

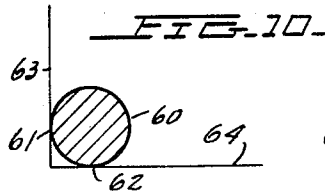
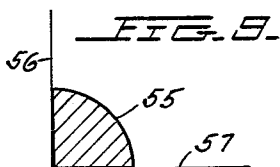
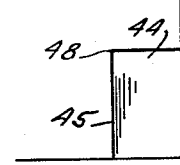
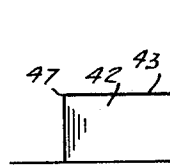
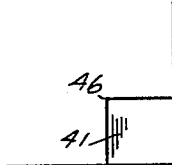
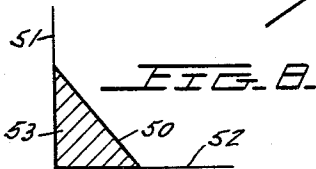
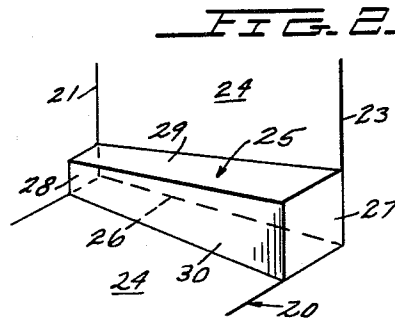
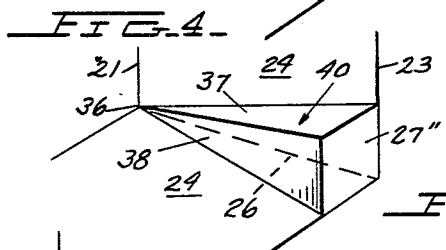
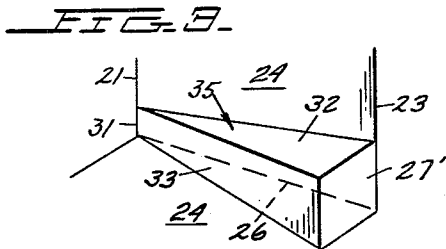
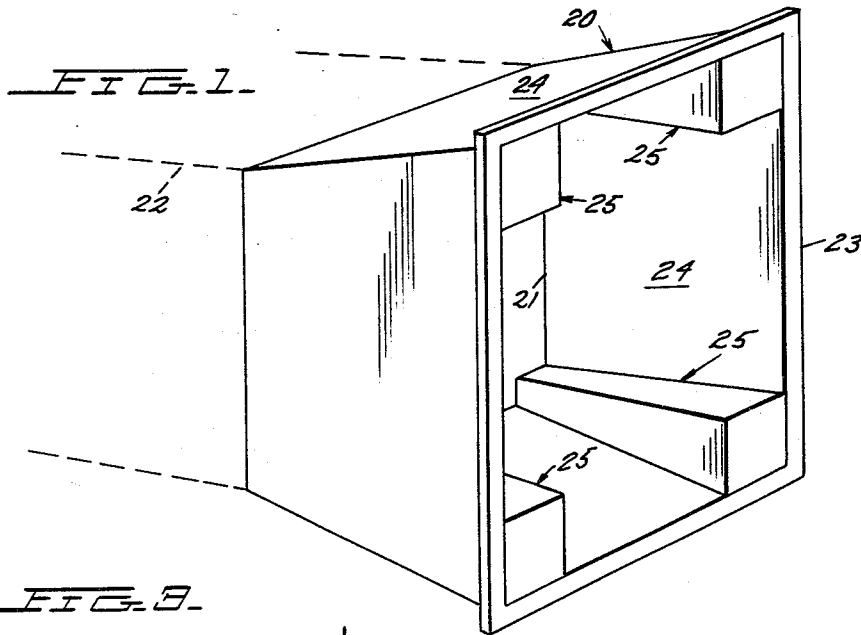
March 9, 1965

