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3,171,129

LOW SIDE LOBE HORN ANTENNA WITH INTERNAL CONDUCTIVE PLATES

Filed Dec. 29, 1961

3 Sheets-Sheet 1

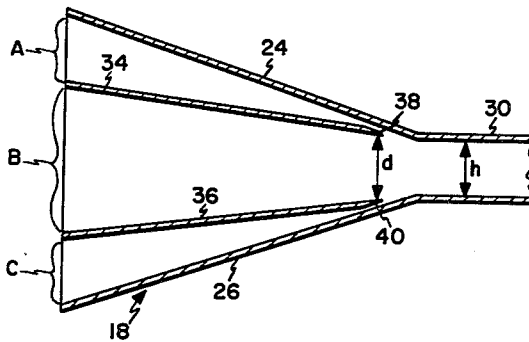


Fig. 2

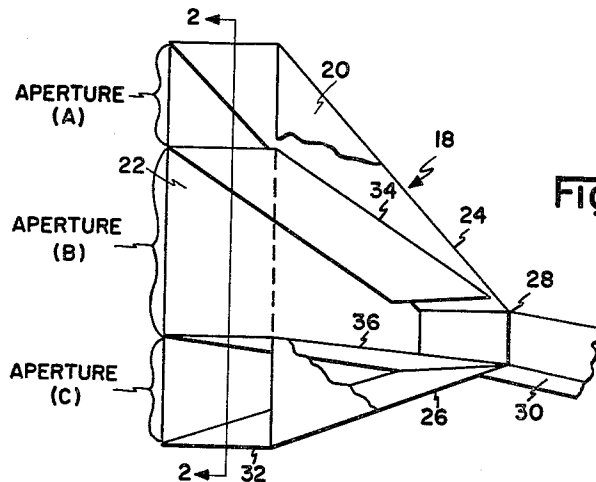


Fig. 1

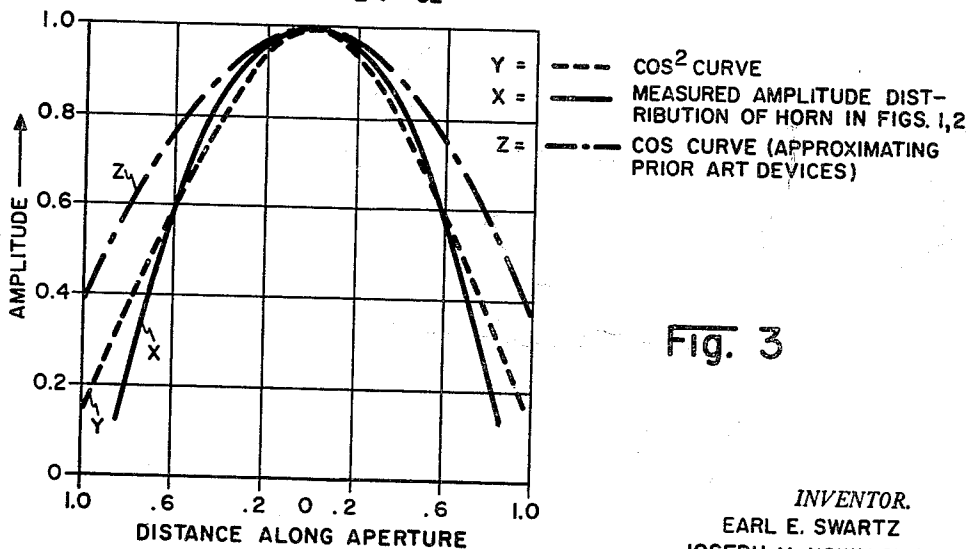


Fig. 3

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3 Sheets-Sheet 2

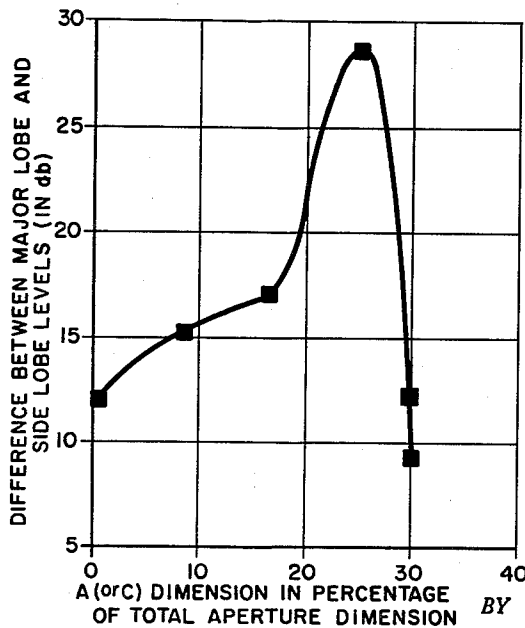
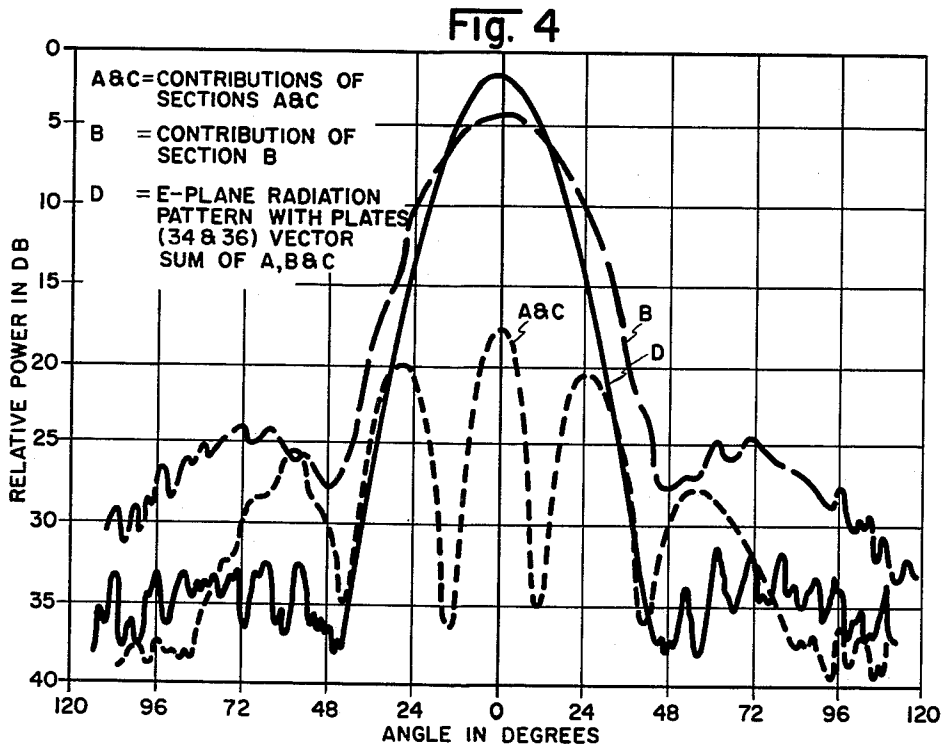


