

April 10, 1951

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2,548,655

DIRECTIVE DIELECTRIC GUIDE ANTENNA

Filed April 26, 1946

4 Sheets-Sheet 1

FIG. 1.

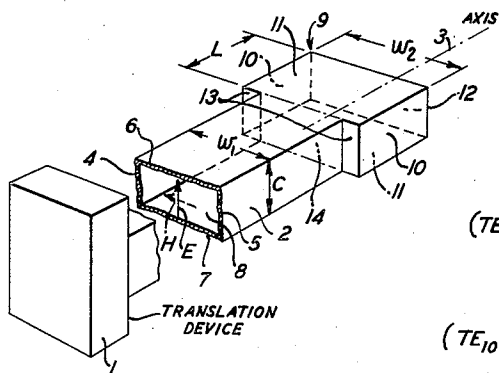


FIG. 2.

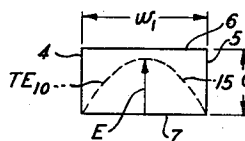


FIG. 3.

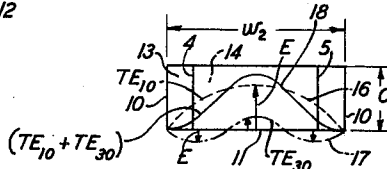


FIG. 4.

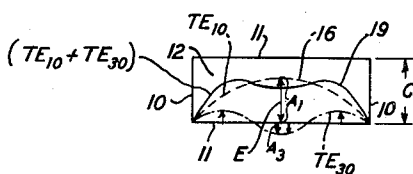


FIG. 5.

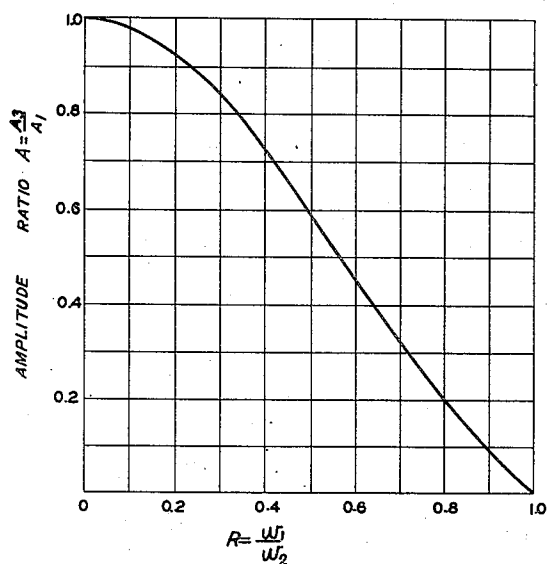
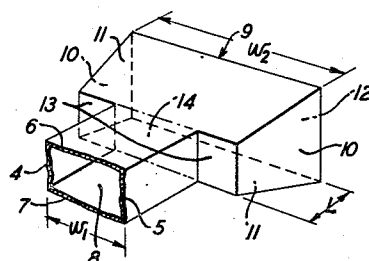


FIG. 6.



