March 10, 1970 R. T. LEITNER ET AL 3,500,419

DUAL FREQUENCY, DUAL POLARIZED CASSEGRAIN ANTENNA

Filed Sept. 9, 1966 3 Sheets-Sheet 1

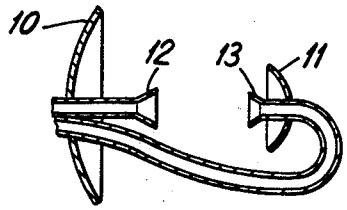


FIG.1A
PRIOR ART

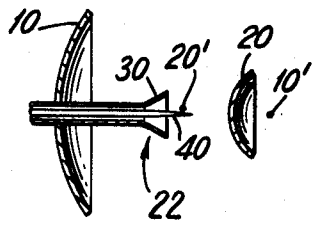


FIG.1B

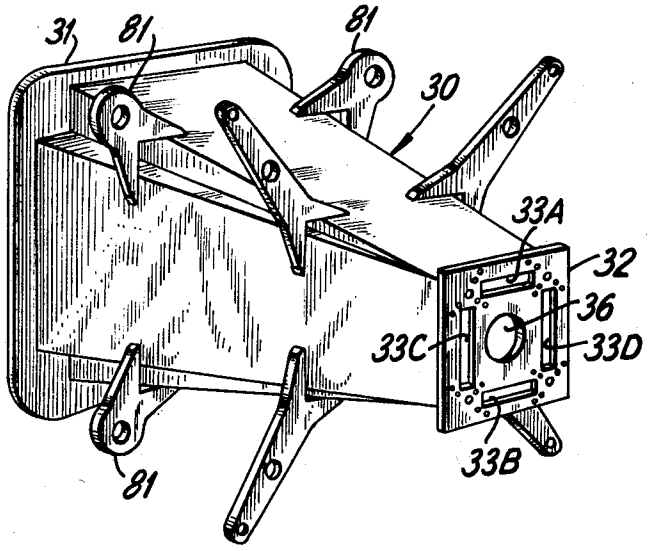


FIG. 3

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DUAL FREQUENCY, DUAL POLARIZED CASSEGRAIN ANTENNA

Filed Sept. 9, 1966 3 Sheets-Sheet 2

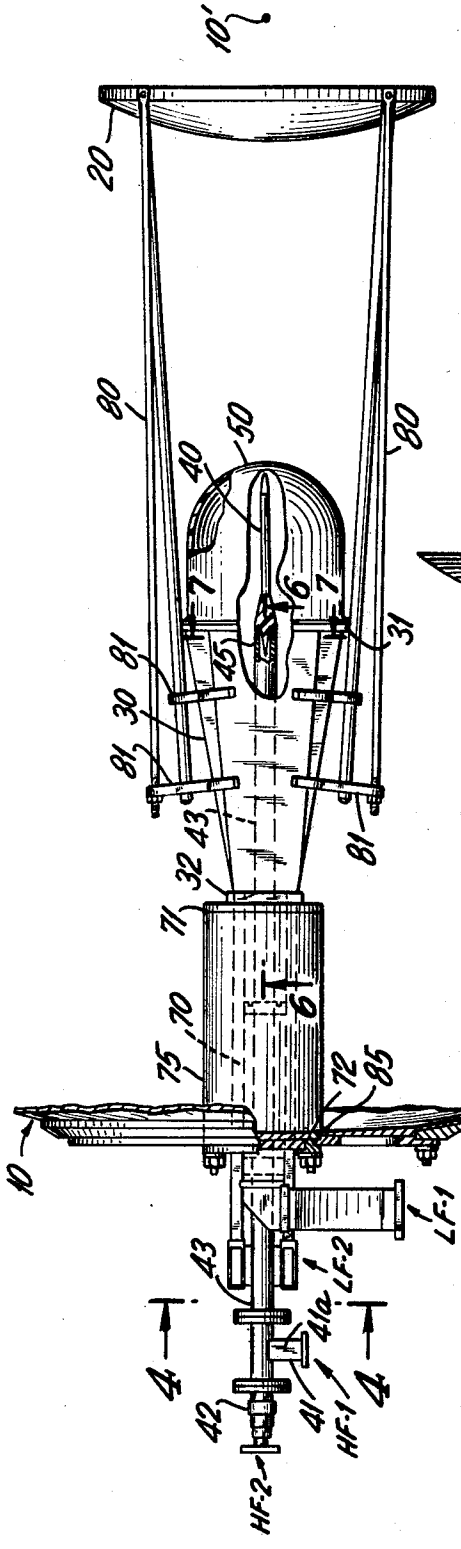


FIG. 2

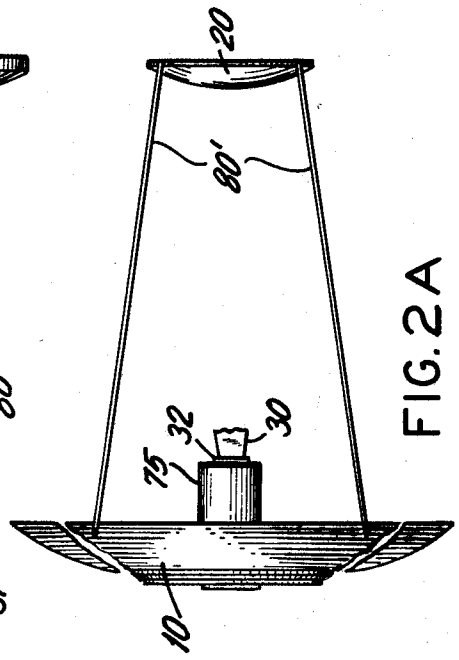


FIG. 2A

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DUAL FREQUENCY, DUAL POLARIZED CASSEGRAIN ANTENNA

Filed Sept. 9, 1966 3 Sheets-Sheet 3

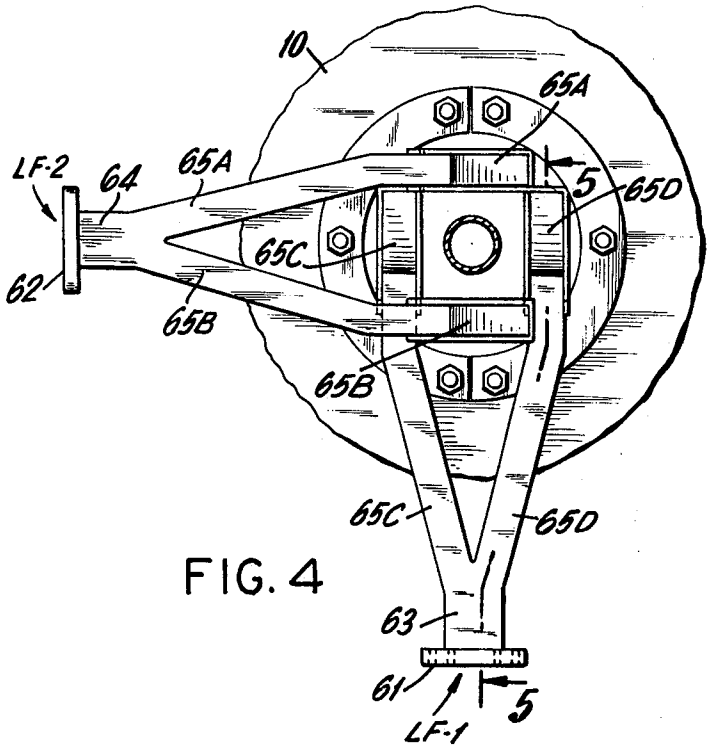


FIG. 4

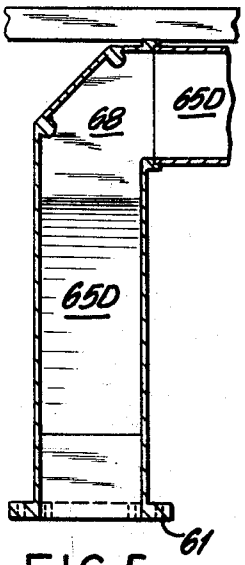


FIG. 5

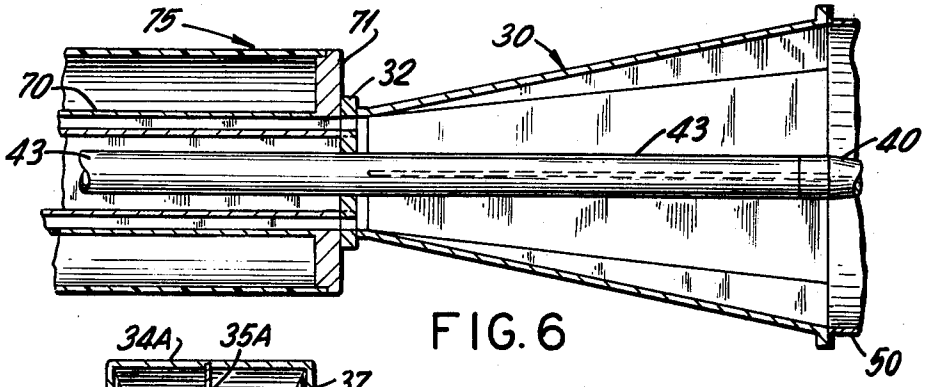


FIG. 6

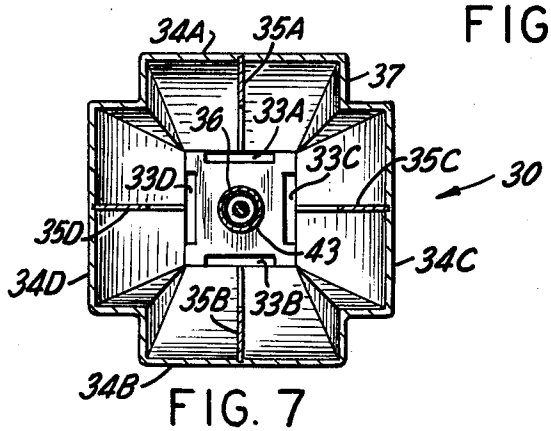


FIG. 7

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3,500,419

DUAL FREQUENCY, DUAL POLARIZED CASSEGRAIN ANTENNA

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Filed Sept. 9, 1966, Ser. No. 578,217
Int. Cl. H01q 21/00
U.S. Cl. 343—725 17 Claims

ABSTRACT OF THE DISCLOSURE