Fig. 5

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3 Sheets-Sheet 3

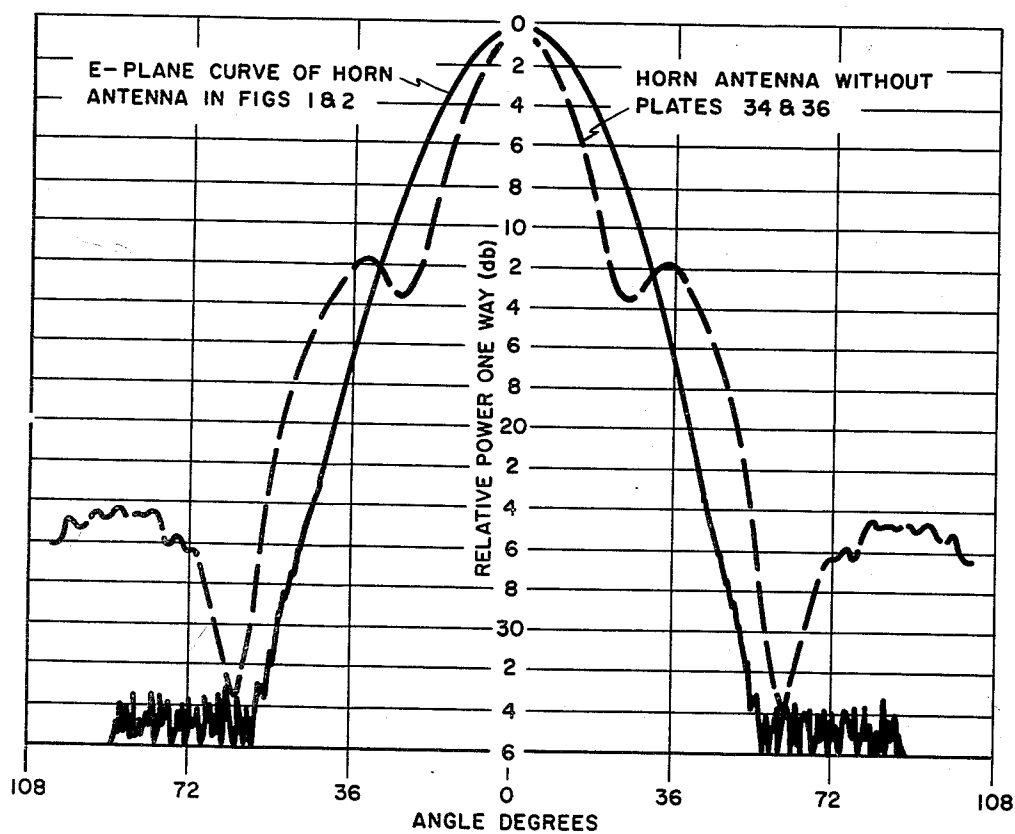


Fig. 6

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4 Claims. (Cl. 343—786)

This invention pertains to a sectorial or pyramidal horn antenna structure which is attached to a waveguide and which has low E plane side lobes.

It is well known that electromagnetic signals, such as those from waveguides, have components in both the E plane, or electrical plane, and the H plane, or magnetic plane, with the E and H planes being perpendicular to each other. For certain applications, it is very desirable to produce an antenna, for transmitting or receiving, which has Fraunhofer signals with very low side lobes so that it is highly directional. While there is usually not much difficulty in suppressing side lobes in the H plane of propagation, considerable difficulty is encountered in obtaining low side lobes in the E plane of propagation. This invention provides an antenna horn structure which obtains low side lobes in the E plane by providing a substantially constant phase distribution in the E plane at the horn aperture and an amplitude distribution in the E plane at the horn aperture that is substantially in the shape of a cosine squared curve.

Applicant accomplishes this by placing in the antenna horn two plates which divide the aperture into sections having a 25–50–25 ratio. These plates extend into the horn and in the preferred embodiment are approximately 1 to 1½ wave lengths shorter than the horn sides. The plates are parallel or divergent and in the preferred embodiment, the plate angle is divergent at 12 degrees 40 minutes and the horn sides are divergent at 36 degrees 34 minutes.

These and other objects and advantages and further description will now be discussed in connection with the drawings in which:

FIGURE 1 is a partially cutaway view in perspective of a preferred embodiment of this invention;

FIGURE 2 is a section taken along 2—2 of FIGURE 1;

FIGURE 3 is a graph showing the actual amplitude distribution across the horn aperture when compared with a cosine squared curve and the more usual cosine curve;

FIGURE 4 is a graph showing the contributions of the various horn aperture sections and the resultant;

FIGURE 5 is a graph showing the change of side lobes as the plates are moved from their 25–50–25 or “binomial” ratio; and

FIGURE 6 is a graph showing the comparison between an uncompensated horn and a horn of this invention.

In FIGURE 1 is shown a sectorial horn, but this invention is equally adaptable to a pyramidal horn. A sectorial horn has two parallel sides and two divergent sides while a pyramidal horn has two pairs of divergent sides.

In FIGURE 1 sides 20, 22 are the parallel sides while sides 24, 26 are the divergent sides. The small end or throat 28 of horn 18 is connected to the open end of a waveguide 30. The large end or aperture 32 of horn 18 is electrically open to receive wave energy in the case of a receiving antenna or transmit wave energy in the case of its use as a transmitting antenna.

Two diverging plates 34, 36 are placed in the horn and are tightly secured or sealed to the parallel sides 20 and 22. This sealing is important as it maintains the desired phase and amplitude distribution as wave energy moves through the horn. Plates 34 and 36 divide aperture 32 into three sections, A, B and C, which are the

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heights of apertures A, B and C and are in the ratio of 25–50–25 respectively, thereby dividing the aperture into areas of the same ratio. The inner ends 38 and 40 of plates 34, 36 respectively (FIGURE 2) are tapered or chamfered so that they are parallel to sides 24, 26.

Plates 34 and 36 are shorter than sides 24 and 26 by an amount which is preferably 1 to 1½ wave lengths of the average propagated frequency for which the horn antenna is designed to operate. The distance “d” between the inner ends of the plates is adjusted for optimum results and will vary corresponding to the particular frequencies of horn operation. Distance “d” should not be smaller than the height “h” of waveguide 30 and should not be larger than the aperture distance B to obtain the cosine squared amplitude distribution later explained.

