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ROTATABLE PARABOLIC REFLECTOR WITH CLOSED WAVEGUIDE HORN FEED

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FIG. 1

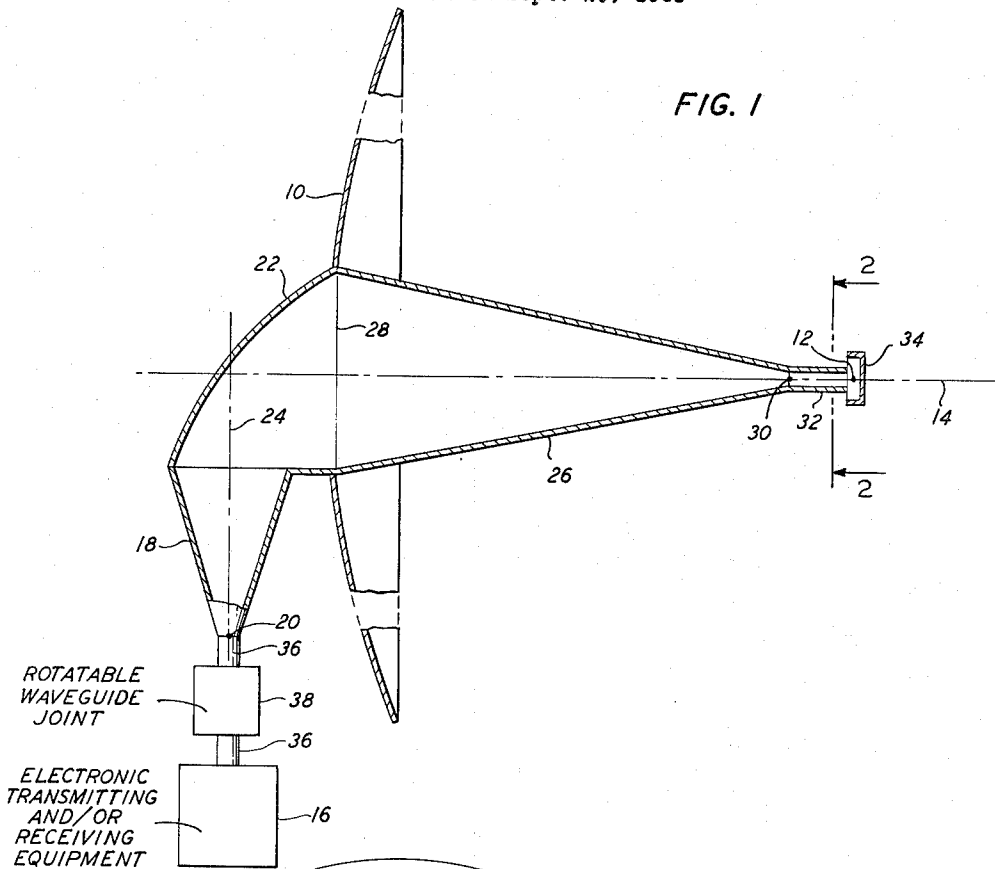
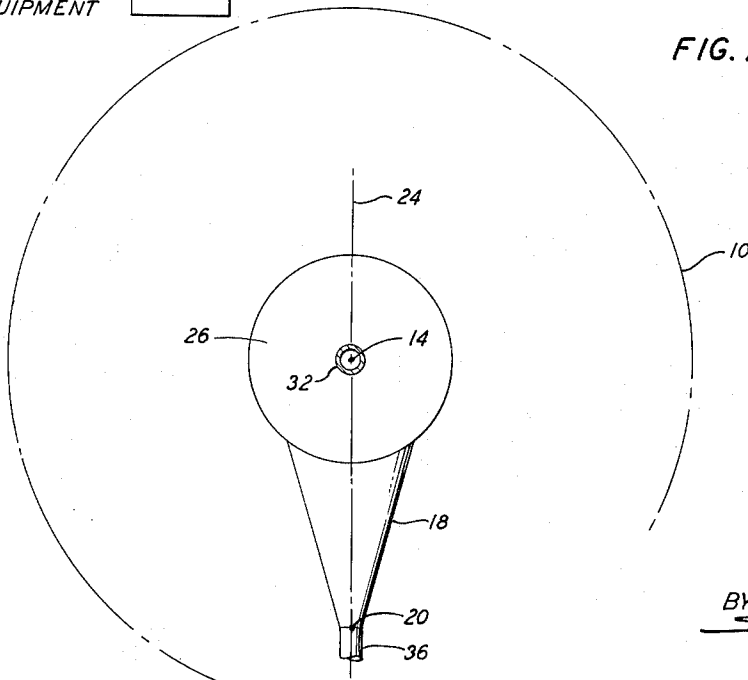