C. T. CARSON
DUAL POLARIZED HORN

3,173,146

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2 Sheets-Sheet 1



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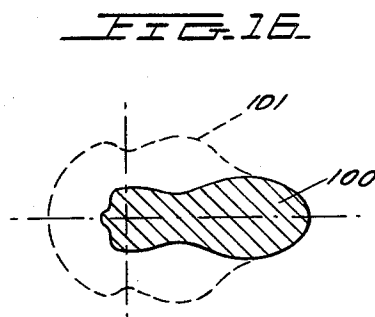
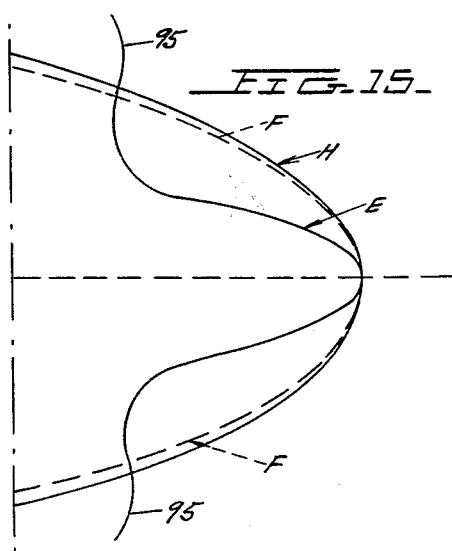
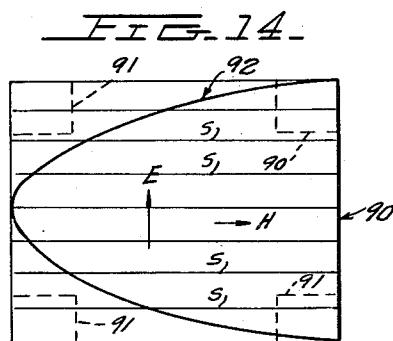
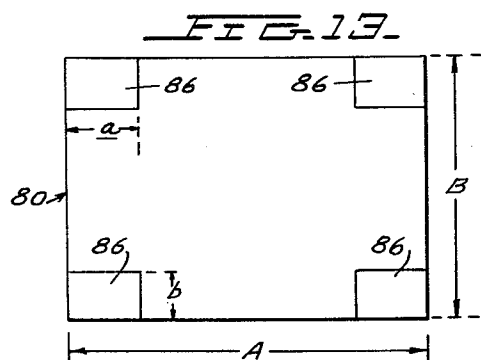
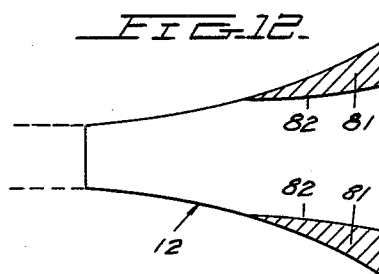
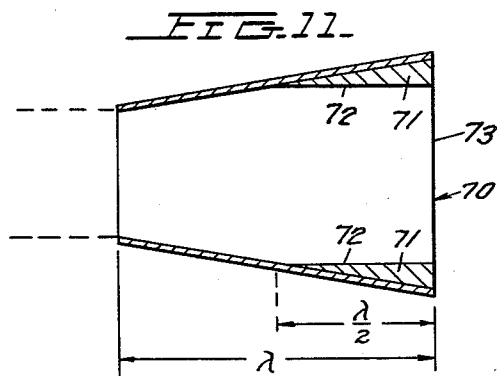
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DUAL POLARIZED HORN

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2 Sheets-Sheet 2



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3,173,146

DUAL POLARIZED HORN

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Filed Jan. 28, 1960, Ser. No. 5,279
5 Claims. (Cl. 343-786)

This invention relates generally to dual polarized horns, apertures and the like, and more particularly relates to novel horns with equal E and H plane radiation patterns.

In a dual polarized horn, two independent microwave signals are utilized, polarized at 90° in space orientation to each other so as to be mutually non-interfering. Such signals may both be either transmitted or received by the horn; or one transmitted, while the other is received. A typical range of application of the invention is between 300 and 3000 megacycles, though it is useful beyond such range. The horn hereof may for example be used in a large scatter-type antenna communication system, for simultaneous transmit and receive with 90° difference in polarization of signals; or in a radar system transmitting circular polarized waves, and receiving reflections thereof. Such simultaneous utilization of the dual horn enhances the practicableness of the systems.

A horn, to be effective in dual polarization operation, should have substantially identical E and H plane patterns. Heretofore thin metallic septa were inserted centrally along the horn interior walls to affect the E plane pattern. The septa had negligible effect on the H plane pattern. In accordance with the present invention novel means of pattern control are incorporated in the dual horn, affording more uniform attenuation of the E pattern skirts. The resultant horn characteristics better match the impedance of the attached wave guide or its air loading, thus having far better VSWR than heretofore attainable.