There is provided a dual frequency, dual polarized antenna having a paraboloid contour main reflector and an hyperboloid contour subreflector. Exciter means are positioned at the near focus to transmit a pair of signals in each of two frequency bands, the exciting means comprises two radiating means positioned substantially at the same electrical space.

This invention relates to an improved double reflector antenna system. More specifically, this invention relates to a double reflector system, also known as a Cassegrain system which transmits in two frequency bands, each of which is simultaneously, horizontally and vertically polarized.

Double reflector of Cassegrain systems using a main paraboloid dish and an auxiliary hyperboloid reflector or subdish are known in the art. In general, such systems have the subdish positioned so that its far focus coincides with the focus of the paraboloid, and an exciter positioned at the near foci to direct radiation towards the subdish. The paraboloid sees a virtual feed from the far focus and radiates by reflection, a collimated beam.

The prior art has utilized at least two exciters for dual frequency transmission. It is known that a convex main dish and a concave subreflector may be used in which the exciters are spaced from and face each other. This technique has disadvantages among which are that the exciters radiate towards each other and each obstructs the radiation from the other.

One of the objects of this invention is to provide an improved reflecting antenna system for transmitting dual polarized, dual frequency signals.

Another object of this invention is to provide an improved double reflector antenna having greater capability, accompanied by higher cross frequency isolation, higher cross polarization isolation, lower side lobe levels and improved VSWR characteristics.

Yet another object of this invention is to provide an improved double reflector antenna system having plural exciters which do not obstruct each other.

Still another object is to provide an improved exciter for an antenna system for transmitting dual polarized, dual frequency signals.

A further object of this invention is to provide an antenna for dual polarization in the common carrier bands of 6 and 11 gc. for use with cross band microwave systems.

