PARABOLIC REFLECTOR HORN FEED WITH SPILLOVER CORRECTION

Filed Sept. 25, 1961 2 Sheets-Sheet 1

FIG. 1.

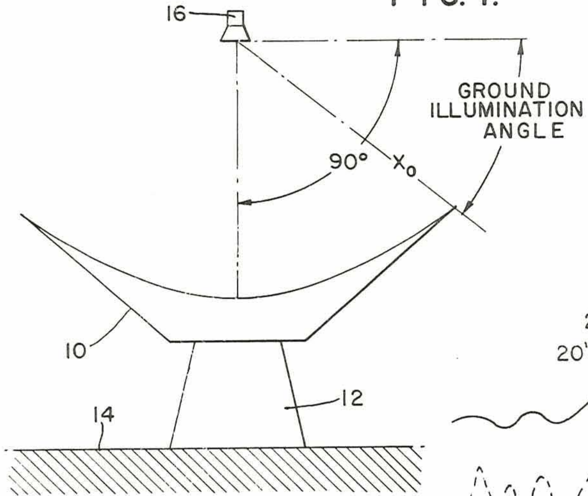
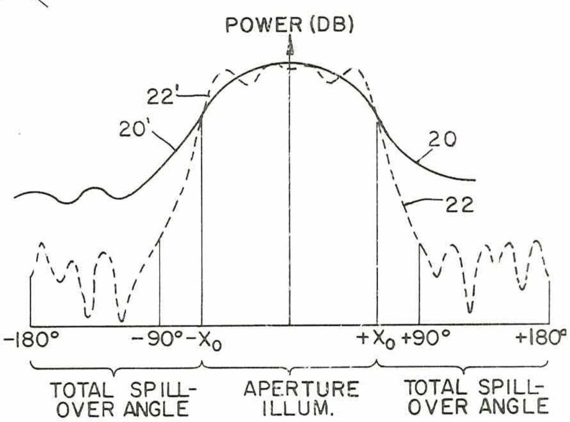


FIG. 2B.



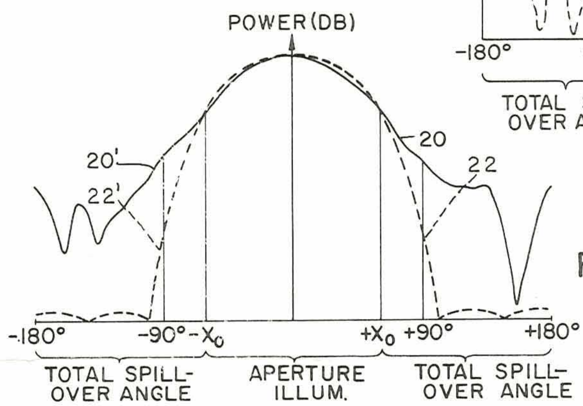


FIG. 2A.

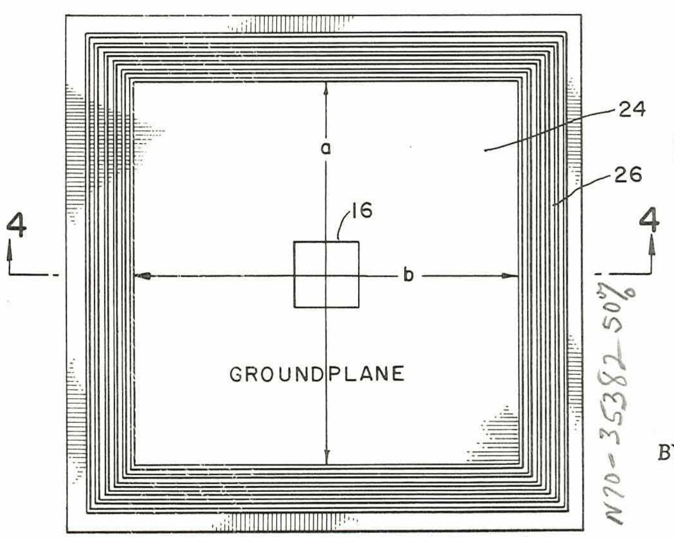


FIG. 3.

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PARABOLIC REFLECTOR HORN FEED WITH SPILLOVER CORRECTION

Filed Sept. 25, 1961 2 Sheets-Sheet 2

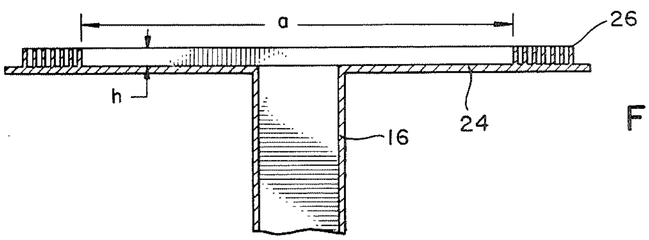


FIG. 4.

