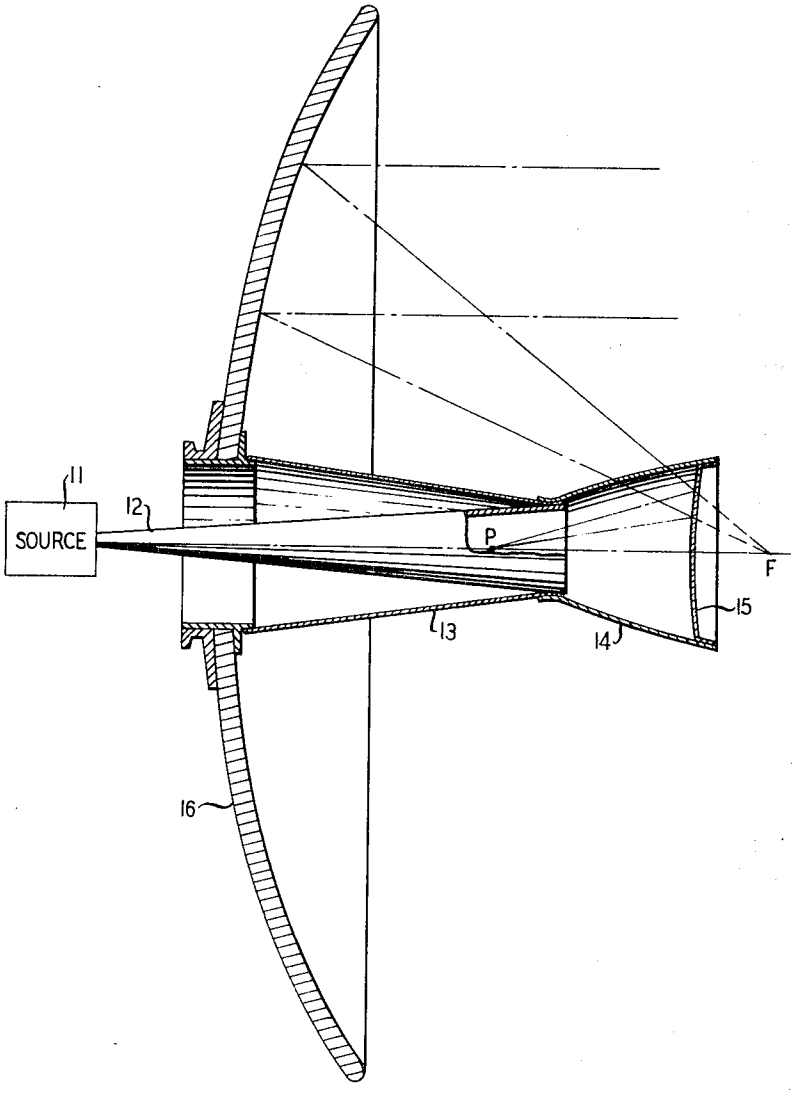
Sept. 22, 1970 L. RONGVED ET AL 3,530,480