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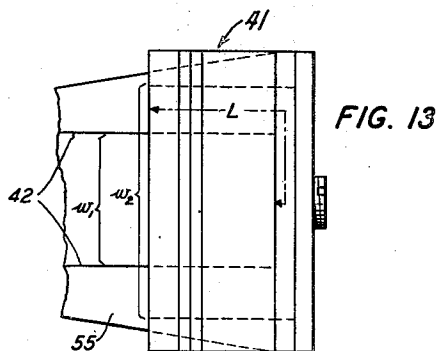
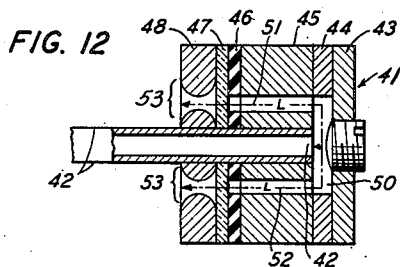
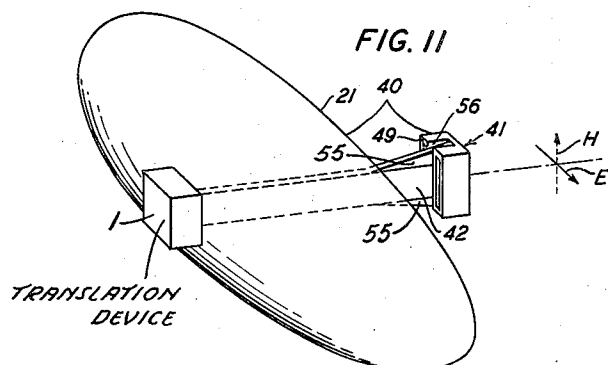
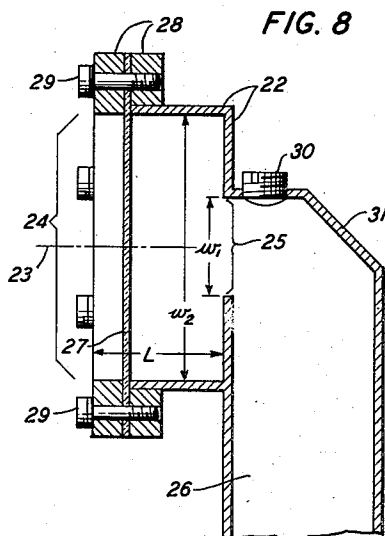
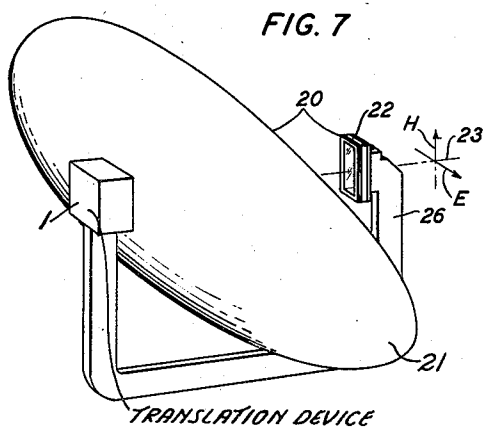
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DIRECTIVE DIELECTRIC GUIDE ANTENNA

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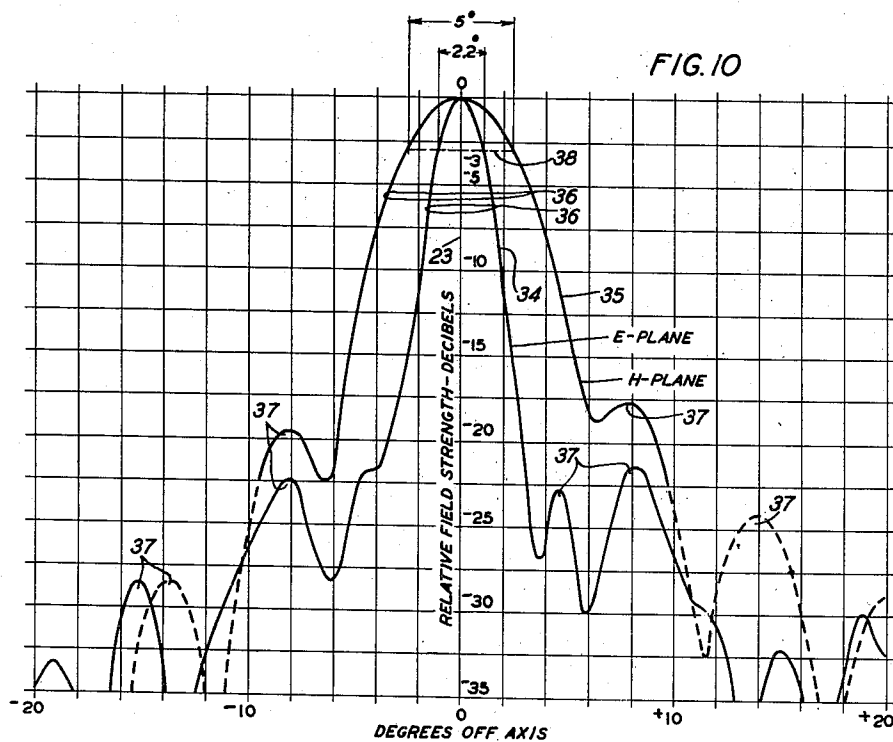
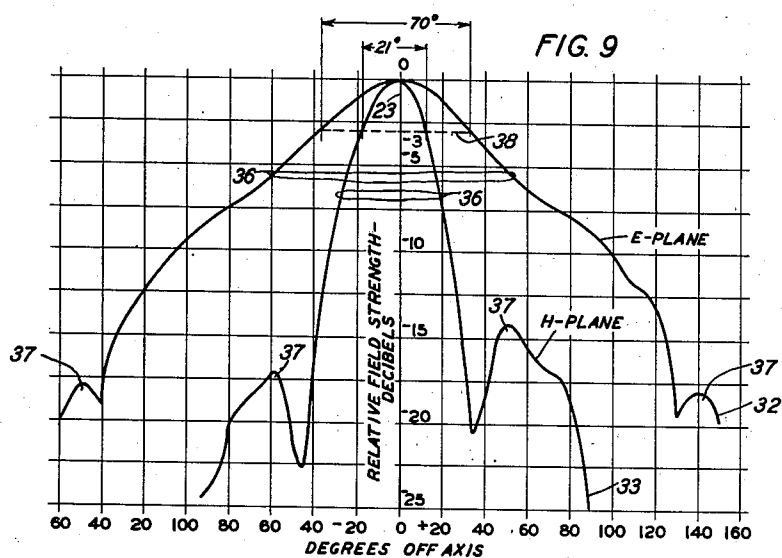
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DIRECTIVE DIELECTRIC GUIDE ANTENNA

