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DIFFRACTION SHIELD CONSISTING OF NOTCHED RING
WHICH FRAMES PASSIVE REFLECTOR
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Fig. 1.

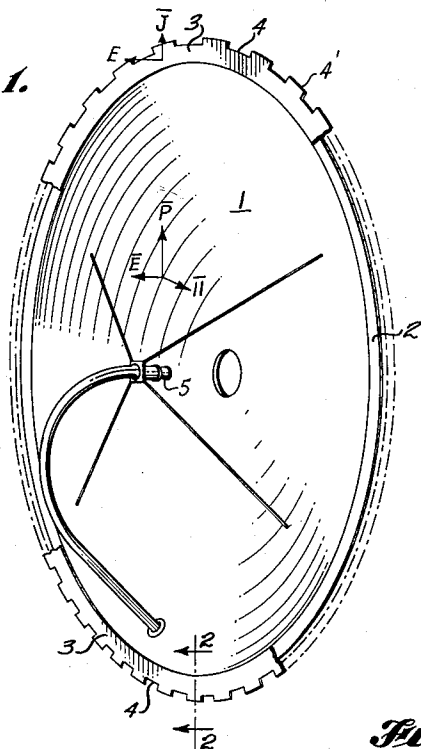


Fig. 2.

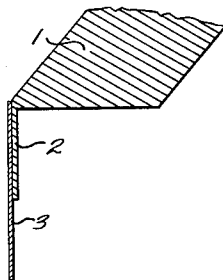
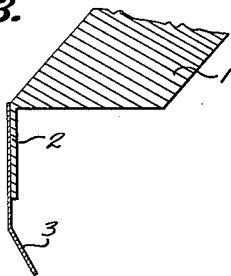


Fig. 3.



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DIFFRACTION SHIELD CONSISTING OF NOTCHED RING WHICH FRAMES PASSIVE REFLECTOR

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This invention relates generally to electromagnetic wave transmission and reception, and more particularly to the control of edge diffraction in microwave antennas of the paraboloid type.

In certain applications of microwave antennas it is often necessary to minimize the amount of energy radiated in some directions as well as maximize the amount of energy radiated in other directions.

In other applications, such as radio-astronomy and microwave relay links, it is very important that the radiation from the back side of a paraboloid antenna be as low as possible. In the field of radio astronomy the main beam of the paraboloid scans the sky to record and map areas of RF radiation. The back side of the antenna also picks up some radiation from the warm earth. This unwanted radiation acts as noise to the desired signal from the sky, the amount being often expressed as noise temperature. For microwave relay links application, unwanted back radiation results in signal distortion.

The back radiation pattern of a paraboloid antenna is caused by currents induced at the outer edge of the paraboloid principally by its primary feed. Most attempts to solve the problem have been based primarily on the reduction of the edge currents by shaping the pattern of the primary radiator, by shielding the edge of the paraboloid by placing it in a tunnel, or by the use of a paraboloid with a very small f/D ratio. The more recent efforts in this field, such as disclosed in U.S. Patents 2,808,586 and 2,942,265, have been to provide means so that the energy radiated directly from the primary feed arrives at the edge substantially out of phase with the energy reflected from the reflector.

The instant invention operates on the principle of cancellation by phase control and basically consists of a ring of sheet metal positioned on the periphery of the paraboloid antenna.

Therefore, an object of the invention is to provide means for controlling the diffraction of microwaves.

A further object of the invention is to provide means for controlling the direction of propagation of diffracted electromagnetic waves.

Another object of the invention is to provide means for substantially reducing the undesirable effects of edge diffraction in antenna systems operating over a broad band of frequencies.

Another object of the invention is to provide means for substantially reducing unwanted back radiation in paraboloid antennas.

Other objects of the invention not specifically set forth above will become readily apparent from the accompanying description and drawings in which:

FIG. 1 is a perspective view of the front side of a typical paraboloid antenna with one embodiment of the invention in place;

FIG. 2 is a cross-sectional view taken on the line 2-2 of FIG. 1; and

FIG. 3 is a cross-sectional view similar to FIG. 2 but showing another embodiment of the invention.

A typical paraboloid antenna 1 composed of conductive material and having a peripheral flange portion 2 is provided with a diffraction shield 3. Antenna 1 is provided with a primary feed 5. Shield 3 consists of a ring

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of sheet metal having notches 4 and 4' extending around segments thereof, said notches being spaced at approximately one wave-length intervals and having a depth of approximately $\frac{1}{2}$ wavelength, the wavelengths being relative to the transmission frequency. The notched shield causes the electric field at the edge of the parabola to be broken into two components which appear to be 180° out of phase when viewed from the rear of the antenna. The result is a broad null in the back radiation pattern.

The theory of the diffraction shield may be better understood by considering the view of a paraboloid antenna as shown in FIGURE 1. Energy is radiated by the primary feed 5 toward the antenna shield 3. The electromagnetic field representation is shown in vector form where $\vec{P}$ is the poynting vector and represents the power density of the field. The electric vector $\vec{E}$ is shown normal to the plane of the shield 3. In accordance with Maxwell's equations, both the electric vector $\vec{E}$ and the magnetic vector $\vec{H}$ are normal to the flow of energy and are related to the poynting vector $\vec{P}$ by the vector relationship $\vec{P} = \vec{E} \times \vec{H}$. When the electromagnetic field reaches the shield 3, it must meet the boundary conditions as dictated by Maxwell's equation. The significant boundary condition is in this case is defined by the vector relationship $\vec{J} = \vec{N} \times \vec{H}$, where $\vec{J}$ is the current density induced in the shield 3 in the direction shown in FIGURE 1, and $\vec{N}$ is the outward normal to shield 3. It is significant to note that the induced current in the shield flows across the shield 3.