CASSEGRAIN ANTENNA HAVING DIELECTRIC SUPPORTING STRUCTURE FOR SUBREFLECTOR

Filed July 3, 1967 2 Sheets-Sheet 1

FIG. 1



INVENTORS L. RONGVED
H. ZUCKER
BY G. E. Hirsch Jr.
ATTORNEY

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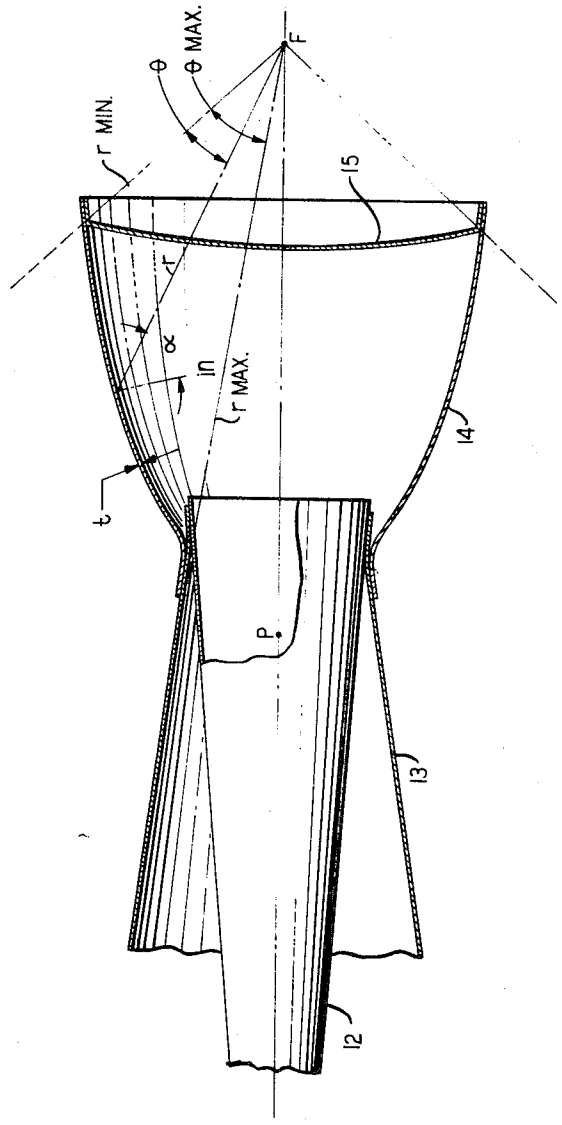


FIG. 2

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CASSEGRAIN ANTENNA HAVING DIELECTRIC SUPPORTING STRUCTURE FOR SUBREFLECTOR

Lief Rongved, Summit, and Henry Zucker, Morristown, N.J., assignors to Bell Telephone Laboratories, Incorporated, Murray Hill, N.J., a corporation of New York

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ABSTRACT OF THE DISCLOSURE

A Cassegrain antenna is characteristically recognized by the presence of a primary and secondary reflector disposed along a common axis. In such an antenna some structural means must be utilized for supporting the secondary reflector in a predetermined position in space relative to the primary reflector. Although metallic structures, such as struts, have been used for this purpose, they suffer from a number of deficiencies. These deficiencies are overcome by the use of a dielectric support member having a predetermined geometrical configuration.

BACKGROUND OF THE INVENTION

Field of the invention

This invention pertains to antennas and, more particularly, to antennas having a Cassegrain configuration.

The Cassegrain antenna has proven to be an excellent and reliable instrumentality for use in the reception and transmission of communication signals. Constructed in accordance with the principles of the Cassegrain optical telescope, the antenna is characteristically recognized by the presence of a primary (main) and secondary (sub) reflector disposed along a common axis. A source of signals, located within the shadow region of the subreflector, radiates energy in the direction of the subreflector. The secondary reflector, i.e., subreflector positioned in the path of the radiating energy, serves to redirect the incident waves in the direction of the primary reflector, there to be redirected into space. Such a structure has been found to be particularly useful as a ground transmitter, or receiver antenna, in a space vehicle-ground communication link.

Description of the prior art

It is readily apparent that in an antenna of the Cassegrain type some structural means must be provided for supporting the subreflector, in a predetermined position in space relative to the main reflector. Although metallic subreflector support structures, such as struts, have been used for this purpose, they suffer from a number of deficiencies. Since the supporting structures are within the antenna radiation pattern, radio frequency energy is reflected, scattered and absorbed; the absorption is due to the finite conductivity of the support members. This results in a reduction of the effective gain of the antenna and in phase distortion of the illuminating energy. For low noise, receiving antennas, conventional supports have even more severe drawbacks. Thus, since a certain amount of power is absorbed by the subreflector and some of the scattered power reaches the ground, due to reciprocity, thermal noise radiation from the subreflector support and the ground is received by the antenna. The antenna noise temperature is therefore increased.

Attempts to remedy these deficiencies have been many and varied; for example, materials having relatively low energy absorption and reflection qualities have been utilized. Although these remedies have been partially

satisfactory, noise and reflection problems are still of significant importance in particular applications. This is especially true in antennas of the larger type, designed for the reception of extremely weak signals.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to improve the performance of communication antennas. Another object is to reduce the noise and reflection problems introduced by the secondary reflector supports of a Cassegrain antenna.

