

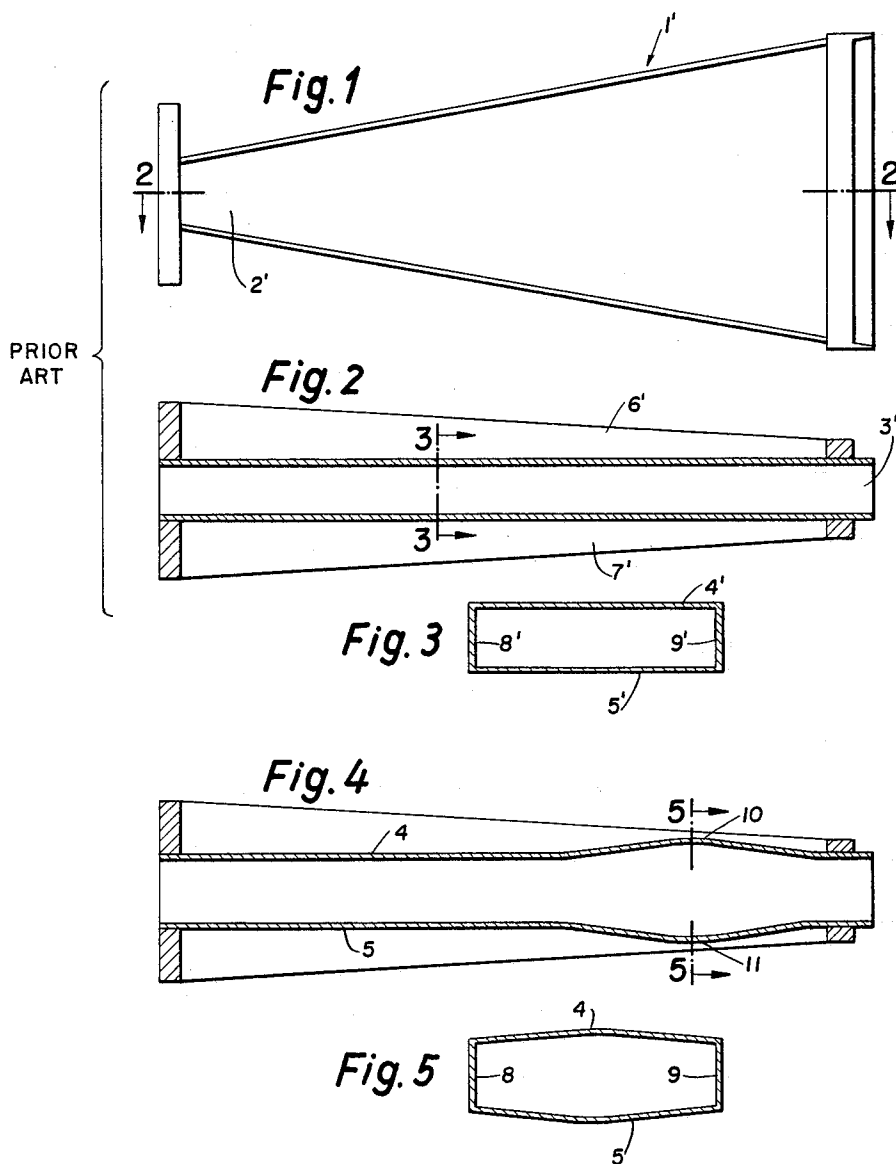
May 17, 1966

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MICROWAVE DEVICE

3,252,160

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4 Sheets-Sheet 1



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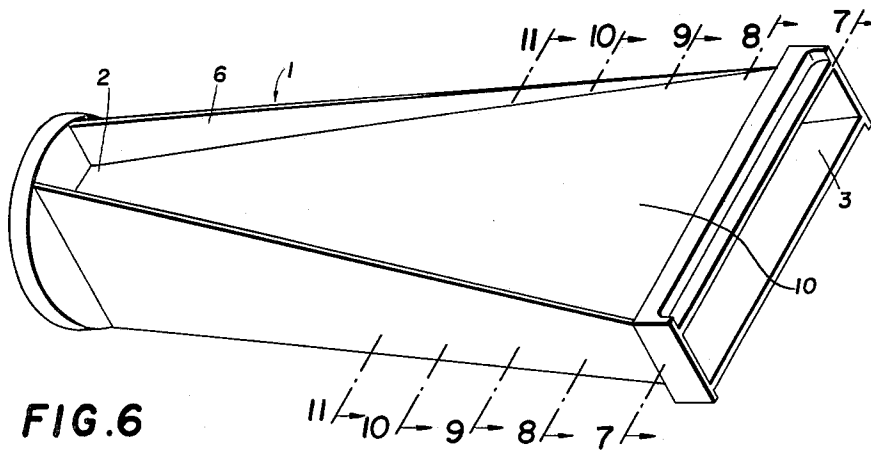


