April 8, 1969 A. G. HOLTUM, JR 3,438,041

PARABOLIC REFLECTOR WITH DUAL CROSS-POLARIZED FEEDS OF DIFFERENT FREQUENCIES

Filed Sept. 15, 1965 Sheet 1 of 2

FIG. 1

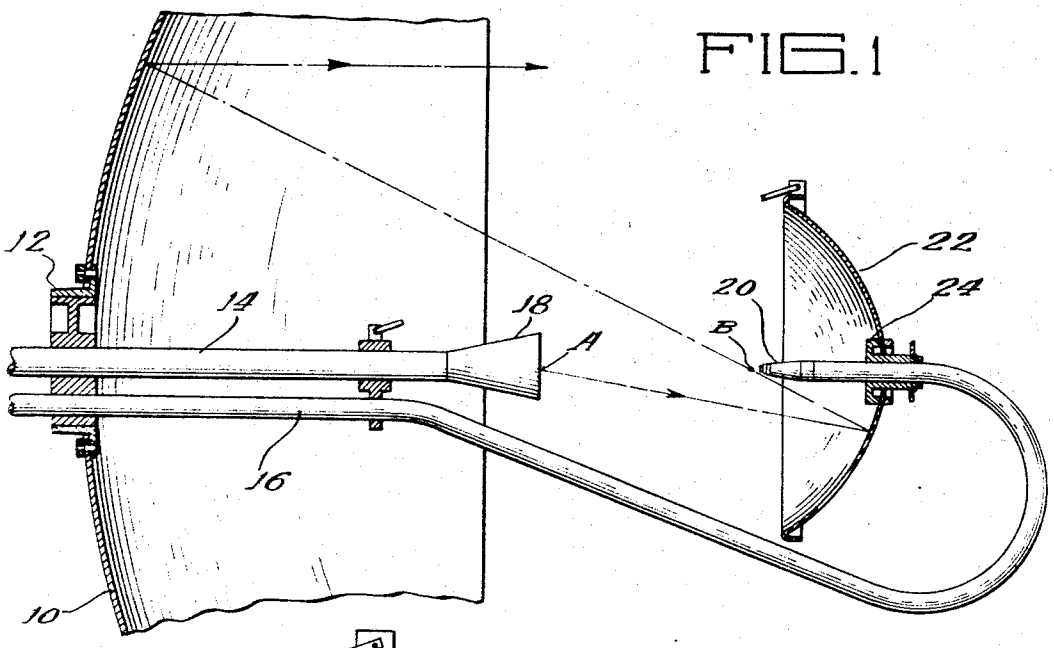
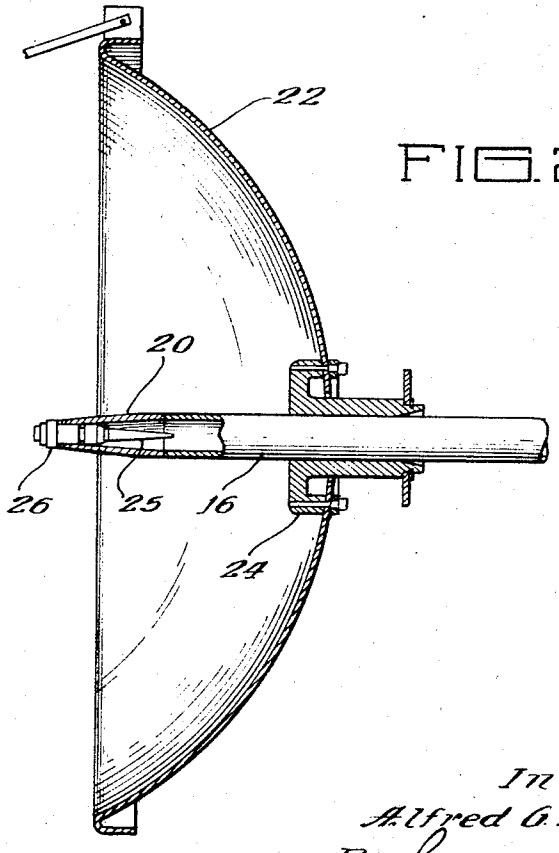


FIG. 2



Inventor:
Alfred G. Holtum, Jr.
By: Leonard S. Nierman
Attorney.