In accordance with the principles of this invention, these and other objects are accomplished by utilizing an antenna subreflector support comprising a dielectric material having a predetermined configuration. More particularly, a Cassegrain antenna, by the practice of this invention, comprises a main reflector, a subreflector, a truncated conical member disposed along the axis of the main reflector and a dielectric member having the configuration of a segment of a logarithmic spiral of revolution, affixed to the truncated conical member, for supporting the subreflector. The use of a dielectric member of this predetermined configuration substantially reduces antenna aperture blocking and presents a constant coefficient of reflection for incident electromagnetic waves of a particular polarization.

These and further features and objects of this invention, its nature and various advantages, may be more fully understood by reference to the following description and the appended drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a sectional view of a Cassegrain antenna constructed in accordance with the principles of this invention; and

FIG. 2 depicts the geometrical properties of the subreflector support of the instant invention.

DETAILED DESCRIPTION OF THE INVENTION

The configuration of a Cassegrain antenna, constructed in accordance with the principles of this invention, is shown in FIG. 1. A source **11**, of microwave energy, excites, in conical feed horn member **12**, a traveling electromagnetic wave. Horn **12** radiates an electrical signal having an approximately spherical wavefront, which may be considered to originate from the point designated as P on the axis of horn **12**. It is noted that the same axis is common to truncated conical member **13**, reflector support means **14**, hyperbolic subreflector **15** and parabolic main reflector **16**. Of course, as well known to those skilled in the art, the subreflector and main reflector may have different geometrical configurations than those illustrated. Subreflector **15** is so disposed such that one of its focal points coincides with the point P.

In accordance with the principles of geometrical optics, subreflector **15** reflects an incident spherical wavefront as a wave effectively emanating from a second point, designated as F, which corresponds to the other focal point of hyperbolic subreflector **15**. Point F also coincides with the focal point of the parabolic main reflector **16**. Primary reflector **16** redirects the reflected spherical wavefront and converts it into a substantially plane wave.

As mentioned above, conventional subreflector support structures give rise to antenna aperture blocking and also introduce phase distortion accompanied by related undesirable characteristics.

A subreflector support member **14**, which substantially alleviates these difficulties is shown in more detail in FIG. 2. Truncated conical member **13**, which advantageously may be constructed of lightweight aluminum, provides a stable structure to which is affixed subreflector support member **14**. A radio frequency transparent dielec-

tric material, for example, fibrous glass, or any other similar material, may be used for member **14**. Furthermore, in order to reduce the weight of subreflector **15** it also may be constructed of fibrous glass, or the like, which has been aluminized in order to reflect microwave signals. Subreflector **15** and its support **14** are nondevelopable shells joined to a single structural unit, which supports only its own weight. Therefore the ability of this structure to withstand vibration and shock is not dependent upon the thickness of the shells. The thickness of the shells of members **14** and **15** is determined by the requisite strength desired for normal handling, for example, a thickness of approximately ten to fifteen thousandths of an inch has been found satisfactory in a particular application.

The advantageous electrical performance of the instant invention arise from the geometrical properties of support member **14**, as depicted in FIG. 2. The configuration of member **14** may be described as a segment of a logarithmic spiral surface of revolution of thickness t. The locus of the surface of member **14** is defined, mathematically, by the following equation:

$$r=r_{\min}\epsilon^{\theta \tan \alpha} \tag{1}$$

where

$$\tan \alpha=\frac{1}{\theta_{\max}} \ln \left(\frac{r_{\max}}{r_{\min}}\right)$$

and α is the angle between the unit normal, i_n, to the surface, depicted in FIG. 2, and the radius vector r originates at the focal point designated F. The respective limit values of θ and r are depicted in the drawing. A surface having a configuration defined by Equation 1 is characterized by the property that the angle α between the normal to the surface and the vector r is constant. The reflection coefficient of a plane wave, obliquely incident on a dielectric plane, is a function of the angle between the incident wave and the normal to the dielectric surface. Thus, the above surface, when large in comparison to the incident wavelength, such that it can be considered locally plane, has a constant reflection coefficient for a spherical wave originating from point F, for a particular polarization. Advantageously, the phase of the transmission coefficient for a spherical wave is also constant. In some applications, for example when the antenna feed is excited by the TM_{01} mode, the electric field is axially symmetrical, that is, entirely radial. In such a case the reflection coefficient is zero when the angle α is equal to the Brewster angle.