Metal fillets or inserts are applied along the corners of the basic horn. These fillets are suitably tapered along the horn flare. The length of the fillets may be as low as one quarter wave length or even a wave length or more (of the signal frequencies of the horn operation). The cross-sectional shape of the fillets or corner inserts may take a number of forms, as will be set forth. The cross-sectional size and form of the fillets may be varied, and optimized empirically for a particular horn.

The invention inserts may be applied to horns of various sectional configurations, e.g. square, rectangular, circular. It is preferable that the horn be at least one wave length long, with the inserts preferably of the order of one half wave long. Substantial impedance matching is accomplished by the invention horn, with VSWR of the order of 1.15. Septa pattern control results in VSWR in the range of 1.5 to 2. The corner fillets hereof changes the E plane up to about 30°, and the H plane only a few degrees, as will be detailed hereinafter. More effective pattern control is thereby provided.

It is accordingly a primary object of the present invention to provide a novel dual polarization horn with substantially equal E and H plane patterns.

Another object of this present invention is to provide a novel horn with corner inserts or fillets effecting pattern control.

A further object of this present invention is to provide a novel dual polarization horn matched to its associated guide or load with VSWR of the order of 1.15.

Still another object of this present invention is to provide a novel horn the relative E and H patterns of which are effectively controlled by simple tapered fillets.

These and other objects of the invention will become

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more apparent in the following description of exemplary embodiments thereof, illustrated in the drawings in which:

FIGURE 1 is a perspective illustration of one form of the invention dual polarized horn.

FIGURES 2, 3 and 4 are perspective views of several forms of tapered corner fillets for the horn of FIGURE 1.

FIGURES 5, 6 and 7 are end views of various corner fillets transverse forms.

FIGURES 8, 9 and 10 are cross-sectional views through modified fillet shapes.

FIGURE 11 is a transverse sectional view at an end region of a further horn embodying the invention.

FIGURE 12 is a diagram illustrating the invention applied to an exponential horn.

FIGURES 13 and 14 are diagrams used in explaining some technical aspects of the invention.

FIGURES 15 and 16 are graphs of E and H patterns showing their control by the invention inserts.

FIGURE 1 illustrates in perspective a horn 20 simultaneously operable with two non-interfering micro-wave signals, polarized at 90° spatial orientation. Horn 20 is rectangular in section with its throat 21 connected to a wave guide 22 indicated in dotted lines. The horn aperture 23 may radiate to (or receive from) open space, a lens or reflector. The four walls 24, 24 taper outwardly from throat 21 to aperture 23. At each interior corner of the horn are metallic inserts or fillets 25, 25. The conductive fillets 25, 25 are tapered, and flare out with the horn. Also fillets 25, 25 extend the full length of horn 20, although such is not necessary as will be explained hereinafter.

FIGURE 2 illustrates one of the fillets 25 with respect to the linear corner 26 along the horn walls 24, 24. The aperture face 27 of fillet 25 is substantially square though not necessarily, corresponding to the square sections 21, 23 of the horn 20. The throat face 28 is correspondingly square in form, though smaller in area than face 27. The two trapezoidal sides 29, 30 are simple and relatively inexpensive to construct.

The corner fillets may be of flat or sheet material, with hollow interiors. The faces 27, 28 may be metallic planes or open as desired. The significant factor is that the longitudinal surfaces (29, 30) be of good conductive material to effect the pattern control. Also, the tapering of the corner fillets 25 may take many alternate forms, with good pattern control.

FIGURE 3 shows the face 27' tapered to a line 31 at throat 21 to form corner fillet 35 with triangular side 32 and trapezoidal side 33. FIGURE 4 shows corner fillet 40 tapered from square face 27" to a point 36, with two triangular faces 37, 38. It is noted that the longitudinal faces of the corner fillets 25, 35, 40 are plane. Plane faces are more economical than curved ones; the latter may be used as well.

The end faces of the fillets may be square, rectangular, or any other desired shape. Where flat sides are used, the horn aperture face 41, shown in FIGURE 5 is square; face 42 is rectangular, with the longer side 43 horizontal, as shown in FIGURE 6. FIGURE 7 shows face 44 with a vertical longer side 45. The interior corners 46, 47 of fillet faces 41, 42 respectively, are sharp or squared, corner 48 of fillet face 44 being rounded. The first order dimensioning of the fillet shape is discussed in more detail hereinafter in connection with FIGURE 13.