April 8, 1969 A. G. HOLTUM, JR 3,438,041

PARABOLIC REFLECTOR WITH DUAL CROSS-POLARIZED FEEDS OF DIFFERENT FREQUENCIES

Filed Sept. 15, 1965 Sheet 2 of 2

FIG. 3

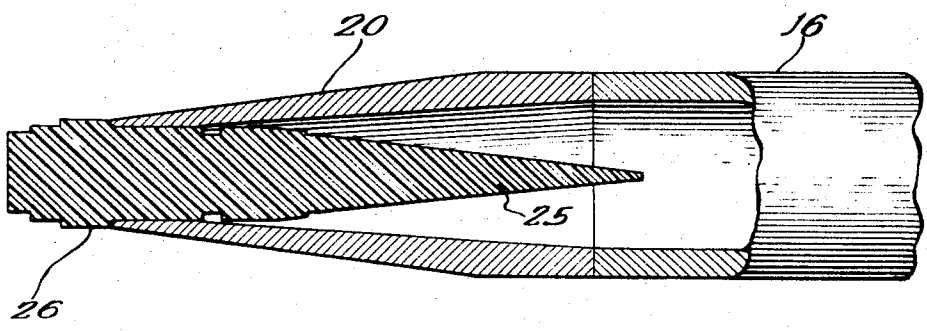
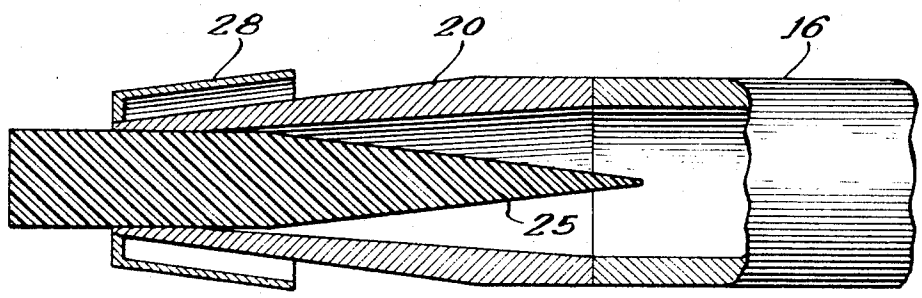


FIG. 4



Inventor:
Alfred G. Holtum, Jr.
By: Leonard D. Nierman
Attorney

United States Patent Office 3,438,041 Patented Apr. 8, 1969

3,438,041

PARABOLIC REFLECTOR WITH DUAL CROSS-POLARIZED FEEDS OF DIFFERENT FREQUENCIES

Alfred G. Holtum, Jr., Chicago, Ill., assignor to Andrew Corporation, Orland Park, Ill., a corporation of Illinois

Filed Sept. 15, 1965, Ser. No. 487,410
Int. Cl. H01g 19/14
U.S. Cl. 343—779 7 Claims

ABSTRACT OF THE DISCLOSURE

Dual cross-polarized feeds of different frequencies are employed with a single parabolic reflector. The feed of higher frequency is adjacent to the focus and illuminates the reflector directly. The feed of lower frequency is a Gregorian feed employing an ellipsoidal reflector having the same focus. A four-port antenna for operation at 6 gc. and 11 gc. is described.

This invention relates to an improved construction for reflector-type antenna, and more particularly to antennas of the type employing a parabolic reflector which may simultaneously be fed with a plurality of frequencies and polarizations, permitting utilization of a single reflector for transmission and reception in a number of channels distinguished by polarization and frequency. The term "parabolic reflector" as herein used will be understood normally to refer to the shape more accurately designated "paraboloidal," as is common practice.

The use of cross-polarized feeds with parabolic reflectors or "dishes" has long been known and is fairly common for the purpose of employing a single reflector for two communications channels. To increase the number of channels or separable signals employed with a single reflector, various systems have been devised to feed the reflector at more than one frequency. The difficulty encountered stems from the fact that the parabolic reflector must be fed from its focus point. This of course causes no difficulty in the use of simple cross-polarization, which is readily obtained at a single feed point by the employment of a simple waveguide feed form at the focus. Various structures have heretofore been devised to add a second feed effectively at this same point at a different frequency.