FIG. 6

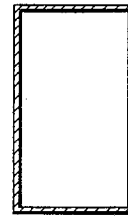


FIG. 11

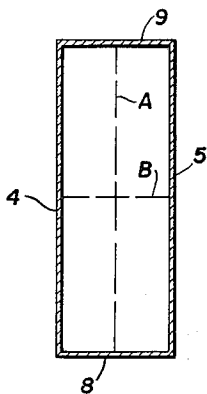


FIG. 7

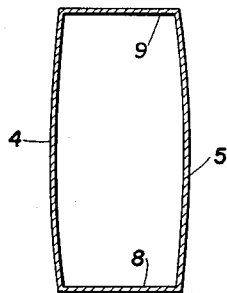


FIG. 8

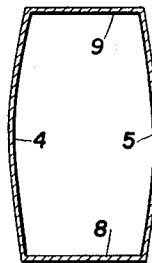


FIG. 9

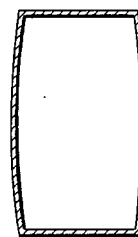


FIG. 10

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3,252,160

MICROWAVE DEVICE

Filed Jan. 18, 1962

4 Sheets-Sheet 3

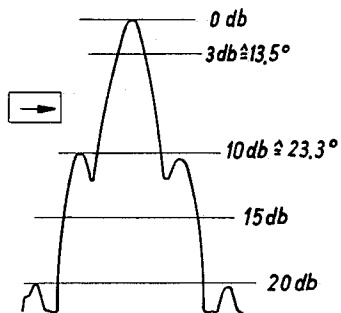


Fig. 12

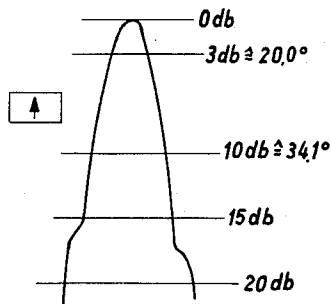


Fig. 13

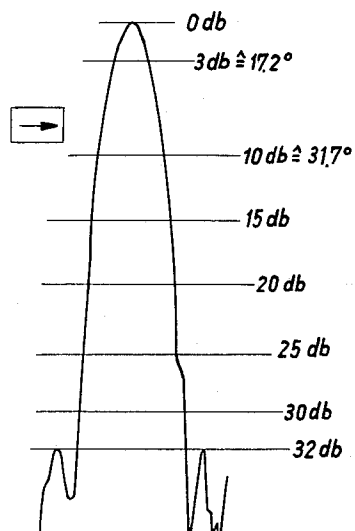


Fig. 14

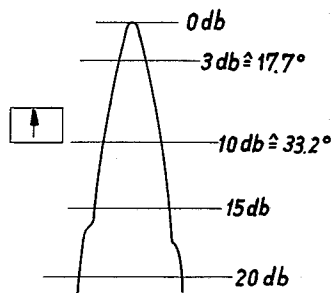


Fig. 15

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4 Sheets-Sheet 4

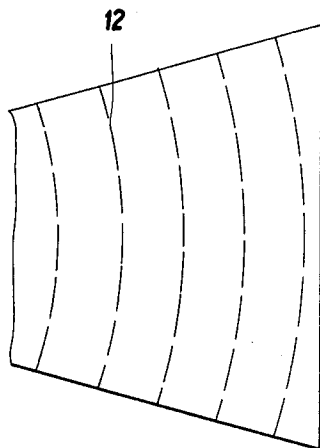


Fig. 16

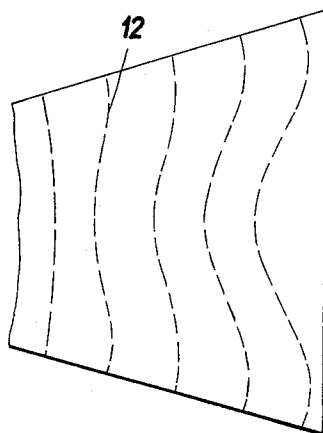


Fig. 17

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1

3,252,160

MICROWAVE DEVICE

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Claims priority, application Germany, Jan. 20, 1961,