FIG. 2



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ROTATABLE PARABOLIC REFLECTOR WITH CLOSED WAVEGUIDE HORN FEED

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4 Claims. (Cl. 343-763)

This invention relates to antenna systems and, more particularly, to an improved transmission line feed arrangement for a paraboloidal reflector.

The large antenna gains demanded by space and other long-range communication systems are most economically attained, considering the factors of cost and space requirements, with giant paraboloidal reflectors fed from the parabolic focus. In such an arrangement the electronic receiving and/or transmitting equipment associated with the antenna is usually remotely situated from the parabolic focus, generally behind the reflector. Interconnection between the parabolic focus and the remote electronic equipment, then, entails transmission of electromagnetic energy over a sizable physical distance. The inherent heat or resistance loss of transmission lines which perform this function is accompanied by the generation of a proportionate amount of noise energy which contributes to the total noise temperature of the communication system.

Prior to the era of space communications the noise introduced by the transmission line in a paraboloidal antenna was generally considered to be insignificant when compared with the overall noise temperature of the system. Improved low noise-generating electronic devices such as masers and parametric amplifiers and a new emphasis placed on achieving low noise systems brought about by space communications has focused attention on the transmission line between the equipment and feed point as are influential source of noise.

One approach to the problem of reducing noise due to transmission line loss has been the application of the principle of the Cassegrainian telescope to radio frequency antennas. Accordingly, considered as a transmitting antenna a point source located at the vertex of the paraboloidal reflector directs energy to a large hyperboloidal reflector located in front of the paraboloidal reflector. Energy emanating from the point source is reflected from the hyperboloidal reflector and impinges upon the paraboloidal reflector as though emanating from a point source at the parabolic focus. With such an arrangement electronic transmitting equipment associated with the antenna may be placed behind the paraboloidal reflector in proximity with the point source at its vertex. Thus, transmission line loss is greatly abated.

The Cassegrainian antenna, as described above, leaves something to be desired, however, as a radio frequency antenna. Supporting spars are required to maintain the position of the hyperboloidal reflector in front of the paraboloidal reflector and the hyperboloidal reflector creates a large shadow in the beam of the antenna. Moreover, some "spillover" from the hyperboloidal reflector of the energy radiated by the point source is inevitable. These factors all tend to increase the side lobe level of the antenna radiation pattern, the adverse effect of which is to increase the noise temperature in the case of a receiving antenna and to cause inefficient radiation from a transmitting antenna.

It is, therefore, the object of the present invention to reduce the resistance loss, and hence the noise contribution, associated with transmitting energy between remotely located electronic equipment and a feed point of a paraboloidal reflector in an antenna system without un-

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duly increasing the side lobe level of the antenna radiation pattern.

In accordance with this object, the noise attributable to the transmission line between remotely located electronic equipment and the feed point of a paraboloidal reflector is reduced by employing a combination of waveguide horns to transmit the energy. Waveguide horns exhibit an extremely low resistance loss and accordingly such a combination contributes little noise to the total of the communication system.