The approaches to the problem of introducing a second frequency at the focal or feed point of a parabolic reflector which have heretofore been taken in the attempt to produce a practical system have either been excessively complex and expensive or have involved severe restrictions on utility. The simplest type of addition to the conventional cross-polarized horn radiator employs a coaxial feed, i.e., an annular feed surrounding the conventional feed. Such antennas are now in commercial use, but known simple constructions therefor are capable of adding only one signal at the frequency of the outer feed, thus adding to the two "ports" or signal channels of a conventional system only one additional channel.

Another system which has heretofore been suggested is based on the Cassegrainian type of reflector "illumination" or excitation, employing a convex hyperboloidal reflector to reflect to the dish the signal from a forwardly-facing conventional feed, in a manner analogous to the optical system of the Cassegrainian telescope. Various workers in the field have utilized the fact that this system has a virtual focus within the auxiliary reflector and suggested the possibility of locating a second feed within the hyperboloid at this virtual focus, which is the actual focus of the parabolic dish, and fabricating the hyperboloid in

such a manner as to be transparent to the radiations from this internal feed, while continuing to act as a reflector for the feed which illuminates the dish by reflection. The difficulty with this proposal is that there is no known practical way in which the reflector structure can be made to approach transparency to the high-frequency feed and perfect reflection of the low-frequency feed without the use of frequency ratios far too high for most uses. Furthermore, even with high-frequency ratios, it is difficult to devise a reflector structure for the low frequency which is sufficiently transparent to both polarizations of the cross-polarized high-frequency feed to provide fully satisfactory operation, even putting aside questions of cost and complexity.

Various other constructions, such as single horns fed at multiple frequencies, have been tried for producing "four-port" operation, but none are known which give performance adequate for the desired purpose and are at the same time sufficiently economical to construct.

Accordingly, although substantial effort has heretofore been made by numerous workers in the field, there has existed, prior to the present invention, no construction suitable for widespread use permitting the employment of a single reflector with cross-polarized signals at two frequencies.

The present invention stems from study of the sources of difficulty of previous proposals for solution of the problem, and the devising of the manner in which these difficulties may be overcome. The present invention, like the Cassegrainian adaptation described above, employs an auxiliary reflector system, and cross-polarized feeds spaced along the axis of the dish, but in a manner producing a relation between the signal paths of the two frequencies which is in certain critical respects more analogous to their relation in the simple three-port coaxial feed. In the Cassegrainian adaptation, the signals of the two frequencies do not actually emanate from the same phase center in illuminating the main reflector, one actually emanating from the focus of the parabola and the other only "virtually" so emanating as a result of the auxiliary reflector. In the case of the coaxial feed, both signals radiate directly from the actual focus of the parabola. It is this formation of an actual or real phase center for both frequencies at the focus of the dish which eliminates the necessity for concern about "transparency." Thus an "optical" system outward of the focus of the parabola, producing at the focus of the parabola a real focus of an illuminating feed, may be combined with another feed having a real phase center there (either of the same description or an ordinary feed at the focus) to eliminate the polarization limitation on the outer feed of the coaxial arrangement while at the same time achieving the advantages of that system in eliminating the requirement of structures having frequency-dependent characteristics of transparency and reflection involved in the Cassegrainian approach.

The broader aspects of the invention as just described may be implemented in a number of ways. In its narrower aspects, however, the invention further provides an extremely simple and inexpensive manner of such implementation. It is found that the reflected feed system used in the Gregorian antenna (a known construction again named from its optical telescope counterpart), when combined with a horn feed at the parabolic focus, each illuminating the dish at a different frequency in conventional cross-polarized fashion, satisfies all requirements to a degree heretofore unknown.

The optimum utilization of the system just described requires the structure of the feed located at the parabolic focus as designed in such a manner as to minimize its effect on the signals from the other feed. As will here-

inafter be more fully described, the invention further provides a feed construction particularly adapted to effectuate this purpose.

For further and more detailed understanding of the invention, reference is made to the embodiment described below and illustrated in the attached drawing, in which:

FIGURE 1 is a central sectional view of an antenna made in accordance with the invention, with the feed elements shown in elevation, and with certain diagrammatic indications of radiation paths illustrated for purposes of explanation;

FIGURE 2 is a somewhat enlarged view in elevation of feed-system structure constituting a portion of FIGURE 1;

FIGURE 3 is a further enlarged view in longitudinal section of a portion of the feed structure of FIGURE 2; and

FIGURE 4 is a view similar to FIGURE 3 but showing a modified form.