And another object of this invention is to provide an improved double reflector antenna system utilizing a main paraboloid and an auxiliary concave hyperboloid as a subreflector in which all of the exciters are concentrically positioned at a single focus of the hyperboloid.

Other objects are to provide:

An improved double reflector system having a tapered horn low band feed and a polyrod high band feed concentrically mounted within the horn;

An improved double reflector system having an integral, compact, dual frequency exciting means having concentrically mounted radiators enclosed with a feedome;

A wave guide structure capable of mixing and radiating dual polarization in two bands suitable for reflector illumination;

Independently rotatably high and low wave guide inputs for polarization adjustment.

Briefly, in this invention, there is employed a main paraboloid reflector and a convex hyperboloid subdish having the far focus in coincidence with the paraboloid focus, and includes a dual polarized, dual frequency exciting means positioned at the near focus of the hyperboloid. Here, the paraboloid sees a virtual feed of dual polarized, dual frequency at its focus and the antenna will radiate a collimated beam.

The feed system of the exciting means includes independently rotatable high and low band wave guides, each having two input ports for respective polarization. The high band wave guide couples to an end fire polyrod radiator which is concentrically mounted at the output end of a horn radiator which couples to the low band wave guide.

The above mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will best be understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings wherein:

FIG. 1A is a schematic drawing of a prior dual frequency double reflector antenna;

FIG. 1B is a schematic drawing of the double reflector antenna of this invention;

FIG. 2 is a side view, partly in section of the feed and reflector assembly;

FIG. 2A is a diagrammatic view of an alternative means for mounting the subreflector to the main reflector;

FIG. 3 is a rear perspective view of the horn radiator;

FIG. 4 is a sectional view along the lines 4—4 of FIG. 2 illustrating dual input ports for the lower of the frequencies radiated;

FIG. 5 is a sectional view along the lines 5—5 of FIG. 4;

FIG. 6 is an enlarged sectional view along the lines 6—6 of FIG. 2 illustrating the position of the high frequency wave guide and radiator in the horn.

Referring now to FIG. 1A, there is diagrammatically shown the previously mentioned prior art system, having two exciters for dual frequency transmission. The concave main dish is illustrated at **10** and the convex reflector is shown at **11**. The two exciters **12** and **13** are spaced from and face each other.

Referring now to FIG. 1B, there is shown a diagrammatic illustration of the double reflector antenna of this invention. The main reflector **10** is a paraboloid having a focal point **10'**. A convex hyperboloid subreflector **20** is located between the main reflector and the focal point **10'** such that the far focus of the hyperboloid coincides with focal point **10'**.

Exciting means **22** is positioned substantially at the near focus **20'** of the hyperboloid. The exciting means **22** comprises low band radiator **30** and high band **40** which are concentrically mounted. Both radiators launch the signals in the same direction and the signals are first reflected from subreflector **20** to the main reflector **10**, which in turn reflects the signals as a collimated beam.

Referring now to FIG. 2 and FIG. 4, the low band radiator has two input or two feed ports illustrated diagrammatically as LF1 and LF2 (FIG. 4) which are coupled through wave guides **31** and **32** to low band radiator horn **30**. The high band input includes two input band ports, illustrated diagrammatically as HF1 and HF2 (FIG. 2), which are coupled through wave guides

41 and 42 to a main circular wave guide 43 to the high band polyrod radiator 40.

Each of the two frequency exciters operate in two orthogonal planes and provide two polarizations at each frequency. In the preferred embodiment, the low frequency band, 5.925–6.425 gc., is radiated from the horn and the high frequency band, 10.7–11.7 gc., is radiated from the polyrod.

One advantage results from the dual reflecting system in which the image of the feed system is at the focal point of the main reflector in place of the real feed. The real feed is aimed in the same direction as the main beam of the parabola instead of the opposite direction as is necessary in a conventional focal point fed parabola. This makes the problem of having the waveguide inputs accessible from the rear and the feed removable from the rear quite simple.