A pair of waveguide horns is provided, the first horn connected at its apex to electronic receiving and/or transmitting equipment and the second horn having its apex located at a selected point, remotely situated from the electronic equipment, with which electromagnetic energy is to be exchanged. An ellipsoidal reflecting section is positioned in the line of sight of the apexes of both horns so that the two focuses of the ellipsoidal section each fall upon the apex of a different one of the two horns. The walls of the horns are extended to close upon each other and the reflecting section to produce a completely closed transmission path within which electromagnetic energy may propagate between the two horn apexes. Energy diverging away from the apex of one of the horns is reflected from the ellipsoidal section and thereupon converges upon the apex of the other horn. Likewise, energy propagating from the apex of the second horn after reflection from the ellipsoidal section converges upon apex of the first horn, so the mode of operation is reciprocal. By means of the described configuration the low loss properties of waveguide horns are utilized to transmit electromagnetic energy between two remotely located points without introducing excessive noise into the signal being transmitted.

The described low loss transmission line may be employed to connect the feeding point of a paraboloidal reflector to remotely located electronic equipment. If the equipment is situated behind the reflecting surface of the paraboloid, one of the horns and the ellipsoidal reflecting section are also situated behind the paraboloid and the other horn extends to the feed point in front of the paraboloid through an opening in the vertex of the paraboloid. Conventional feeding means terminating the second horn near its apex redirects energy to and from the reflecting surface of the paraboloid.

The transmission line may be fastened to the paraboloid and the feeding means may be attached to the transmission line so that the entire feed arrangement is capable of being supported and maintained without the necessity of spars or other external supports acting as obstructions in the beam of the antenna.

If it is desired to rotate the paraboloidal reflector and feed while maintaining the remote electronic equipment stationary and circularly-polarized waves are to be employed in the system, the described transmission line feed will convey the circularly-polarized waves around a corner between the remote equipment and feed without distorting the phase relationship between the component polarizations of the circularly-polarized waves. This cannot be accomplished with a conventional circular waveguide bent to conform to the corner.

The above and other features of the invention will be considered in detail in the following detailed description taken in conjunction with the drawing in which:

FIG. 1 is a side section of an antenna employing the principles of the invention; and

FIG. 2 is a front elevation of the antenna illustrated in FIG. 1.

FIGS. 1 and 2 show a paraboloidal reflector 10, that is to be fed from its focus 12, centered upon an axis of symmetry 14. Electronic transmitting and/or receiving equipment, represented by block 16, is connected from

its location behind the reflecting surface of paraboloid 10 to parabolic focus 12 by the low loss transmission line now to be described. Short circular waveguide sections 36 and a rotatable waveguide joint 38, the function of which will become apparent hereinafter, connect electronic equipment 16 with a conical horn 18 having an axis of symmetry 24 passing through the horn apex 20. Horn 18 is provided with an ellipsoidal reflecting section 22 which directs signals between vertex 20 and the side wall aperture of horn 18. The combination of horn 18 and section 22 may be thought of as a conventional horn-reflector with an ellipsoidal section. The base of a second conical horn 26 is joined to the combination of horn 18 and reflecting section 22 at its side aperture. An opening 28 in the vertex of paraboloid 10, coextensive in size with the base of horn 26, permits horn 26 to extend between the vertex and focus of paraboloid 10. The axis of horn 26 preferably is coincident with axis of symmetry 14; the base of horn 26 is attached to paraboloid 10 at its vertex; and the walls of horn 26 taper down toward focus 12 into an apex 30 just short of focus 12. From that point a short circular waveguide 32 interconnects with focus 12. Any conventional rear feed technique may be employed to complete the antenna feed, that is to provide a change in direction of the electromagnetic energy so transmission may be carried on between waveguide 32 and paraboloid 10. A cup-shaped reflector 34, similar to that disclosed in C. C. Cutler Patent 2,482,158, issued September 20, 1949, is shown in FIG. 1 as performing this function. Reflector 34 may be connected to waveguide section 32 by means of any number of well-known electromagnetically transparent materials. As taught in the Cutler patent, the radiation pattern of the antenna may be improved by making paraboloid 10 a "ring focus" reflector.