The outer edge of the shield creates a second boundary condition since the current flow must be interrupted. This condition causes the energy entrapped on the shield to be reradiated. The radiation pattern tends to be cardioid and hence a substantial amount is reradiated to the rear of the paraboloid. The notches 4 provide a means of providing an out-of-phase segment. By cutting the notches $\lambda/2$ deep, the energy generally reradiated to the rear of the antenna as a result of the current discontinuity at the notch is 180° out of phase from that reradiated from the outer edge or tooth 4'. In order to radiate the notches must be at least $\lambda/2$ wide. On the other hand, the notches should not be too wide or too far apart. Considering the notches as an array, the width and spacing should not be substantially greater than λ to effect good pattern control. A value of λ was chosen for test and was found to be adequate.

The following is a description of the operation of the FIG. 1 device:

Consider the rim of the paraboloid of FIG. 1 marked as a compass rose. The linearly polarized primary feed 5 emits an electromagnetic wave in the direction of the flange portion 2 polarized substantially perpendicular to the aperture plane in the 0° (north) and 180° (south) directions and parallel to the aperture plane in the 90° (east) and 270° (west) directions. The plane of polarization rotates uniformly from perpendicular to parallel polarization for directions from 0° (north) to 90° (east) and 180° (south) to 270° (west); but rotates from parallel to perpendicular polarization for directions from 90° (east) to 180° (south) and 270° (west) to 0° (north).

Diffraction is associated with only the perpendicularly polarized component of the electromagnetic wave. For this polarization, a radial component of current is induced in the diffraction shield 3. The discontinuity of this current at the edge of the shield produces a re-radiated electromagnetic wave. The current induced in the notch 4 is 180° out of phase with the current induced in tooth 4' due to the one-half wavelength difference in distance from the primary feed 5. As seen from the rear of the paraboloid, the notches and the teeth appear as

two segmented line sources spaced one-half wavelength apart and 180° out of phase. The resulting far-field radiation pattern has a null directly to the rear of the paraboloid. Hence back radiation is virtually eliminated.

For a linearly polarized primary feed polarized in the north and south direction, substantial diffraction shielding is provided by only a segment of the shield located at the north and south edges of the paraboloid. Some additional shielding is provided by extending the shield completely around the paraboloid. This also provides shielding for dual polarized primary feeds.

FIG. 3 shows another effective type of diffraction shield which consists of a ring of sheet metal attached to the flange portion 2 of the paraboloid as in FIGS. 1 and 2. However, in this embodiment the outer one-half wavelength is bent back at approximately 30° and is not provided with notches as the FIGS. 1 and 2 embodiments. The embodiment of FIG. 3 provides a partial current discontinuity to the radial current at the point of bend. This causes the shield to re-radiate at this point. The reradiated energy cannot radiate to the rear of the paraboloid because the outer portion of the shield acts as a barrier. Some current is still present at the shield edge and is radiated as before. This radiation is substantially reduced because of the radiation at the bend.

Based upon the above explained theory, and the well known principle that radiation will occur at points of current discontinuity, which discontinuity may take on the form of slots, probes, or abrupt changes in directions such as a bend, it was determined that the total diffraction pattern is a composite of the bend, the length of the bent portion, as well as residual current at the edge of the reflector. As the result of such a determination, satisfactory performance was obtained experimentally with 30 degrees. However, the exact value of 30 degrees is not critical to the operation of the FIG. 3 shield.

The embodiments of FIGS. 2 and 3 can also be combined to provide an effective diffraction shield.

It has thus been shown that the invention provides a simple and effective means for reducing the radiation from the back side of a paraboloid antenna.

Although particular embodiments of the invention have been illustrated and described, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from the invention, and it is intended to cover in the appended claims all such changes and modifications that come within the true spirit and scope of the invention.

What we claim is:

1. A microwave system having means for controlling edge diffraction comprising: reflector means, ring means extending around at least a portion of said reflector means, said ring means being provided with a plurality of notches.

2. The device defined in claim 1 wherein said notches are spaced at approximately one wave length intervals and have a radial depth of approximately one-half wave length.

3. A microwave system having means for controlling edge diffraction comprising: reflector means having a reflecting surface, ring means extending around at least a portion of said reflector means, said ring means having an outer edge disposed in a direction backwards with respect to the outer periphery of said reflecting surface.

4. The device defined in claim 3 wherein the said outer edge is approximately one-half wave length in radial depth and is disposed backwards at approximately 30° from the plane of the ring means.

5. A device for controlling edge diffraction of a reflecting means comprising: means adapted to be positioned about the edge of at least a portion of a reflecting means, said means including a portion thereof defining two segmented line sources spaced one-half wave length apart and 180° out of phase.

6. The device defined in claim 5 wherein said portion of said means comprises material having a plurality of notches which have a radial depth of approximately one-half wave length, said notches being spaced at approximately one wave length intervals.

7. The device defined in claim 5 wherein said portion of said means comprises material having an outer portion disposed in a direction of approximately 30° from the plane of said material, said portion having a radial depth of approximately one-half wave length.

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