Circular wave guide 43 is a hollow tube which terminates so as to electrically couple and mechanically secure a Teflon high frequency radiator 40. The outer periphery of wave guide 43 is recessed at 45 to provide a socket over which the depending circular edge 46 of the radiator 40 will plug. The effective diameter of the wave guide at the transition with the polyrod will be constant and there are no abrupt discontinuities. Radiator 40 projects somewhat from the leading edge of horn 30 but is still effectively positioned at the near foci of the subreflector. The high band circular wave guide and the polyrod are concentrically mounted in the center of the horn 30 and occupy, substantially, the same space at the same time; both high and low band feeds are therefore perfectly aligned with the subreflector.

Horn 30 (FIG. 3) has front and rear flanges 31 and 32. Rear flange 32 provides a means for physically securing the horn to the wave guides and also provides narrow rectangular slots or apertures 33A, 33B, 33C, 33D through which the lower frequency may pass. Apertures 33A and 33B provide coupling for one polarization of the wave while aperture 33C and 33D provide coupling for the opposite polarized wave.

The sides of horn 30 taper outwardly as illustrated in FIG. 7 and terminate in sections of equal dimension 34A, 34B, 34C and 34D. These sides direct the surface wave before launching and the horn employs four fins 35A, 35B, 35C and 35D for E plane and H plane compensation. The sides of the horn are each separated by a right angle tapering bend having dimensions at the horn end approximately equal to the height of the parallel fin. Since the use of fins for this purpose is known, it will not be discussed further here.

Flange 32 has a central recess 36 through which waveguide 43 passes. Flange 31 is integrally joined to horn 30 but does not obscure any of the aperture thereof.

The solution of having the phase centers of both feeds occupying the same point and not interfering with each other mechanically and only minimally electrically is significant. As explained, the feeds are concentric and the high band polyrod feed has a relatively small physical aperture compared to its electrical aperture and the low band horn feed has a large physical aperture relative to its electrical aperture.

A plastic, thin walled feedome, preferably made of "Cycolac" is used to seal the horn and polyrod. The sealed unit may be internally pressurized and it is evident that this feedome assembly reduces wind and other environmental losses. The entire assembly is made integral with handling and transportation loss minimized.

The low band feed comprises 2 ports, LF–1 and LF–2 (FIG. 4) having their openings defined by flanges 61 and 62 which feed full height wave guide sections 63 and 64. Section 64 branches or Y splits into two half height wave guides while section 63 splits into half height wave guides 65C and 65D.

Typical half height wave guide 65D is subjected to a bend at 68 (FIG. 5) but otherwise feeds the polarization through an intermediate wave guide 70 of the same shape to the input slot 33D of the horn (FIGS. 2 and 3). Similarly, wave guides 65A, 65B, 65C feed slots 33A, 33B and 33C.

Coupling flanges 71 and 72 of intermediate wave guide 70 are secured to the horn and half height wave guides respectively as those skilled in the art will readily understand. It will be apparent that the input ports LF1, LF2, the half height wave guides and the horn are mechanically interconnected and are not independently rotatable. A cylindrical housing 75 may be attached between flanges 71 and 72 to seal and protect the intermediate wave guide.

As mentioned previously, the high band ports HF1 and HF2 are the inputs for the E and H high frequency polarizations which are applied through circular guide 43 to the polyrod 40. In this invention, as will be apparent, the inputs to the concentric feeds for both radiators are physically and electrically separate while achieving broadband low VSWR capability.

As shown in FIG. 2, the polarization applied to HF1 is coupled to an inhomogeneous wave guide 41A to a circular guide step transformer (not shown in detail). The other polarization is unidirectionally coupled through a resonant window and septum structure. Circular wave guide 43 is fed by a mode coupler having two rectangular input ports, each corresponding to the dimensions of the HF1 and HF2 ports. The walls of the mode coupler which define the rectangular input ports gradually transition into the circular guide.

The mode coupler, per se, is well known but is used here to retain the physical and electrical separation of the dual frequencies. It is also evident that the circular high band wave guide and the four surrounding low band half height wave guides retain independent polarization adjustment.