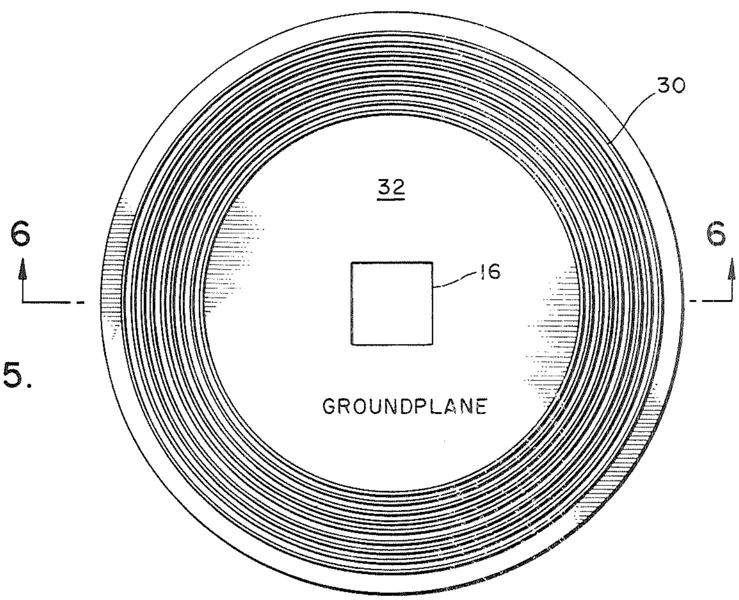
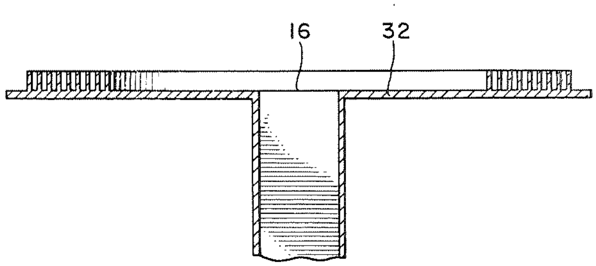


FIG. 5.

FIG. 6.



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PARABOLIC REFLECTOR HORN FEED WITH SPILLOVER CORRECTION

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4 Claims. (Cl. 343—781)

This invention relates to antennas of the type having a reflector dish and, more particularly, to improvements therein.

A typical paraboloidal antenna has a wave-guide horn positioned at the focus for exciting the antenna and also for receiving any signals reflected therefrom. It is known that a considerable amount of power is wasted in the region outside of the paraboloidal-dish-illumination angle. This may be called spillover power. A significant amount of power (at least eight to ten percent of the total) falls within the region known as the ground-illumination angle. The ground-illumination angle is the region included between a plane passing through the mouth of the horn perpendicular to the antenna axis and a line which connects the center of the horn mouth to the edge of the paraboloidal dish. Since ground-temperature radiation is usually the largest contributor to the antenna temperature of a receiving antenna, it is important to reduce the amount of spillover power in the ground-illumination region.

An object of this invention is the provision of structure for reducing the percentage of power received by a wave-guide horn from the ground-illumination region.

Another object of this invention is the provision of a simple and improved structure whereby the efficiency of a paraboloidal-type antenna is increased either for receiving or transmitting.

These and other objects of the invention may be achieved in an arrangement whereby means are provided including a ground plane positioned around the mouth of the wave-guide horn for preventing the H-plane component of the undesired power from being radiated into the ground-illumination region. The ground plane also includes a radio-frequency choke structure for attenuating the E-plane component of the undesired radiation, and for shaping the desired E-plane radiation for better efficiency.