T 19,568

5 Claims. (Cl. 343—783)

The present invention relates generally to the microwave art, and, more particularly, to a horn which is suitable for circular polarization and has apertures axes, i.e., vertical and horizontal aperture dimensions, which are of different size for generating a radiation pattern having small side lobes.

Quite frequently, radar apparatus is operated with circularly or elliptically polarized waves, especially for suppressing rain echoes. Because of the polarization-dependency of the aperture of the horn which is conventionally used for this purpose as the primary antenna and which has rectangular cross section, the two components which are out of phase and linearly polarized at right angles to one another and which form a circularly or elliptically polarized wave, are radiated in different patterns.

A known type of rectangular horn may be adapted to generate substantially equal radiation patterns for the two components of a circularly or elliptically polarized wave by using triangular plates which project inwardly from the horn walls at substantially right angles thereto. However, this may only be accomplished in the event that the length or width of the aperture is larger than 1.5λ , where λ is the wave length of the hollow tube waves in the aperture plane of the horn. If this relationship is not provided, even this horn, adapted as mentioned above, will cause marked polarization deformations and distortions of the radiation patterns.

Quite frequently it is necessary to use horns having a very small aperture, for example, in order to permit irradiation of reflector mirrors having a pronounced elliptically shaped aperture. Furthermore, with this type of horn, it is not possible to provide a point phase center common to both planes of polarization. Also, these plates which project into the horn cause reflections having inductive or capacitive components and which create a mismatch. Also, resonance of the plates cannot be avoided and thus this horn has a fairly small bandwidth.

Another type of horn having a rectangular cross section which is known in the prior art, does not permit the generation of equal radiation patterns of the horizontally and vertically polarized waves with the desired common phase center. In order to provide for equalization of the radiation patterns, a dielectric plate is provided in the horn with its plane being coincident to that in which the equalization of the pattern is to be achieved. Such a plate does not extend for the full width of the aperture. Because of this dielectric plate or disc, mismatches cannot be prevented in this type of horn either.

With these defects of the prior art in mind, it is a main object of the present invention to provide a microwave horn suitable for elliptical or circular polarization of waves and which has different horizontal and lateral aperture dimensions and which provides a wide bandwidth.

Another object of this invention is to provide a horn of the type described which is less expensive to manufacture than those horns of the prior art.

A further object of this invention is to provide a horn wherein the horizontal and vertical radiation patterns are equal or substantially similar to each other.

Still a further object of the present invention is to provide a horn of the type described wherein a point phase

2

center is provided which is common to both planes of polarization.

Yet a further object of this invention is to provide a horn which has extremely small side lobes in the radiation pattern.

These objects and others ancillary thereto are accomplished according to preferred embodiments of the invention wherein the horn has a major and a minor aperture axis, with said axes being of different length. Considering the horn to be rectangular, then the axes may be considered as vertical and horizontal dimensions thereof. In each of the two horn walls which are parallel to the major aperture axis, an outwardly extending convex dome is provided which is of such a size that a correction of the phase velocity of the hollow tube wave in the horn takes place, dependent upon the location in the plane of the major aperture axis. Also, a substantially point-like phase center is formed and/or the amplitudes of the side lobes of the radiation pattern are a minimum.

In the following description, horizontal polarization means that the E vector is parallel to the wide or major wall.

Additional objects and advantages of the present invention will become apparent upon consideration of the following description when taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a plan view of a conventional horn of the type having a rectangular cross section.

FIGURE 2 is a vertical sectional view of the horn of FIGURE 1, taken substantially along the plane defined by reference line 2—2 of FIGURE 1.

FIGURE 3 is a vertical sectional view, taken substantially along the plane defined by reference line 3—3 of FIGURE 2.

FIGURE 4 is a vertical longitudinal sectional view similar to FIGURE 1, but constructed in accordance with the present invention.