The wave guides 41, 42, mode coupler 43 all are interconnected, but are still rotatable as a unit within the intermediate wave guide 70 and the horn 30, and may be locked in a fixed position by conventional means. In the preferred embodiment, the high band assembly can be locked in position so that the 11 gc. collimated beam is concentric, codirectional and within the respective 6 gc. beam.

Reflector 10 has a central aperture 80 which allows the wave guides of the feed assembly to pass. Specifically, the aperture 85 has a dimension to accommodate flange 72 which may be physically secured thereto by conventional fastening means.

The auxiliary reflector 20 as illustrated is supported by struts 80 which are attached to the external surface of the horn by ears 81. As a result the spacing between the main reflector, the subreflector and the radiators is fixed. Preferably, the subreflector may be supported by similar struts 80' which depend from the main reflector as shown diagrammatically in FIG. 2A.

The entire structure may be enclosed by a radome or cover which is disclosed in more detail in patent application Ser. No. 564,677, entitled "Radomes" filed on July 12, 1966, now Patent No. 3,444,558.

The foregoing antenna has certain desirable features in addition to those theretofore mentioned. The dual polarized, dual frequency capability of the antenna is accompanied by a high cross frequency isolation and a high cross polarization isolation. Cross frequency isolation minimizes the energy which is coupled from one port of one frequency to another port of another frequency, i.e., 11 to 6 gc. or 6 to 11 gc. In this invention, we have recognized the importance of cross frequency isolation. For example, 11 gc. energy coupled into the 6 gc. system will be reflected back out, perhaps after it has traveled through a long section of 6 gc. waveguide, to cause delay distortion and severe limitations on loading capability. This is of concern only on the basis of 11 to 6 gc. since the 6 gc. energy cannot be supported in the 11 gc. waveguide. This cross frequency isolation has been tested at approximately a minimum of 30 db. The cross

polarization isolation is a minimum of 40 db at 6 gc. and 35 db at 11 gc. Side lobe levels are greater than 15 db for both bands. VSWR's of 1.10 maximum have been measured in the 6 gc. band and 1.12 maximum in the 11 gc. band. This invention thus provides unique and improved characteristics in a simple and economic manner. These characteristics are here summarized:

(1) Low VSWR, all ports.
(2) Good aperture efficiency, both bands.
(3) Low side lobes, both bands.
(4) High cross polarization isolation.
(5) High cross frequency isolation.
(6) High polarization discrimination.
(7) Precise beam coincidence.
(8) Independent polarization rotation.
(9) All four ports accessible from center rear of reflector.
(10) Feed insertable from the rear of the reflector.

While the principles of the invention have been described in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of the invention as set forth in the objects thereof and in the accompanying claims.

What is claimed is:

1. A double reflector antenna system comprising a main reflector having a paraboloid contour and having a focus defined thereby;
a subreflector having a hyperboloid contour, and having a near focus and a far focus defined thereby;
means positioning said subreflector to locate the far focus thereof in coincidence with the said paraboloid focus;
plural exciter means positioned at said near focus, to transmit a pair of signals in each of two frequency bands with one signal in each said pair of signals being orthogonally polarized with respect to the other signal in each of said respective bands;
said exciter means directing said signals at said subreflector.

2. The antenna system of claim **1** in which the main reflector is concave and the subreflector is convex with respect to the radiation reflected from each.

3. The double reflector system of claim **1** in which the exciting means includes a horn radiator having walls of dimensions to launch a first pair of said orthogonally polarized signals in the low frequency band with one signal horizontally polarized and the other signal vertically polarized, and a higher frequency radiator positioned concentrically within said horn to launch a second pair of said orthogonally polarized signals in the high frequency band, with one signal horizontally polarized and the other vertically polarized.

4. The double reflector system of claim **1** in which the exciter means includes two, two port wave guide means, each port coupling a different polarization of the said frequency signals.

5. The double reflector system of claim **4** in which one of said wave guide means is a circular guide having means to receive a dielectric rod as a radiating element.