Energy is transmitted between apex 20 and apex 30 by making the two ellipsoidal focuses of reflector 22 congruent with apexes 20 and 30, respectively. An ellipsoid is characterized as the locus of a point the sum of whose distances from a pair of focuses is a constant. Accordingly, all the energy diverging away from apex 20 upon reflection from ellipsoidal section 22 converges upon apex 30 in phase. The same is true for signals transmitted from apex 30 to apex 20. By means of the described arrangement, the low loss characteristics of waveguide horns resulting from their large cross sections are fully exploited to interconnect remote electronic equipment 16 with focus 12 of paraboloid 10, thus materially reducing the noise introduced into the signal being transmitted as compared with conventional transmission lines.

The extremely large cross section of the transmission line formed by horns 18 and 26 and reflecting section 22, particularly in the region of section 22, provides essentially distortion-free transmission of circularly-polarized waves through the transmission line. Hence, rotation of reflector 10 and the feed equipment, while maintaining electronic equipment 16 stationary, may be accomplished by employing circularly-polarized waves and placing a rotatable joint 38 of any conventional design in waveguide section 36. Were a conventional circular waveguide having a 90-degree bend to be used to interconnect focus 12 with equipment 16, the small cross section of the waveguide would account for an appreciable difference in transmission time in traversing the bend between the orthogonal, component, linearly-polarized waves. This would distort the circularly-polarized composite wave appearing at the termination of the transmission line, an undesirable result.

The feed for paraboloid 10, moreover, is completely self-supporting. Cup-shaped reflector 34 is fastened to waveguide 32 and the transmission line is attached to paraboloid 10, therefore no supporting spars are required. Furthermore, the low transmission loss is achieved at the expense of only a small shadow in the antenna beam

due to the feed apparatus (shown as horn 26, waveguide 32, and reflector 34) as compared with that caused by the large reflectors that must be placed in the beam of Cassegrainian antennas.

What is claimed is:

1. An antenna system comprising a reflector of electromagnetic signals, means for directing energy to and from said reflector from a feed point, and a low loss transmission line interconnecting said feed point with a remotely situated point comprising a first waveguide horn having an apex aperture located at said remote point, a second waveguide horn having an apex aperture located near said feed point, said second horn connected at its apex to said means for directing energy, an ellipsoidal reflector facing both of said apertures, said ellipsoidal reflector being oriented such that one of its focuses coincides with the apex of said first horn and the other of its focuses coincides with the apex of said second horn, and the walls of said first and second horns being extended to close on one another and said reflector forming a completely closed transmission line between said apexes.

2. In an antenna system, a paraboloidal reflector, a first waveguide horn having an apex aperture which is connected to electronic equipment located behind the reflecting surface of said paraboloid, feeding means located at the focus of said paraboloid for directing energy toward and collecting energy from said paraboloid, a second waveguide horn having an apex aperture connected to said feeding means, an opening in said paraboloid, and an ellipsoidal reflecting section disposed in the line of sight of both of said apertures such that energy radiated from either aperture is reflected off said ellipsoidal section and through said opening to the other of said apertures, said ellipsoidal section being situated so that its focuses coincide with the apex of said first and said second horns, respectively.

3. In an antenna system, a paraboloidal reflector, a horn reflector having an ellipsoidal reflecting section located behind said paraboloid, said paraboloid having at its vertex an opening coextensive with the side aperture of said horn reflector cut into the paraboloid at its vertex, a second horn whose base is connected at said opening to the side aperture wall of the said horn reflector, the focuses of said ellipsoid being located at the apex of said horn reflector and the apex of said second horn, respectively, and feeding means connected to the apex of said second horn for directing energy to and receiving energy from said paraboloidal reflector.

4. In an antenna system, means for interconnecting a feed point for a rotating reflector of electromagnetic waves with remotely located stationary electronic equipment comprising a first waveguide horn having an apex aperture, a rotatable transmission line joint interconnecting said stationary equipment with said apex aperture of said first horn, a second waveguide horn having an apex aperture located in the proximity of said feed point, and an ellipsoidal reflecting section disposed in the line of sight of both said apexes, the focuses of said ellipsoid coinciding with the apex of said first and said second horns, respectively, said interconnecting means being fastened to said reflector.

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