In an application for patent by Danver M. Schuster for Antenna Beam-Shaping Apparatus, filed September 25, 1961, Serial No. 140,443, (Docket 107/2) which is assigned to a common assignee, there is shown and described a beam-shaping arrangement suitable for use with linear-polarized waves. The inventions described herein are suitable for use with linearly or circularly polarized waves.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which:

FIGURE 1 shows, for the purpose of illustration, an

antenna of the general type with which this invention is employed;

FIGURE 2A is a graph showing, for comparative purposes, the H-plane energy distribution for the antenna of the type shown in FIGURE 1, without this invention and with this invention;

FIGURE 2B is a graph showing, for comparative purposes, the E-plane energy distribution for the antenna of the type shown in FIGURE 1, without this invention and with this invention;

FIGURE 3 is a plan view of an embodiment of the invention;

FIGURE 4 is a sectional view of an embodiment of the invention;

FIGURE 5 is a plan view of another embodiment of the invention; and

FIGURE 6 is a cross-sectional view of the embodiment of the invention shown in FIGURE 6.

Reference is now made to FIGURE 1, which is a schematic view of the general type of antenna for which this embodiment of the invention is intended. Such an antenna usually comprises a parabolic-dish reflector **10**, supported on a base **12**, which is positioned on the ground **14**. A feed horn **16** is positioned approximately at the focus of the parabolic antenna. For the purposes of subsequent discussion herein, consider a line which is on the axis between the center of the parabolic dish **10** and the feed horn **16** as an axis or reference line; and the angle made between a plane perpendicular to the axis through the mouth of the feed horn and the reference line is 90°, and the angle made between the reference line and the tip of the antenna dish is an angle X_0. The angle between X_0 and 90° is known as the ground-illumination angle. The angle between X_0 and 180° is the region in which spillover of the horn power occurs. A significant amount of received power comes from the ground-illumination angle over which the ground radiates thermal noise power into the horn, to cause noise signals which interfere with the desired signals reflected from the antenna dish.

Considering FIGURE 2A, there is shown a plot of the distribution of the H-plane power radiated or received by the type of antenna shown in FIGURE 1 versus the angle made with the reference plate. The power-distribution curve **20** indicates a maximum power on the axis, or the zero-degree line, and then tapers off on either side of this line. The actual useful power is the power included between $+X_0$ and $-X_0$, which is known as the aperture illumination. The regions between $+X_0$ and $+90°$ and $-X_0$ and $-90°$ indicate the ground-illumination power. The power shown between $+X_0$ and $+180°$ and $-X_0$ and $-180°$ is the total spillover power. By employing structure as shown by this invention, the amount of the total spillover power is reduced substantially to the extent shown by the dotted lines **22, 22'**. Effectively, the power radiated in the total spillover angle, and to a large extent within the ground-illumination angle, is attenuated considerably. This, of course, results in the thermal noise power being reduced considerably, whereby the antenna temperature is reduced. The antenna efficiency is improved because the power formerly wasted in spillover is now utilized in aperture illumination.

FIGURE 2B shows a plot of the distribution of the E-plane power radiated or received by the antenna of FIGURE 1. The same remarks made above in connection with FIGURE 2A apply to FIGURE 2B, the E-plane power distribution curve.

FIGURE 3 is a plan view of an embodiment of this invention, and FIGURE 4 is a view in section along the lines 4—4 of FIGURE 3. The mouth of the horn **16** is at the center of a metallic ground plane **24**. This ground plane is mounted at the horn mouth. The use of a large, flat conductive ground plane around the mouth of the horn eliminates unwanted side and back radiation for the H-plane pattern, but not for the E-plane pattern.

The E-plane field directed toward the sides may be blocked by placing a choke surface-wave structure on the ground plane. This surface-wave structure **26** constitutes, as shown in FIGURE 4, a plurality of concentric, conductive-metal rectangles, which are spaced from one another and are disposed around the mouth of the horn and in contact with the ground plane. The dimensions of this surface-wave structure must be chosen so that it is near cutoff for the frequency of operation. A simple method is to make the height of each one of the rectangles, or chokes, above the ground plane approximately equal to one-quarter wavelength. The width of the choke and the spacing between the chokes is made much less than one wavelength. In an embodiment of the invention which was built, this dimension was on the order of 0.1 wavelength. The wavelength referred to, of course, is the wavelength at which the antenna is operating. This surface-wave structure may be thought of as blocking the propagation of a plane wave close by it, or as blocking the propagation of surface currents associated with the plane wave, thereby accomplishing the same thing.

To obtain the best shape for the E-plane pattern, the inside dimensions, a, b, and h, of the surface wave structure are critical. For a circular paraboloidal reflector, a and b should be equal. By chosing the best value for these dimensions, the slope at the side of the pattern is increased, side radiation is reduced, and, in addition, a ripple appears on the top of the pattern which tends to distribute some energy away from the center of the pattern and increase the gain of the antenna. The inside dimensions a and b are somewhat dependent on the shape of the parabolic reflector as affecting the edge-illumination angle X_0. For large antennas with an angle X_0 of about 61° it has been found that best results are obtained when the inside dimensions a and b of the innermost or first rectangle are equal and on the order of 3.85 ± 0.2 times the antenna wavelength. The number of chokes should be at least two. The more employed, the better the operation obtained. In an embodiment of the invention which was built, ten chokes were used and found to be quite satisfactory.

