimension of said aperture being greater than 1.25 wave lengths and greater than the long transverse dimension of said guide.

6. In combination, a reflector having a concave reflecting surface and an ellipsoid periphery, a focus and a principal axis, a rectangular wave guide extending through said reflector and along said axis, said guide having an end rectangular opening positioned substantially at said focus, a resonant chamber comprising a first metallic wall for receiving the end portion of said guide and a second metallic wall facing said opening and said first wall, said first wall being positioned between said opening and said reflector and having a pair of spaced rectangular apertures facing different portions of said concave reflector, said guide being included between said apertures, the corresponding sides of said apertures and said opening being substantially parallel and the long side of said apertures each being greater than 1.25 wave lengths and greater than the long side of said opening, and a translation device connected to said wave guide.

7. In combination, a concave reflector having an axis and a focus, a resonant wave guide chamber positioned at or near said focus and comprising a metallic wall, said wall having a pair of rectangular apertures facing said reflector and positioned in the latus rectum plane of said reflector, a rectangular wave guide extending along the reflector axis and connected to said wall between said apertures, the long transverse dimensions of said apertures being greater than 1.25 wave lengths and greater than the long transverse dimension of said guide, and a pair of reflective shield members attached to said guide and wall and positioned between said apertures, whereby each aperture energizes a different half of said reflector substantially.

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