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UNITED STATES PATENT OFFICE

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DIRECTIVE DIELECTRIC GUIDE ANTENNA

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Application April 26, 1946, Serial No. 665,027

6 Claims. (Cl. 250—33.63)

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

As is known sectoral, pyramidal and conical horn antennas are widely used for energizing a passive antenna member, such as a parabolic reflector or a lens, and for receiving energy therefrom. In general, these flared horns are not entirely satisfactory inasmuch as the intensity of the emitted wave at the periphery of the mouth aperture is relatively low, as compared to that at the center of the aperture, and the phase distribution over the aperture is usually not uniform. The undesired amplitude variation and phase distribution are undoubtedly produced by the addition, at the mouth aperture, of different dissimilarly phased wave modes propagated in the horn. To illustrate, a sectoral horn flared in the H-plane has, by reason of symmetry, no even order modes, but may have several odd modes such as the TE_{10} , TE_{30} and TE_{50} modes; and these modes may have unfavorable phase and amplitude relations at the mouth aperture. In addition, the sectoral horn heretofore employed for energizing a fan-beam passive member, such as a rectangular or elliptical paraboloidal reflector, has two separated phase centers or foci and hence the phasing at the mouth aperture is distorted. More specifically, the focus in the plane of the long mouth aperture dimension of the sectoral horn is at the throat aperture, whereas the focus in the plane of the short mouth aperture dimension is at the mouth aperture and, since these apertures are spaced a distance equal to the axial length of the horn, the wave front emerging from the mouth aperture is not flat. Again, the horns mentioned above are not especially directive for their size. Accordingly, it now appears desirable to secure a relatively small horn antenna which is suitable for use with a fan-beam passive member and is devoid of the disadvantages inherent in the horn antennas heretofore proposed.

It is one object of this invention to obtain a highly directive horn antenna.

It is another object of this invention to obtain, in a horn antenna, a relatively flat emergent wave front of substantially uniform amplitude.

It is another object of this invention to combine, in a horn antenna, a plurality of wave modes in an advantageous manner.

It is still another object of this invention to obtain a highly directive horn antenna which is especially suitable for use with a fan-beam passive antenna member.

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In accordance with one embodiment of the invention, a box or unflared horn antenna comprises a rectangular dielectric guide having at one end a large horn mouth aperture and at the other end a wall containing an iris constituting a throat aperture. A small rectangular guide connects the throat aperture to a transmitter or receiver. Assuming TE waves are utilized and considering only the odd H-plane modes, the H-plane transverse dimension of the small guide is sufficiently narrow to permit only the TE_{10} mode, whereas the corresponding dimension of the large guide is wide enough to support both the TE_{10} and the TE_{30} modes. The actual length of the large guide and the ratio of the H-plane dimensions of the guides are critically selected, such that the two modes combine in the horn mouth aperture to produce a substantially flat wave front.

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 on which:

Fig. 1 is a perspective view of a box or two-mode horn antenna constructed in accordance with the invention;

Figs. 2, 3 and 4 are mode diagrams, and Fig. 5 is an amplitude curve, all used in explaining the embodiment of Fig. 1;

Fig. 6 is a perspective view of another embodiment of the invention;

Fig. 7 is a perspective view of an embodiment of the invention comprising a fan-beam reflector and a front feed dual-mode horn;

Fig. 8 is an H-plane sectional view of the front feed two-mode or dual-mode horn utilized in the system of Fig. 7;

Figs. 9 and 10 are measured directive patterns for the system of Fig. 7;

Fig. 11 is a perspective view of an embodiment of the invention comprising a fan-beam reflector and a rear feed dual-mode horn;

Figs. 12 and 13 are, respectively, E-plane and H-plane sectional views of the rear feed dual-mode horn employed in the system of Fig. 11, and

Figs. 14 and 15 are measured directive patterns for the system of Fig. 11.