The ripple which is induced is believed to be caused by out-of-phase reflected fields. These are due to reflection of the diffracted fields from the area of the ground plane inside of the surface-wave structure. This explains the critical spacing of this structure. The amplitude, phasing, and direction of the reflected fields are determined by this dimension, as will be the total pattern due to direct and reflected fields.

Since the amplitude ripple on the E-plane pattern is caused by out-of-phase fields, it is worth noting that phase measurements show that the peak phase deviation across the E-plane is less than + or −5 electrical degrees. This is acceptable and its contribution to gain loss is insignificant.

This type of feed may be constructed with a rectangular layout of surface-wave chokes, as shown in FIGURE 5, or, to achieve best symmetry, a circular layout of radio-frequency chokes **30** on a ground plane **32** may be used, as shown in FIGURE 5. FIGURE 6 is a cross-section of FIGURE 5, along the lines 6—6 in FIGURE 5. With this type of layout of the surface-wave structure, the radiating horn can be either round or square. A square, circularly polarized horn was used for convenience. However, this shaped beam system works equally well with either circular or linear polarization. The comments made regarding the dimensions of the chokes in connection with the rectangular layout apply here, as well. The inside diameter of the innermost choke ring, to give optimum performance, should be from 4.05 to 4.15 times the wavelength. The other dimensions of choke height and spacing and comments given previously apply equally.

There has accordingly been described above a novel and useful arrangement for effectively attenuating that mouth of said horn said surface wave structure having which causes deleterious effects, whereby the operation of the antenna is improved to a considerable extent.

We claim:

1. The improvement for an antenna of the type having a reflector dish and a wave-guidehorn for radiating energy at said reflector dish and for receiving energy therefrom comprising a ground plane adapted to be mounted about the mouth of said wave-guide horn and to extend in a plane intersecting said horn mouth, and a surface-wave structure on said ground plane spaced from the mouth of said horn and extending all around the mouth of said horn, said surface wave structure having a plurality of spaced rectangular-shaped ridges concentrically disposed about the mouth of said wave-guide horn and in the shape of a rectangle.

2. The improvement for an antenna of the type having a reflector dish and a wave-guide horn for radiating energy at said reflector dish and for receiving energy therefrom comprising a ground plane adapted to be mounted about the mouth of said wave-guide horn and to extend in a plane intersecting said horn mouth, a plurality of concentric rectangularly shaped surface-wave structures mounted on said ground plane, said structures being disposed concentrically relative to the mouth of said horn, the inside dimensions of said innermost surface wave structure being on the order of 3.85 ± 0.2 times the wavelength of said energy for an antenna with edge angle of about 61°, the height of said surface-wave structure above said ground plane being on the order of one-quarter times the wavelength of said energy, the spacing between said surface-wave structures being much less than a wavelength of said energy and the thickness of each of said surface-wave structures being much less than a wavelength.

3. The improvement for an antenna of the type having a reflector dish and a wave-guide horn for radiating energy at said reflector dish and for receiving energy therefrom comprising a ground plane adapted to be mounted about the mouth of said wave-guide horn and to extend in a plane intersecting said horn mouth, a plurality of circularly shaped surface-wave structures mounted on said ground plane, said structures being disposed concentrically relative to the mouth of said horn, the inside dimensions of said innermost surface-wave structure being on the order of 4.05 to 4.15 times the wavelength of said energy, the height of said surface-wave structure above said ground plane being on the order of one-quarter times the wavelength of said energy, the spacing between said surface-wavestructures being much less than a wave-length of said energy and the thickness of each said surface-wave structures being much less than a wavelength.

4. The improvement for an antenna of the type having a reflector dish and a wave-guide horn for radiating energy at said reflector dish and for receiving energy therefrom comprising a ground plane adapted to be mounted about the mouth of said wave-guide horn and to extend in a plane intersecting said horn mouth, and a surface wave structure on said ground plane spaced from the mouth of said horn and extending all around the mouth of said horn, said surface wave structure in-

cluding a plurality of spaced ridges concentrically disposed about the mouth of said wave-guide horn and in the shape of a circle.

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