FIGURE 5 is a vertical sectional view, taken substantially along the plane defined by reference line 5—5 of FIGURE 4.

FIGURE 6 is a perspective view of the horn of the present invention which is illustrated in FIGURES 4 and 5.

FIGURE 7 is a vertical sectional view, taken substantially along the plane defined by reference line 7—7 of FIGURE 6.

FIGURE 8 is a vertical sectional view, taken substantially along the plane defined by reference line 8—8 of FIGURE 6.

FIGURE 9 is a vertical sectional view taken substantially along the plane defined by reference line 9—9 of FIGURE 6.

FIGURE 10 is a vertical sectional view taken substantially along the plane defined by reference line 10—10 of FIGURE 6.

FIGURE 11 is a vertical sectional view taken substantially along the plane defined by reference line 11—11 of FIGURE 6.

FIGURE 12 is a diagram illustrating the radiation pattern of the horn of FIGURE 1 operating with horizontal polarization.

FIGURE 13 is a diagram illustrating the radiation pattern of the horn of FIGURE 1 operating with vertical polarization.

FIGURE 14 is a diagram illustrating the radiation pattern of the horn of the present invention operating with horizontal polarization.

FIGURE 15 is a diagram illustrating the radiation pattern of the horn according to the present invention operating with vertical polarization.

FIGURE 16 is a diagrammatic view illustrating the

characteristic of the phase fronts in the horn of FIGURE 1.

FIGURE 17 is a diagrammatic view illustrating the characteristic of the phase fronts in the horn in accordance with the present invention.

With more particular reference to the drawings, FIGURES 1-3 illustrate a horn having a rectangular cross section and of the type which is known in the prior art. This conventional horn 1', with its rectangular cross section, has an inlet opening 2' and an aperture plane 3'. As is clearly shown in FIGURE 3, the horn is rectangular in cross section and is constructed with wide walls 4' and 5' which are parallel to the major axis thereof and short vertical walls 8' and 9' which are parallel to the minor axis thereof. Mechanical sheet metal stiffening plates 6' and 7' are added for mechanical strength.

The horn comprising the present invention is illustrated in FIGURES 4 through 11. In these figures, the horn also has a rectangular cross section and is provided with walls 4 and 5 which extend in a direction which is parallel to the major axis of the aperture. It is also provided with vertically extending walls 8 and 9 which are in a direction which is parallel to the minor axis of the aperture. As is clearly shown in FIGURE 6, this horn also is provided with an inlet opening 2 and an aperture plane 3. For purposes of clarification, the major axis A and the minor axis B of the aperture are specifically designated in FIGURE 7.

The present invention differs from the horn of the prior art of FIGURES 1-3 in that outwardly extending or convexly dimpled hill-shaped or domed deformations or projections are provided at points 10 and 11. The details of this deformation will be more readily apparent if the cross sections therethrough, as shown in FIGURES 5 and 7 through 11, are considered.

In order to indicate the advance of the present invention over the prior art, a comparison of the radiation patterns, during the operating conditions thereof, will now be considered. In FIGURES 12 and 13, it may be seen that diagrams of the radiation patterns for the horn of FIGURES 1-3 are provided, with that of FIGURE 12 being for horizontal polarization and that of FIGURE 13 being for vertical polarization. It may be seen from these figures that this horn is not suitable for circular polarization because the two patterns differ markedly or substantially from one another. For example, at the three decibels width of the radiation pattern of FIGURE 12 for horizontal polarization with the conventional horn, a value of 13.5° is obtained while the corresponding value for vertical polarization amounts to 20° . With horizontal polarization the first side lobe occurs at about 10 decibels and corresponding to a pattern width of 22.3° , with the second side lobe occurring at about 20 decibels. On the other hand, in FIGURE 13 in the case of vertical polarization the side lobes are disposed at higher values than 10 decibels.