In this embodiment, which is designed for a particular beamwidth, the included horn angle between sides 24 and 26 is 36 degrees and 34 minutes while the included angle between plates 34 and 36 is 12 degrees and 40 minutes.

The reason for applicants’ low side lobes and improved directivity is that the amplitude distribution across the aperture is higher at the center and lower at the sides than in previous devices. This can be seen in FIGURE 3 where along the abscissa is measured the Distance Along the Aperture with zero indicating the aperture center; and measured along the ordinate is the amplitude of the signal. The solid line curve X is the measured distribution over the aperture of a horn such as shown in FIGURES 1 and 2 while the dotted line curve Y is a cosine squared curve and the dashed line curve Z is a curve approximating the distribution over the aperture of prior art devices. It is seen that curve X of this invention is much more peaked than curve Z and slightly more peaked than curve Y resulting in lower side lobe wave propagation.

Further characteristics of this invention are shown in FIGURE 4 where Amplitude Power in DB is measured along the ordinate of the graph and Angle in Degrees along which the propagated signal is measured is plotted along the abscissa. The curve labeled “A+C” is the contribution of aperture sections A and C of the horn shown in FIGURES 1 and 2. The curve labeled B is the contribution of the aperture section B and the graph labeled D is the vector sum of curve B and curve A+C. In FIGURE 6, the curve E is the E plane radiation pattern of the horn of FIGURES 1 and 2 without plates 34, 36 and when compared with curve D, where plates 34, 36 are used, it is seen that D has much lower side lobes.

The graph shown in FIGURE 5 indicates the change in side lobe depression as the spacing between plates 34 and 36 at the aperture end is changed. The percentage that each aperture section A and C is of the whole aperture (A+B+C) is measured along the abscissa. It is seen that when A and C are each 25 percent of the entire aperture section, as they are in the embodiment of FIGURES 1 and 2, the side lobe depression is at a maximum, but falls off sharply when apertures A and C are either increased or decreased.

Although this invention has been disclosed and illustrated with reference to particular applications, the principles involved are susceptible of numerous other applications which will be apparent to persons skilled in the art. The invention is, therefore, to be limited only as indicated by the scope of the appended claims.

Having thus described our invention, we claim:

1. Antenna apparatus for terminating a feeding waveguide having a mouth comprising
 - a horn type structure having a four sided enclosure forming a throat end and aperture end, said throat end being connected to said feeding waveguide mouth,
 - at least two sides of said horn structure being divergent,

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two plate members each having an outer end and an inner end being in said horn structure, said plate members and divergent sides being positioned so that they are substantially perpendicular to a common plane,

said plate members being positioned at the aperture end of said horn structure, so that the aperture is divided into three sections having sizes substantially in the ratio of 25-50-25,

the total volume of said plate members being less than the total unoccupied volume within said horn.

2. The apparatus of claim 1 where the throat ends of said plate members are at least as far apart as the feeding waveguide walls attached to said diverging sides,

said plate members being divergent in the same direction as said diverging sides,

said horn structure sides being divergent at an angle of less than 40°,

and said plate members being tightly sealed against opposite sides of said horn structure.

3. The apparatus of claim 1 with said plate members being tapered at the throat end of said horn structure so that the outer surface of said plates are parallel with the surface of the horn side which it faces.

4. Antenna apparatus for terminating a feeding waveguide having a mouth comprising

a horn type structure having a four sided enclosure forming a throat end and aperture end, said throat end being connected to said feeding waveguide mouth,

at least two sides of said horn structure being divergent, two plate members each having an outer end and an inner end being in said horn structure, said plate members and divergent sides being positioned so that

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they are substantially perpendicular to a common plane,

said plate members being positioned at the aperture end of said horn structure so that the aperture is divided into three sections having sizes substantially in the ratio of 25-50-25,

the total volume of said plate members being less than the total unoccupied volume within said horn, the throat ends of said plate members being at least as far apart as the feeding waveguide walls attached to said diverging sides,

said plate members being divergent in the same direction as said diverging sides,

said horn structure sides being divergent at an angle of less than 40°,

said plate members being between one and one and one half wavelengths shorter than said sides,

and said plate members being tightly sealed against opposite sides of said horn structure.

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