The wave and mode symbols, for example, the symbol TE_{10} , used herein are the same as those given on page 395 of the textbook "Electromagnetic Waves" by S. A. Schelkunoff and now more or less universally adopted in the art. Formerly, TE and TM waves were designated H and E waves, respectively.

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Referring to Fig. 1, reference numeral 1 denotes a translation device, such as a transmitter or a receiver, and numeral 2 designates a relatively small open ended rectangular dielectric guide connected thereto and having an axis 3. The guide 2 comprises two narrow parallel longitudinal metallic walls 4, 5, two wide metallic longitudinal walls 6, 7 and the dielectric medium 8 bounded by the aforesaid four walls. The particular medium utilized in the embodiment of Fig. 1 is air but, as is well known, other dielectric substances, such as solid dielectric material, may be employed in place of the air dielectric. The narrow walls 4, 5 are parallel to the electric polarization E, and hence perpendicular to the magnetic polarization H, of the TE waves conveyed by the guide or, stated differently, walls 4, 5 and walls 6, 7 are parallel to the E-plane and the H-plane, respectively.

Numeral 9 denotes a dual-mode box horn comprising a relatively large rectangular dielectric guide having a longitudinal axis 3, narrow longitudinal E-plane walls 10, wide longitudinal H-plane walls 11, an open end 12 constituting a horn mouth aperture and an end or throat wall 13 having a central iris 14 constituting a throat aperture. The dual-mode horn 9 is directly connected to guide 2, the iris 14 and the open end of guide 2 being coincident. As shown on the drawing, the walls 4 and 10 have equal transverse E-plane dimensions, C, whereas the transverse H-plane dimension, w_1 , of guide 2 is smaller than the corresponding dimension, w_2 , of the horn 9. As will now be explained, the dimensions w_1 and w_2 each have, preferably but not necessarily, minimum and maximum values, as measured in wavelengths, λ_0 , in the air dielectric medium 8, that is, in free space; the ratio

$$R = \frac{w_1}{w_2} \quad (1)$$

of the aforesaid dimensions being judiciously chosen, and the axial length, L, of the dual-mode horn 9 being critically selected.

The dimensions w_1 and w_2 are preferably chosen in accordance with the following relations:

$$\frac{3\lambda_0}{2} > w_1 > \frac{\lambda_0}{2} \quad (2)$$

$$w_2 > \frac{3\lambda_0}{2} \quad (3)$$

Hence, considering the odd order H-plane (first subscript) modes, guide 2 supports only a TE₁₀ wave mode and the guide or horn 9 supports both the TE₁₀ and TE₃₀ modes. In other words, the H-plane dimensions w_1 of guide 2 is preferably not large enough to permit the existence of higher order H-plane modes such as the TE₃₀ and TE₅₀ modes; but the H-plane dimension w_2 of the horn 9 is sufficiently large to support the TE₁₀ and TE₃₀ modes. The dimension w_2 of horn 9 may have any practical maximum value, but ordinarily

$$w_2 < \frac{5\lambda_0}{2} \quad (4)$$

whereby odd H-plane modes, higher than the TE₃₀ mode, are not supported by the horn. As discussed below, if

$$w_2 > \frac{5\lambda_0}{2} \quad (5)$$

the horn 9 will support higher modes, such as TE₅₀ and the TE₇₀ modes and, in order to achieve the desired phase and amplitude distributions in

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the horn mouth aperture, the horn 9 must be properly dimensioned. Even order H-plane modes, such as the TE₂₀ mode, are not excited in either the guide 2 or horn 9, inasmuch as these dielectric paths are symmetrical about an E-plane containing the axis 3. Also

$$C < \frac{\lambda_0}{2} \quad (6)$$

so that a complete E-plane mode is not supported in guide 2 or horn 9.