Referring first to the general showing of FIGURE 1, the main or principle reflector dish **10** is of generally conventional parabolic construction, but its vertex plate or support **12** provides the mounting of two waveguides **14** and **16**. These are of conventional construction for the frequencies used. The guide **14** terminates in a feed horn **18**, facing outwardly as is conventional in such auxiliary-reflector feed systems. Preferably (the magnitude of the advantage varying with the frequency ratio), this feed assembly is employed for the lower frequency, for example 6 gc. The guide **16**, preferably for the higher frequency, for example 11 gc., is of a shape resembling the conventional "buttonhook," and its radiating end **20** faces back toward the dish **10** in the manner of conventional direct feeds.

The portion of the guide **16** adjacent to the radiating end **20** extends through an ellipsoidal reflector **22**, to which it is secured by a vertex plate **24** in a manner generally similar to the relation of reflector **10** and guide **14**, the two feeds facing each other along the common axis of the reflectors **10** and **22**.

It will be understood that the showing of FIGURE 1 is more or less schematic, omitting such details as the supports and guys, fasteners, etc., which are irrelevant for present purposes.

As is conventional in a Gregorian antenna (or optical system), the feed **18** is located at one of the two foci of the ellipsoidal reflector **22**, designated A, the other focus B of which is at the focus point of the parabola. The feed **20** is of course at this same point (except for a small displacement later to be discussed). The feed horn **18** is shaped to form a pattern illuminating the ellipsoidal reflector, which produces a focus of this pattern such that the phase centers of the signals of the two frequencies are essentially identical, as indicated diagrammatically by the direction arrows in FIGURE 1.

The above discussion has thus far neglected certain practical considerations which enter into achieving fully optimum performance. The finite dimensions of the high-frequency guide **20**, although having relatively slight effect in other regions as in conventional single-feed structures, become a major consideration as regards effect on the low-frequency pattern in the region of the common focus point of the two reflectors. Further the mutually facing orientation of the two feeds is such as to produce direct reflection effects on the impedance and other characteristics of the low-frequency feed which are desirably minimized where, as in the present example, the transverse dimensions of the high-frequency feed cannot be negligible compared to the low-frequency wavelength.

As shown in FIGURES 2 and 3, the feed **20** is designed to minimize the effects of its presence upon the low-frequency signal. Its outer end is inwardly tapered and a more or less conical plug **25** of dielectric is inserted, with the butt or base portion **26** extending therefrom. The taper of course reduces the size in the most critical region. The plug **25** serves to maintain the proper impedance match for efficient radiation despite the tapering of the tubular conductor. Additionally, and perhaps more importantly, the combination of the tapering and the dielectric plug produces a radiation pattern having its phase center substantially beyond the tip of the tubular conductor, thus removing the conducting portion of this feed outward of the region where the maximum problem of interference with the low-frequency signal exists.

The useful area of the auxiliary reflector **22** is the region which is not blocked from the focus point B by the conducting body of the feed, and the taper accordingly adds substantially to the efficiency, both because of the diminishing of the solid angle subtended by the feed at any given distance from the focus and because of the outward withdrawal from the phase center of the pattern produced by the tapered feed. In the central region of the auxiliary reflector, where reflected energy could not be utilized in any event, the reflector is made non-ellipsoidal by the flat plane vertex plate **24**, to avoid the focusing of reflections from this region on the conducting guide, with resulting unfocused dispersion injuring the antenna's radiation pattern. The vertex plate front surface is spaced inwardly from the surrounding reflector surface by an amount producing minimum impedance changes and similar effects on the feed **18** due to the direct reflection. The diameter of the vertex plate more or less corresponds to the base of the conical "unusable volume" defined by the solid angle of the focus subtended by the end of the feed. However, because of diffraction by the edge of the vertex plate and also diffraction by the protruding region **26** of the plug **25**, this relation is not necessarily exact for optimum efficiency and pattern shape, and simple experimentation of the type conventional in empirical optimization of other high-frequency antennas for particular frequencies, bandwidths, etc., is desirable on the design parameters for particular uses.