In the case where a spherical wave, propagating in the TE_{11} mode, may be considered to originate at point F, the electric field has components both in the plane and perpendicular to the plane of incidence. Accordingly, reflection coefficients for both polarizations must be considered. The thickness t of the dielectric support member **14** is limited by such a consideration. For example, for an angle α of 45 degrees, a dielectric shell thickness t of 0.012λ, where λ equals the free space wavelength, and a dielectric constant of 4, the calculated power reflection coefficients are 2.5 percent for perpendicular polarization and 0.25 percent for parallel polarization. The phase difference between the transmission coefficients for the two polarizations is less than five degrees.

Tests of the antenna of the instant invention, both for TE_{11} and TM_{01} mode excitations, indicate an excellent agreement between the computed and measured antenna characteristics. Accordingly, the subreflector support structure of this invention introduces a negligible amount of distortion.

It is to be understood that the embodiments shown and described are illustrative of the principles of this invention only, and that modifications of this invention may be implemented by those skilled in the art without departing from the scope and spirit of the invention. For example, the configuration of the subreflector support of the instant invention may find use in related communication

antennas not of the Cassegrain type. Furthermore, the manner of supporting the subreflector support is merely illustrative; sundry and diverse materials and techniques exist for constructing and uniting the antenna of this invention. For example, truncated conical member **13** may be comprised of a dielectric material.

What is claimed is:

1. A Cassegrain antenna including:
a main reflector and a subreflector, oppositely disposed along a common axis, for reflecting incident electromagnetic energy,
wherein said subreflector is affixed to said main reflector by a dielectric member,
a predetermined section of said dielectric member, positioned in the path of said reflected electro-magnetic energy, having a configuration such that the angle of incidence of said reflected electro-magnetic energy on the surface of said predetermined section is constant.

2. A Cassegrain antenna comprising:
a main reflector,
a subreflector,
first support means affixed to said main reflector and disposed along the axis thereof,
and dielectric support means affixed to said first support means and disposed along the axis of said main reflector in the path of electromagnetic energy propagating between said main reflector and said subreflector for supporting said subreflector,
said dielectric support means having the configuration of a segment of a logarithmic spiral surface of revolution such that the angle of incidence on the surface of said dielectric support means, of energy propagating between said mean reflector and said subreflector, is constant.

3. A Cassegrain antenna comprising:
a main reflector having a predetermined focal point,
a secondary reflector,
a truncated conical member symmetrically disposed along the axis of said main reflector and affixed to said main reflector,
and a dielectric member having the configuration of a segment of a logarithmic spiral surface of revolution symmetrically disposed about said axis and affixed to said conical member for supporting said secondary reflector,
said surface of revolution having the property that the angle between a normal to said surface and a line extending from said focal point through said secondary reflector and said surface to said main reflector is a constant.

4. A Cassegrain antenna comprising:
a main reflector,
a hallow truncated conical member affixed to said main reflector and symmetrically disposed along the axis of said main reflector,
a secondary reflector disposed in space along the axis of said main reflector,
means for radiating electromagnetic waves from the interior of said conical member in the direction of said secondary reflector,
and dielectric support means having the configuration of a segment of a logarithmic spiral surface of revolution affixed to said conical member for supporting said secondary reflector in said position in space,
said surface of revolution having the property that the angle between a normal to said surface and an incident electromagnetic wave reflected by said secondary reflector is constant.

5. A communication antenna comprising:
a parabolic reflector member symmetrically disposed about an axis and having a first focal point coinciding with said axis,
a hyperbolic reflector member having two focal points,

one of said focal points being coincident with said first focal point,

and dielectric means affixed to said parabolic reflector member for supporting said hyperbolic reflector member in space relative to said parabolic reflector member such that the second of said two focal points of said hyperbolic reflector is coincident with said parabolic reflector axis, the surface of said dielectric means having the property that the angle between a normal to said surface and a line extending from said first focal point to said surface is a constant.

6. The antenna as defined in claim **5** wherein said dielectric means comprises:

a member having the configuration of a segment of logarithmic spiral surface of revolution.

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343—784, 837, 840