Referring now to Figs. 2, 3 and 4, and considering the transmitting operation, a TE₁₀ wave mode 15 of relatively large amplitude in guide 2, Fig. 2, enters the dual-mode horn 9 through the throat aperture 14 and produces at the junction or throat wall 13 a TE₁₀ mode 16, of smaller amplitude, Fig. 3, and, by reason of the value of dimension w_2 and the abrupt expansion (w_1 to w_2) in the H-plane dimension, initiates a TE₃₀ mode 17 of small amplitude. Since modes 16 and 17 are derived from mode 15, the sum of the amplitudes of modes 16 and 17 is approximately equal to the amplitude of mode 15. At the junction 13, other odd order modes are present dependent upon the value of w_2 but, for the purpose of this explanation, it is assumed that w_2 is less than $5\lambda_0/2$ and that only the TE₁₀ and TE₃₀ modes exist in the horn 9. Also, at the junction 13, the intermediate loop or alternation of the TE₃₀ mode 17 and the sole alternation of the TE₁₀ mode 16 have similar phases or polarizations, for example, positive, and accordingly, the two end negative alternations of the TE₃₀ mode 17 have a phase or polarity opposite that of the TE₁₀ mode 16. Hence, generally speaking, at the throat 13 the modes 16 and 17 are oppositely phased. Also

$$A = \frac{A_3}{A_1} < 1 \quad (7)$$

where

A_1 is the amplitude of the TE₁₀ mode 16
 A_3 is the amplitude of the TE₃₀ mode 17

A is the amplitude ratio of the two modes so that at throat 13 the wave front 18 in the H-plane, Fig. 3, resulting from the algebraic addition of modes 16 and 17, is curvilinear rather than linear. Hence, considering the E and H planes, the wave is convex rather than flat.

Now the phase velocities for the two modes in the air-filled horn 9 are;

$$V_1 = \frac{V_0}{\sqrt{1 - \left(\frac{\lambda_0}{2w_2}\right)^2}} \quad (8)$$

and

$$V_3 = \frac{V_0}{\sqrt{1 - \left(\frac{3\lambda_0}{2w_2}\right)^2}} \quad (9)$$

where

V_1 is the phase velocity of the TE₁₀ mode 16

V_3 is the phase velocity of the TE₃₀ mode 17

V_0 is the phase velocity in free space

but,

$$\frac{V_1}{V_3} = \frac{\lambda_1}{\lambda_3} \quad (10)$$

where λ_1 is the guide wavelength at the TE₁₀ mode 16 and λ_3 is the guide wavelength at the TE₃₀ mode 17. Now in order to secure a relatively flat wave front in the mouth aperture 12 of the horn 9, the axial length L of the horn must be

such as to produce a 180-degree relative phase shift between the two modes 16 and 17, that is,

$$L = \frac{\lambda_1 \lambda_3}{2(\lambda_3 - \lambda_1)} \quad (11)$$

or

$$\frac{L}{\lambda_0} = \frac{1}{\sqrt{4 - \left(\frac{3\lambda_0}{w_2}\right)^2} - \sqrt{4 - \left(\frac{\lambda_0}{w_2}\right)^2}} \quad (12)$$

Accordingly, at the horn mouth aperture 12, Fig. 4, the two end loops of the TE₃₀ mode 17 and the single loop of the TE₁₀ mode 16 are similarly polarized and the central loop of mode 17 is oppositely polarized relative to mode 16, that is, in one sense the two modes are in phase agreement in the mouth aperture 12, by reason of the critically selected physical dimension L. Hence, assuming the amplitude ratio, A, is properly chosen, the modes combine in the mouth aperture 12 to form a fairly linear wave front in the H-plane. In the E-plane, the wave front is fairly linear in the mouth aperture 12, since the E-plane dimension is small. Consequently, in mouth aperture 12 the wave front is fiat, whereby at a distance from aperture 12 the front becomes spherical, so that the dual mode horn is particularly suitable for illuminating a paraboloidal reflector or a point focus lens.

The amplitudes A₁ and A₃, and the amplitude ratio A, may be obtained by making a Fourier analysis of the incident field at the junction 13 and considering only the first two terms. The field, f(x), at the junction or throat 13 may be expressed

$$f(x) = A_1 \cos x + A_3 \cos 3x \dots A_p \cos px \quad (13)$$

where p is an odd integer and x is the normalized distance from the horn axis to the point in question, measured in the magnetic plane. This normalized distance is equal to π/2 times the ratio of the distance from the axis to the width w₂ of the horn 9. The constants A_p may be found from

$$A_p = \frac{4}{\pi} \int_0^{\pi/2} f^1(x) \cos (px) dx \quad (14)$$

where f¹(x) is the field incident to the junction and is equal to f(x). It may be taken as

$$f^1(x) = \cos \frac{x}{R} \Bigg|_{x=0}^{x=\frac{\pi}{2}R} \quad (15)$$

and

$$f^1(x) = 0 \Bigg|_{x=\frac{\pi}{2}R}^{x=\frac{\pi}{2}} \quad (16)$$

where R is the ratio given by Equation 1. Substituting values of 1 and 3 for p, the values of A₁ and A₃ may be obtained and, since higher order modes are not propagated, the first two terms of Equation 13 give the field propagated in the dual-mode horn 9. At any point in the horn 9 the amplitude ratio, A, is

$$A = \frac{A_3}{A_1} = \frac{(R^2 - 1) \left(\cos \frac{3\pi R}{2} \right)}{(9R^2 - 1) \left(\cos \frac{\pi R}{2} \right)} \quad (17)$$

Hence, the amplitude ratio A is a function of the ratio R. The curve of Fig. 5 illustrates the relation given by Equation 17. In practice, a ratio R, and therefore a ratio A, are selected such that the central portion of the wave front 19, Fig. 4, is slightly convex or depressed, whereby optimum

gain and comparatively low minor lobes are obtained. While, as shown by Fig. 5, R and A may each have any practical value greater than zero and less than unity, a value of R in the order of 0.4 to 0.8, corresponding to a value of A in the order of 0.7 to 0.2, is particularly satisfactory.

In reception, the operation is, by reason of the reciprocity theorem, the converse of the transmitting operation. The incoming wave establishes similarly phased TE₁₀ and TE₃₀ modes in the horn mouth aperture 12. By reason of the horn length L, these modes are rendered in opposite phase at the throat aperture 14 and a strong TE₁₀ wave is initiated in guide 2 and conveyed to the receiver 1.

As shown in Fig. 6, if desired, the narrow walls 10 of the dual mode horn 9 may be flared and, also if desired, the wide walls 11 may be flared. In antenna systems comprising a passive member, such as a parabolic reflector or a lens, and a primary dual-mode horn, the flaring may be advantageously utilized to secure optimum energization of the passive member.

Referring to Figs. 7 and 8 the antenna system 20 comprises a quasi-elliptical paraboloidal reflector 21 of the type disclosed in my copending application Serial No. 546,687, filed July 26, 1944, now Patent No. 2,483,575 issued October 4, 1949, and a single aperture dual-mode horn 22 positioned at the point focus of the reflector. More particularly, the projection of the reflector periphery on a plane perpendicular to the reflector axis is an ellipse. The quasi-elliptical contour of the reflector eliminates the so-called "corner" minor lobes which are present in the pattern of the conventional rectangular parabolic reflector. Numeral 23 denotes the axis of the reflector 21 and of the dual-mode horn 22. The horn 22 has a mouth aperture 24 and is connected through an iris 25 to a front feed dielectric guide 26. The E-plane dimension of the iris 25 is slightly less than the E-plane dimension of guide 26. The H-plane dimension, w₁, of iris 25 and the H-plane dimension, w₂, of the horn 22 are properly selected, as explained in connection with Fig. 1. Guide 26 is connected to a translation device 1 which serves as a support for the reflector 21. A dielectric window 27 is positioned near the mouth aperture 24 of the dual-mode horn 22 and is rigidly secured to the horn by means of the metallic members 28 and the bolts 29. Numeral 30 denotes a tuning plug in guide 26 and numeral 31 denotes an inclined metallic member or elbow in guide 26. As in Fig. 1, the reference letter L denotes the actual length of the dual mode horn 22. The phase velocity in air is different from that in the window so that, if the window is thick, this difference must be taken into account in determining the value of L. In practice, the window is usually relatively thin so that the above-mentioned difference in velocities may be disregarded in determining L.

The operation of the antenna 20, Figs. 7 and 8, is believed to be obvious in view of the description given above and the disclosures in my above-mentioned copending applications. Briefly, a TE₁₀ mode is produced in guide 2 by device 1 and the energy, after passing through the iris 25, appears in the horn 22 in the form of the two modes TE₁₀ and TE₃₀. By reason of the critical horn length L, and the selected ratio, w₂/w₁, the two modes produce a flat front in the mouth aperture of the dual mode horn 22. Since the wave front in the mouth aperture is

fairly flat, the front of the wave arriving at the reflector is fairly spherical, as is desired. In other words, the mouth aperture simulates a point source. The beam produced by the dual-mode horn 22 is of the horizontal fan-beam type, the beam being wider in the E-plane than in the H-plane, and therefore suitable for illuminating in an optimum manner the quasi-elliptical reflector 21 which produces a vertical fan-beam, as explained in my first-mentioned copending application. While, in Fig. 7, the E and H-planes are horizontal and vertical, respectively, they may of course be reversed or have other quadrature orientations. It may be noted here that the shape of the wave front impinging upon the reflector is dependent primarily upon the relative phasing of the diverse wavelets forming the front, whereas the shape of the beam is dependent primarily on the relative amplitudes of the wavelets.