FIGURE 4 shows a variant of the feed of FIGURE 3 employing a choke structure to absorb the lower-frequency energy striking the high-frequency feed. The end of the latter is here surrounded by a choke **28** of a quarter-wavelength at the lower frequency, suppressing reflections. Such a choke is of particular value in applications where pattern shape must be held to close tolerances, although efficiency is slightly reduced by the inherent enlargement of the portion of the auxiliary reflector masked from the focus. Generally similar considerations are applicable to the use of absorber materials, which involve much greater effective dimensional increase for comparable suppression of reflections. The region of the guide **16** outward of the conical feed region is of course less critical as regards efficiency, so that absorber material may be used on this region without substantial impairment of efficiency.

As will be obvious, although the invention was made in seeking a desirable construction for a dual frequency dual polarized dish-type antenna, the teachings of the invention are not necessarily limited to such uses. As one obvious example, the invention may be used for other purposes wherein it is desirable to illuminate a parabolic reflector from two physically separated feeds each producing radiation of at least partially orthogonal polarization directions, as in dual-frequency circular polarization. As a further obvious example, the basic principle may be applied in feeding other focusing reflectors, such as reflectors which are not of circular symmetry. Other examples of variants utilizing the teachings of the invention will become apparent to those skilled in the art upon study.

What is claimed is:

1. A dual-frequency cross-polarized antenna having:

(a) a parabolic main reflector,

(b) a relatively small auxiliary ellipsoidal reflector facing the main reflector on the axis thereof and having one focus substantially coinciding with the focus of the main reflector,

(c) a cross-polarized lower-frequency feed at the other focus of the auxiliary reflector directed toward the auxiliary reflector for cross-polarized illumination thereof,

(d) and a waveguide feed extending inward from the auxiliary reflector and having a tapered inner end adjacent to the substantially coinciding focus, at least the inner portion thereof having means to suppress reflection.

2. The antenna of claim **1** having the central portion of the auxiliary reflector non-focusing to minimize the reflection of radiations to the focus along paths intercepted by the end of the waveguide.

3. The antenna of claim **2** having a flat surface at said central portion of the auxiliary reflector at an axial location minimizing the effects of reflections back to the feed illuminating the auxiliary reflector.

4. The antenna of claim **2** having the solid angle of the coinciding focus subtended by the non-focusing central portion approximately coextensive with the solid angle subtended by the inner end of the waveguide.

5. A plural-feed reflector antenna having:

(a) a main reflector having a focus and adapted to reflect radiations emanating from the focus and impinging on the reflector to form a desired directional pattern,

(b) auxiliary smaller reflector means substantially wholly outside the region between the main reflector and its focus and having a focus substantially coinciding with the main reflector focus.

(c) means inward of the focus for illuminating the auxiliary reflector means with radiations of one frequency to illuminate the main reflector at that frequency through the substantially common focus,

(d) and means in the region of the common focus for illuminating the main reflector at a second frequency from said focus,

(e) the means for illuminating the main reflector at the second frequency being a waveguide feed having a radiating mouth facing the main reflector and having a guide portion extending outward through the auxiliary reflector,

(f) the radiating mouth having a conducting portion outward of the common focus of the main and auxiliary reflectors and having means for repressing reflection from at least the inner end thereof,

(g) both of said illuminating means producing radiation of at least partially identical polarization direction at their respective frequencies and the second frequency being substantially higher than the first.

6. A dual-frequency cross-polarized antenna having:

(a) a parabolic main reflector,

(b) a relatively small auxiliary ellipsoidal reflector facing the main reflector on the axis thereof and having one focus substantially coinciding with the focus of the main reflector,

(c) a cross-polarized lower-frequency feed at the other focus of the auxiliary reflector directed toward the auxiliary reflector for cross-polarized illumination thereof,

(d) and a cross-polarized higher-frequency feed between the lower-frequency feed and the auxiliary reflector to produce a second source of cross-polarized illumination of the main reflector having the coinciding focus at its phase center,

(e) the means for producing the second source of illumination comprising a waveguide having its inner end outwardly spaced from the coinciding focus, said end having a radiation termination constructed and arranged to produce a pattern having its phase center at the coinciding focus.

7. The antenna of claim **6** having the body of the waveguide extending out through the center of the auxiliary reflector.

References Cited

UNITED STATES PATENTS

3,148,370	9/1964	Bowman	343—756
2,972,743	2/1961	Svensson et al.	343—840
3,276,022	9/1966	Brunner	343—840

ELI LIEBERMAN, *Primary Examiner.*

U.S. Cl. X.R.

343—785, 836