The cross-sectional form of the corner inserts or fillets may be varied. In FIGURE 8 a single plane 50 subtends perpendicular horn walls 51, 52, being inclined therebetween at a desired angle. The interior portion 53 may be hollow or solid. The interior surface 55 of FIGURE 9 between horn walls 56, 57 is arcuate; being a 90° circular section. The fillet section 60 of FIG-

FIGURE 10 is a full circle or tangent at 61, 62 respectively to walls 63, 64.

The important factors of the fillets hereof is that their surfaces interior of the horn be of material of good conductivity, such as aluminum, that there be good electrical contact between the edges of these surfaces and the metal horn walls they subtend. The waves passing along the horn are short circuited at the fillet areas, with short-circuiting currents flowing across the fillet surfaces to the adjacent horn walls, as will be set forth in more detail in connection with FIGURE 14. A given horn will generally, though not necessarily, be provided with fillets of the same form, construction, and length. Also, a particular horn may use only two fillets, generally diagonally arranged.

Horns are generally at least one-half wave length long; usually a full wave length, or longer. The horn 70 of FIGURE 11 is shown to be one wave length λ long; and may of course be even longer (or shorter). The corner fillets 71, 71 of horn 70 are one-half wave length long, $\lambda/2$. The fillets may be shorter, such as even to one-quarter wave length, $\lambda/4$, or less; or longer, to one wave length λ or more. Their length is not critical. In practice, a length of one-half the wave length of the horn design center frequency is most economical for effective results. There is no frequency discrimination produced by the corner fillets, hence the broad band characteristic of the horn is unimpaired. The shorter fillets 71, 71 preferably, though not necessarily, extend to the aperture 73 of the horn.

The E and H plane pattern control by the corner inserts hereof is also equally operative on exponential horns. Horn 80 of FIGURE 12 is of such type. The fillets 81, 81 are in the corners of horn 80 if of square or rectangular form. They are one-half wave length long in horn 80. The interior surfaces 82, 82 of fillets 81, 81 are shown as curved. They may be flat for reasons of economy, as are the corresponding surfaces 72, 72 of horn 70. Where conical or other round, horn shapes are used, the fillets therefor are located in the effective "corners" thereof, corresponding to the 45° points between the 90° orientations of the two signals through the horn.

The cross-sectional area of the corner fillets are best arrived at experimentally or empirically. The larger the area of the fillets extending into the horn interior, the greater the effect on the E-H patterns. The horn 85 of FIGURE 13 has a rectangular aperture with four corner fillets 86, 86. The faces of fillets 86, 86 are rectangular with dimensions a , b . The a width of the fillet faces corresponds to the A dimension of the horn aperture; the b height, to the B dimension. As a first order approach the ratio of a to b is chosen as that of A to B. However, the desired pattern control for a given horn is then best trimmed empirically, and optimized if required.

Each corner fillet in a horn of the invention affects the surrounding E plane substantially more than the H plane. The E plane pattern may be changed up to 30°, while the H plane pattern, only a few degrees. The fillets short out parts of the horn aperture, controllably distorting both the E and H plane patterns simultaneously. The extent of such distortion corresponds to the surface area intercepted by the waves passing through. The short circuiting currents flow across the fillet surfaces and around the subtended horn corners.

FIGURE 14 is a graphic representation of the physical action of horn 90 with corner fillets 91, 91. The E field through the horn is vertically oriented for one of the signals. The horizontal lines s , s divide the horn area into equal segments of arbitrary number. The integration of the field intensity E^2 across each segment results in an equal amount of energy in each segment. The fillets 91, 91 short circuits the electric fields E at the corners, and blocks out the magnetic fields H therein as well. The

resultant intensity distribution across the horn is indicated by smooth curve 92. A similar smoothing action occurs on the transverse E pattern for the second 90° signal. The respective magnetic H patterns are correspondingly affected, to a lesser degree.

FIGURE 15 is a radiation pattern of the E and H planes (in solid lines) of a typical horn configuration, unaltered by corner fillets, septa, etc. The objective of E, H plane pattern control hereof is to alter the basic E and H plane patterns so that they more closely coincide, with least VSWR impact. The corner fillets of the present invention widen both 90° signal E plane radiation patterns, and effectively remove their wide angle radiations. As viewed in FIGURE 15, the result is to widen the E plane patterns to coincide with H plane patterns and give low skirt levels as shown in dotted curve F. To a lesser extent, the sides of the H pattern are trimmed to coincide with the resultant E plane pattern per curve F.