Referring to Figs. 9 and 10, reference numerals 32 and 33 denote, respectively, the measured E-plane and H-plane directive patterns of a front-fed dual-mode horn 22 actually constructed and tested at a design wavelength of 3.2 centimeters. Numerals 34 and 35 denote, respectively, the measured E-plane and H-plane patterns for the complete system comprising a horn 22 and a quasi-elliptical reflector 21 as illustrated by Fig. 7. In each pattern numeral 36 denotes the major lobe, numerals 37 designate the minor lobes and numerals 38 denotes the half power angular width of the major lobe. As shown in Fig. 9, the half power widths 38 of the major lobes 36 in the E-plane and H-plane patterns 32 and 33 are respectively about 70 and 21 degrees and hence, as stated above, the beam of the horn is of the fan type. As compared to the fan-beams of feed horns of the prior art, the fan-beam is more pronounced, that is, the lobe width ratio is greater. Hence the dual-mode horn is especially suitable for use with an elliptical reflector having a pronounced fan-beam characteristic, that is, an elliptical reflector having a relatively large ratio of major axis to minor axis, for example, 1:3 to 1:5. The minor lobes 37 of the horn patterns 32 and 33 are at least 15 decibels down and therefore negligible. As shown in Fig. 10, the half power widths 38 of major lobes 36 of the E and H-plane patterns 34 and 35, for the entire system, are 2.2 and 5 degrees, respectively, and the beam is therefore of the fan type. The reflector fan-beam Fig. 10 is in a sense the converse of the horn fan-beam, Fig. 9, since in Fig. 9 the beam is wide in the E-plane and narrow in the H-plane whereas, in Fig. 10, the beam is narrow in the E-plane and wide in the H-plane. The minor lobes 37 of patterns 34 and 35, are below 19.5 decibels and therefore insignificant.

Referring to Figs. 11, 12 and 13, the antenna system 40 comprises a quasi-elliptical reflector 21 and a dual aperture dual-mode horn 41. The horn 41 is positioned at the focus of the reflector and is connected to a rear feed dielectric guide 42 having an H-plane dimension, w_1 . The horn 41 encloses the open end of guide 42 and comprises the three brass plates 43, 44 and 45, the rubber gasket 46, the dielectric plate 47 and the brass plate 48, all held securely by brass screws 49. Numeral 50 designates a resonant chamber and numerals 51 and 52 denote two small dielectric guides, each having a horn mouth aperture 53 and an H-plane dimension, w_2 . The dielectric plate 47 extends across both small guides

51, 52. Numeral 54 denotes a threaded plug for tuning the chamber 50 and numerals 55 denote reflective wedges positioned in slots 56 and attached to the top and bottom walls of guide 26. As shown on the drawing, the critical horn length L, extends from the open guide end or throat aperture to the mouth aperture 53. As in the previously described embodiments, the length L as measured in guide wavelengths for the TE₁₀ mode differs a half wavelength, or a multiple thereof, from the length as measured in guide wavelengths for the TE₃₀ mode.

The operation of the system of Fig. 11 is believed to be apparent in view of the description given above. Briefly a TE₁₀ mode is produced in guide 42 and the energy, after passing through the iris or open end, appears in each of guides 51 and 52 in the form of the two modes TE₁₀ and TE₃₀. By reason of the critical length L, and the selected ratio, w_2/w_1 , the two modes produce a substantially flat wave front in each of the two horn mouth apertures 53, and a spherical wave front is projected toward the reflector 20. The wedges 55 function to direct the wavelets emitted by the apertures toward the outermost or central peripheral portions of the left-half and the right-half of the reflector 21. In reception the converse operation is obtained.