FIGURES 14 and 15 show patterns which correspond to those of FIGURES 12 and 13, respectively, but which are for the horn of the present invention, i.e., FIGURE 14 is for horizontal polarization and FIGURE 15 is for vertical polarization. As may be seen from these figures, the 3 decibel width is substantially equal for both planes of polarization. Also the side lobe characteristic is substantially more favorable than with the conventional horns, i.e., the lobes in the two polarization planes are more nearly similar. As indicated in FIGURE 14 for horizontal polarization, the first side lobe occurs at about 32 decibels while in vertical polarization no side lobes at all occur above 20 decibels. Not only the 3 decibel width ratio but also the 10 decibel width ratio of the radiation patterns of this horn of the present invention in the two planes of polarization are substantially more favorable than the 10 decibel width ratio of the radiation patterns for the two planes of polarization of the conventional horn.

In short, a comparative analysis of FIGURES 12 through 15 indicates that the horn according to the present invention provides a radiation pattern in both planes of polarization which is very well suited for circular polarization. This pattern is by far better than that of the conventional horn, and the side lobe damping of the known horn could be increased by 22 decibels and must thus be considered as being very good.

Phase measurements which have been taken for the embodiment of the present invention indicate that there is a point-like phase center common to both planes of polarization.

FIGURE 16 indicates that with the horn 1' of the conventional type the phase fronts 12 indicated by dashed lines will occur. However, if the dome-like deformations of the present invention are provided in the wider walls of the horn, the curvatures in the phase fronts according to FIGURE 17 are corrected in such a manner that waves radiated by the horn have a point-like phase center. In horns with aperture axes of different size, the narrow walls may also, if desired, be provided with corresponding dome-like deformations, either alone or in addition to the deformations in the wide walls.

An example of such a structure may be considered as follows:

Using a horn of the type illustrated in FIGURE 6, which is designed to operate at 9090 megacycles per second, the length of the horn between elements 2 and 3 would be 28.0 cm. The width of wall 4 at the narrow end near point 2 would be 14.0 cm. and its width at the wider end near the aperture would be 0.25 cm. Also, the center of the deformation is placed so that it is a distance of 7.0 cm. from the radiation aperture and is disposed midway between the vertical walls. The amount of such a deformation between the highest point on the dome and the point it would occupy if the wall were flat, is 0.17 cm. The length of a deformation from side to side is 9.0 cm. while from front to back it is 13.75 cm.

The geometrical shape of the hill-like dome at point 10 of the horn according to the above-mentioned example is parabolic or spherical and may be preferably determined empirically. The characteristic of the wavefront produced essentially is independent from the exact geometrical shape of said dome, this shape effecting primarily the matching of the load to the transmitter. For mechanical reasons said dome preferably must be located near the aperture of the horn.

It will be understood that the above description of the present invention is susceptible to various modifications, changes, and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

What is claimed is:

1. A microwave horn for circular and any elliptical or linear polarization, comprising, in combination:

(a) a hollow member having walls and a feed end and a radiating end;

(b) said member at the radiating end thereof defining a rectangular aperture having different vertical and horizontal dimensions and at least one of said walls being parallel to the larger dimension of said aperture; and

(c) each of the member walls parallel to the larger dimension having a convex dome formed therein arranged, shaped, and dimensioned to correct the phase velocity of the propagated wave to form a substantially point-like center of the main lobe of the radiation pattern.

2. A horn as defined in claim 1 wherein each dome is disposed near said aperture.

3. A microwave horn, comprising, in combination:

(a) a hollow member

(1) formed of vertical and horizontal walls,

5

- (2) being of rectangular cross section for at least the major portion thereof, and
 (3) having a feed end and a radiating end;
 (b) said member defining a rectangular aperture at the radiating end thereof, said aperture having different vertical and horizontal dimensions; and
 (c) each of the larger dimension member walls having an outwardly directed hill-like deformation defining means dimensioned and disposed to correct the phase velocity of the propagated wave in the horn and to provide similar radiation pattern widths for all polarizations in the same plane of measurement and to form a substantially point-like center of the main lobe of the radiation pattern.
4. A microwave horn for circular and any elliptical or linear polarization, comprising, in combination:
 (a) a hollow member having walls and a feed end and a radiating end;
 (b) said member at the radiating end thereof defining a rectangular aperture having different vertical and horizontal dimensions and at least one of said walls being parallel to the larger dimension of said aperture; and

6

- (c) each of the member walls parallel to the larger dimension having a convex dome formed therein arranged, shaped, and dimensioned to correct the phase velocity of the propagated wave to minimize the side lobes of the radiation pattern.
 5. A horn as defined in claim 4 wherein each dome is disposed near said aperture.

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