The polar radiation pattern 100 (hatched area) of FIGURE 16 is illustrative of the E plane radiation altered by corner fillets in the horn in accordance with this invention as compared with the pattern 101 obtained using septa. This is readily accomplished by the invention conductive inserts, with a residual VSWR of the order of 1.15.

The use of the corner fillets permit an overall better impedance matching of the horn to either or both ends thereof, as aforesaid. The resultant E and H radiation patterns are made substantially equal thereby, for effective operation of the horn, with dual polarization. By effective design following the principles of this invention, the E and H radiation patterns are made substantially equal thereby, for effective operation of the horn with dual polarization. By effective design following the principles of this invention, the E and H radiation patterns in both 90° signal orientations are similarly controlled for efficient results. Also, some or all of the metal inserts may be located away from the corners, to provide effective action, on the E/H pattern ratio.

One practical embodiment of this invention, as a feed horn in a tropo-scatter communication system, had the following physical and electrical characteristics:

Aperture: 15" x 13.5"

Length: 40"

Throat: 11.75" x 11.75"

Center frequencies:

Polarization A: 777 mc. ($\lambda=15.2"$)

Polarization B: 857 mc. ($\lambda=13.75"$)

Fillet dimensions (one in each corner):

Length: 12"

Height at aperture: $3\frac{1}{8}"$

Width at aperture: $2\frac{7}{8}"$

Height at interior end: Zero

Width at interior end: $2\frac{7}{8}"$

VSWR = ± 1.10 for both A and B signals.

10 db beam width *without* fillets:

E plane at 777 mc.: 98°

H plane at 777 mc.: 112°

E plane at 857 mc.: 76°

H plane at 857 mc.: 109°

10 db beam width *with* fillets:

E plane at 777 mc.: 107°

H plane at 777 mc.: 104°

E plane at 857 mc.: 105°

H plane at 857 mc.: 104°

Although this invention has been described in connection with exemplary embodiments thereof, it is to be understood that variations and modifications may be made by those skilled in the art that fall within the broader spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. A dual polarized horn of the character described

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comprising a flared structure having walls joined at corner regions and conductive means secured to adjacent ones of said wall surfaces, at said corner regions, interior of the walls and longitudinally of the horn for substantially narrowing the radiation pattern in the E-plane with relatively low VSWR effect, each of said conductive means being a plane triangular sheet of conductive material being positioned to form a pyramidal shell with its associated corner region, and substantially confined to the intersection of the adjacent wall surfaces at its respective corner region.

2. A dual polarized horn of the character described comprising a flared structure having walls joined at corner regions and conductive means secured along the corner regions interior of the walls and longitudinally of the horn for substantially narrowing the radiation pattern in the E-plane with relatively low VSWR effect, each of said conductive means being a plane triangular sheet of conductive material being positioned to form a pyramidal shell with its associated corner region, said pyramidal shell being tapered to narrow in the direction from the aperture towards the throat of said horn.

3. A dual polarized horn of the character described comprising a flared structure having walls joined at corner regions and conductive means secured along the corner regions interior of the walls and longitudinally of the horn for substantially narrowing the radiation pattern in the E-plane with relatively low VSWR effect, each of said conductive means being a curved sheet of conductive material being positioned to form a prismatic shaped shell with its associated corner region, said shell having a taper running from the aperture to the throat of said horn.

4. A dual polarized horn of the character described comprising a flared structure having walls joined at corner regions and conductive means secured to adjacent ones

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of said wall surfaces, at said corner regions, interior of the walls and longitudinally of the horn for substantially narrowing the radiation pattern in the E-plane with relatively low VSWR effect, each of said conductive means being a substantially L-shaped sheet of conductive material being positioned to form a rectangular shell with its associated corner region, and substantially confined to the intersection of the adjacent wall surfaces at its respective corner region, said rectangular shell having a taper running from the aperture to the throat of said horn, narrowing towards the throat of said horn.

5. A dual polarized horn of the character described comprising a flared structure having walls joined at corner regions and conductive means secured along the corner regions interior of the walls and longitudinally of the horn for substantially narrowing the radiation pattern in the E-plane with relatively low VSWR effect, each of said conductive means being a plane triangular sheet of conductive material being positioned to form a pyramidal shell with its associated corner region, the length of said shell being substantially equal to one-half wave length of the mean frequency of the horn signals.

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