Referring to Figs. 14 and 15, reference numerals 57 and 58 denote, respectively the measured E-plane and H-plane directive patterns of a rear feed dual-mode horn 41 which was actually constructed in accordance with Figs. 11, 12 and 13, and tested at a design wavelength of 3.2 centimeters; and numerals 59 and 60 denote, respectively, the measured E-plane and H-plane patterns for the complete system 40. As shown in Fig. 14, the half-power widths 38 of the major lobes of the E-plane and H-plane dual-mode patterns 57 and 58 are, respectively, about 20 and 50 degrees, respectively, and the horn beam is of the fan type. The minor lobes 37 of patterns 57 and 58 are about 17 decibels down and therefore negligible. As in the case of the front feed dual-mode horn 22, Fig. 7, the rear feed dual-mode horn 41, Fig. 11, is especially suitable for use with an elliptical reflector having a large ratio of major axis to minor axis, for example, 1:3 to 1:5. As shown in Fig. 15, the half power widths 38 of the major lobes 36 of the E and H-plane patterns 59 and 60, for the complete system, are 2 and 5.1 degrees respectively and the beam is therefore of the fan type. The minor lobes 37 of patterns 59 and 60 are more than 20 decibels down and therefore negligible.

What is claimed is:

1. A box or two-mode horn for transmitting or receiving a combined TE₁₀ and TE₃₀ wave, said horn comprising a first dielectric guide for conveying only a TE₁₀ wave mode and a second guide connected thereto for conveying said wave mode and a TE₃₀ wave mode, said wave modes having different guide wavelengths, the difference between the length of said second guide as measured in guide wavelengths at one of said modes and the length of said second guide as measured in guide wavelengths at the other mode being a half wavelength.

2. A front feed two-mode horn antenna system for transmitting or receiving TE waves, said system comprising a first dielectric guide and a second dielectric guide each having E and H-plane walls, said second guide having an end wall and an iris in said end wall, said first guide being

electrically connected to said second guide through said iris, the H-plane walls of said second guide being wider than the H-plane walls of said first guide, the difference between the length of said second guide as measured in guide wavelengths for the TE_{10} mode and the length of said second guide as measured in guide wavelengths for the TE_{30} mode being a half wavelength, or an odd multiple thereof.

3. A rear feed two-mode horn antenna system comprising a main dielectric guide having an open end, a resonant chamber enclosing the end of said guide, a pair of auxiliary guides connected to said chamber and each having an antenna aperture, said main and auxiliary guides being parallel and having given H-plane dimensions, the H-plane dimensions of said auxiliary guides being greater than that of the main guide and such as to permit the conveyance of TE_{10} and TE_{30} wave modes, the difference between the distance from said open end to each aperture as measured in guide wavelengths for the TE_{10} mode and said distance as measured in guide wavelengths for the TE_{30} mode being a half wavelength.

4. In combination, a paraboloidal reflector having a focal point and a quasi-elliptical periphery, the ratio of the major axis to the minor axis of said periphery being in the order of 5:1 to 3:1, a two-mode horn at said focal point for radiating or receiving a wave including a TE_{10} component and a TE_{30} component, a guide connecting said horn to a translation device, said horn having at least one rectangular mouth aperture facing said reflector, said horn and aperture each having an H-plane dimension extending parallel to said minor axis, the axial length of said horn as measured in guide wavelengths for the TE_{10} component being a half wavelength different from said length as measured in guide wavelengths for the TE_{30} component.

5. In combination, a paraboloidal reflector

having a focal point and a quasi-elliptical periphery, an unflared dual-mode horn at said focal point, said horn having a single mouth aperture facing said reflector and transverse E and H-plane walls, a dielectric guide having E and H-plane walls extending across a portion of said reflector and attached to said horn, an iris in an E-plane wall of said guide for electrically connecting said guide and horn, the H-plane walls of said horn being wider than the H-plane walls of said guide and wider than the H-plane dimension of said iris.

6. In combination, a paraboloidal reflector having a focal point and a quasi-elliptical periphery, a rectangular guide extending through said reflector and having an open end near the focus of said reflector, a resonant chamber enclosing the end of said guide, a pair of auxiliary guides connected to said chamber and each having an antenna aperture facing said reflector, the difference in the distance from said open end to each antenna aperture as measured in guide wavelengths for the TE_{10} mode and said distance as measured in guide wavelengths for the TE_{30} mode being a half wavelength or an odd multiple thereof.

CASSIUS C. CUTLER.

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2,396,044	Fox	Mar. 5, 1946
2,405,242	Southworth	Aug. 6, 1946
2,415,807	Barrow et al.	Feb. 18, 1947
2,416,698	King	Mar. 4, 1947