6. A double reflector antenna system comprising a main reflector having a paraboloid contour and having a focus defined thereby;
a subreflector having a hyperboloid contour, and having a near focus and a far focus defined thereby;
means positioning said subreflector to locate the far focus thereof in coincidence with the said paraboloid focus;
exciter means, positioned at said near focus, to transmit two orthogonally polarized signals in a lower frequency band and two orthogonally polarized signals in a higher frequency band;
said exciter means directing said signals at said subreflector;
said exciter means comprising a rear feed having two input ports for the orthogonally polarized signals in the lower frequency band; and
two input ports for the orthogonally polarized signals in the higher frequency band;
means applying two orthogonally polarized signals at the respective ports in the lower frequency band;
means applying two orthogonally polarized signals at the respective ports in the higher frequency band;
a low frequency band radiator;
a higher frequency band radiator concentric with the low frequency radiator;
rectangular waveguide means coupling said low frequency orthogonally related signals to said low frequency radiator; and
circular waveguide means coupling said high frequency orthogonally related signals to said high frequency radiator.

7. The antenna system in claim **6** in which said low frequency radiator is a tapered horn and said high frequency radiator is a dielectric rod.

8. Radiating means for use in an antenna system comprising four port wave guide means including a first dual port, lower frequency, wave guide means for coupling dual polarized signals at a lower frequency, and a second, dual port, higher frequency wave guide means for coupling thereto, dual polarized signals at a higher frequency, said low frequency wave guide means including rectangular input ports and said higher frequency guide means including a circular waveguide, and a transitioning means between the circular waveguide and the input ports of said higher frequency, dual port, waveguide means.

9. The radiating means of claim **8** further including a horn radiating means and in which said lower frequency wave guide means includes plural rectangular wave guides, said rectangular wave guides terminating into said horn radiating means, said circular wave guide being concentric with said horn and said plural rectangular wave guides and being independently rotatable therewith.

10. The radiating means of claim **9** in which said plural rectangular wave guides include a first full height wave guide means, a Y wave guide having half height branch wave guides and being coupled to said first full height wave guide means, whereby the electromagnetic wave representing the first polarized signal travels along the two half height branches,
a second full height wave guide means, a second Y wave guide having half height branch wave guides and being coupled to said second full height wave guide means,
whereby the electromagnetic wave representing the second polarized signal travels along the two half height wave guides.

11. The radiating means of claim **10** in which the radiating horn has plural apertures to transitionally couple to each of said half height wave guides.

12. The radiating means of claim **11** in which the first half height wave guides are parallel for a predetermined length before coupling to said horn, and said second half height guides are parallel to each other for the said predetermined distance but are perpendicular to the first half height wave guide to define thereby a cavity therebetween.

13. The radiating means of claim **12** in which said circular waveguide is located in said cavity.

14. A double reflector antenna system including the radiating means of claim **8**, and further including a main paraboloid, a convex hyperboloid subreflector, exciting means formed of a pair of radiating members for radiating said lower and higher frequencies, and means supporting and positioning said pair of members concentrically to radiate from a single focus of the hyperboloid.

15. The antenna system of claim **14** in which said

exciting means includes a compensated horn and a concentrically mounted polyrod.

16. A rear feed system for dual low and high frequency transmission comprising a low band radiator having a wide physical aperture,

a high band radiator having a small physical aperture,

means for concentrically positioning said radiators with respect to one another at substantially the same electrical space,

input means for said low band radiator, and

substantially separate input means for said high band radiator, each radiator being capable of radiating dual polarized signals,

said input means for said high band radiator comprises a circular wave guide having input port means, and

said input means for said low band radiators comprise at least two half height rectangular wave guides parallel to and effectively concentric with said circular wave guide and having input port means.

17. The feed system of claim **15** in which said high band radiator is a polyrod coupled to said circular wave guide, and

said low band radiator is a horn coupled to said rectangular wave guides.

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ELI LIEBERMAN, Primary Examiner

U.S. Cl. X.R.

333—9; 343—781, 785, 786, 840

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,500,419 March 10, 1970

Robert T. Leintner et al.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 7, line 20, claim reference numeral "15" should read -- 16 --.

Signed and sealed this 8th day of December 1970.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents