Feb. 6, 1951 T. M. GLUYAS, JR 2,540,518

DIRECTIONAL ANTENNA

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Fig. 1.

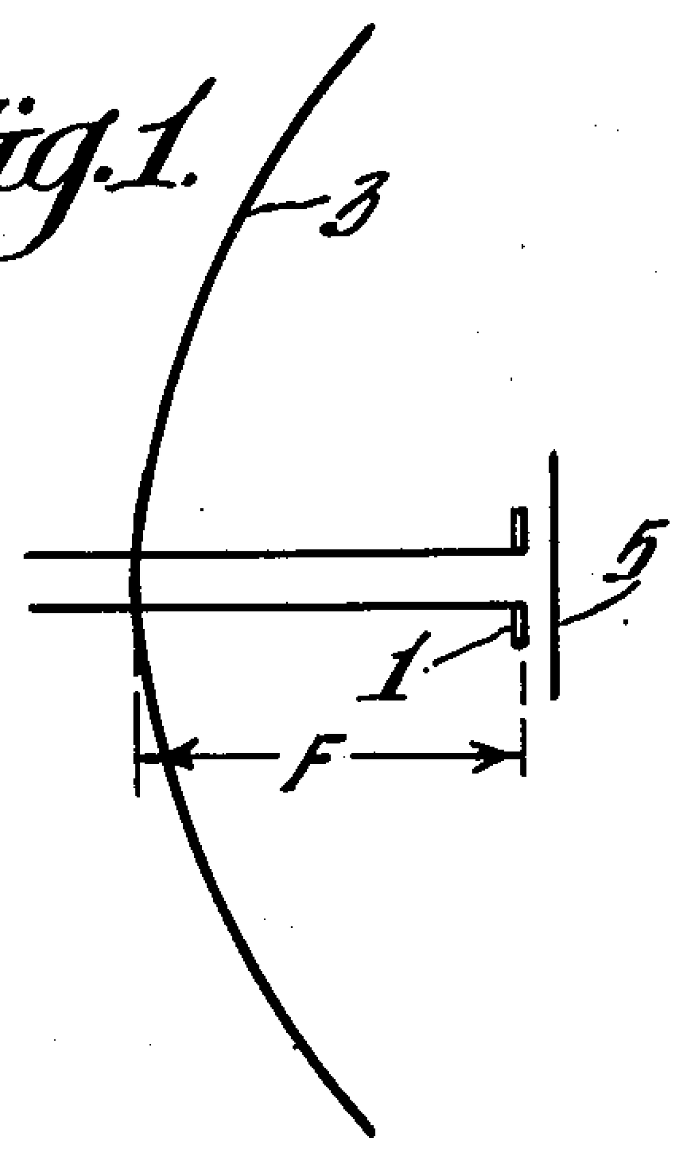


Fig. 2.

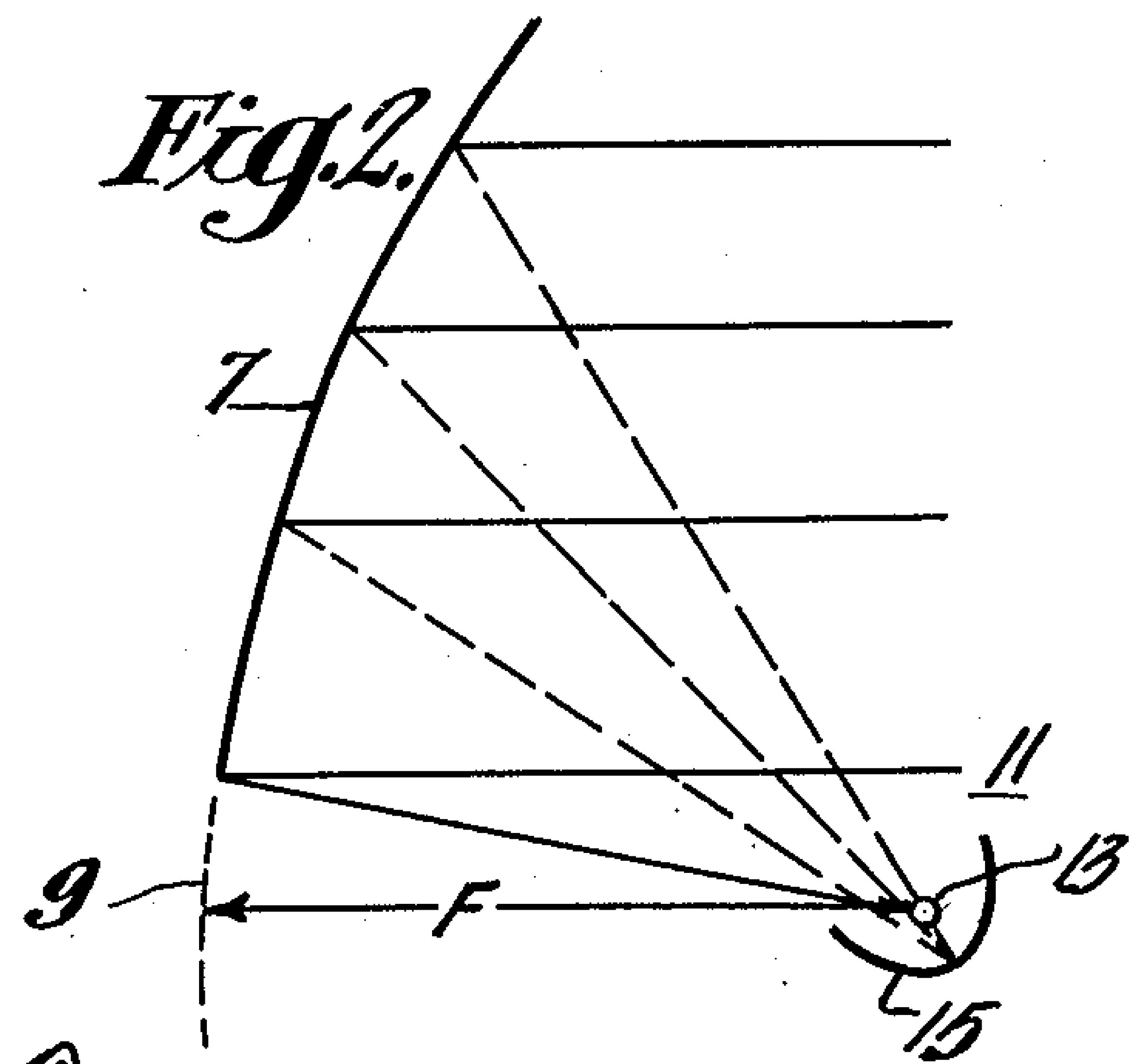
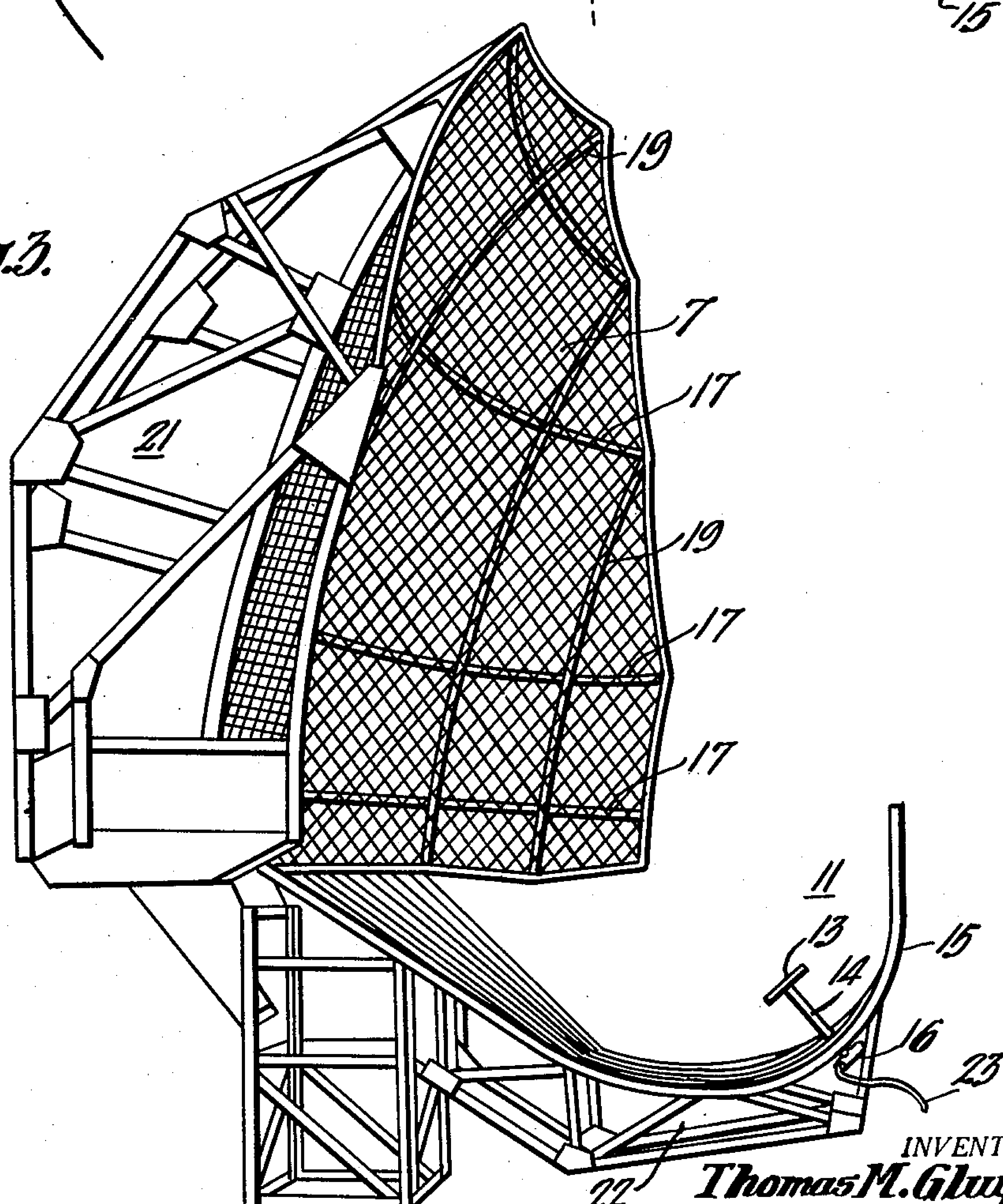


Fig. 3.



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DIRECTIONAL ANTENNA

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3 Claims. (Cl. 250—33.65)

This invention relates to directive antennas, and more particularly to improvements in antenna systems of the type including curved or parabolic reflector means for providing directivity.

The use of parabolic reflectors with antennas is well known, being described in Radio Engineers' Handbook, by F. E. Terman, first edition, 1943, published by McGraw Hill Book Company, on page 837 et seq. The sharpness of the directive beam obtained by such a structure is limited substantially only by the size of the reflector. However, prior art antennas of this type will operate efficiently only at the single frequency for which they are designed. At other frequencies, the spacing in wavelengths between the radiator and the reflector varies from its optimum value, introducing variations in the impedance presented by the antenna to its feed system and producing undesirable side lobes in the directive pattern.

Accordingly, it is the principal object of this invention to provide an improved antenna system of the described type capable of operation throughout a relatively wide frequency band with a minimum variation of directive pattern and impedance.

Another object is to provide an antenna of the described type wherein a relatively large reflector may be used without incurring the disadvantages inherent in similar systems of prior art type.

A further object of the invention is to provide an antenna system of the described type which is simple to design and construct, and will meet typical performance requirements with a single primary radiator, in contradistinction to the usual array of a large number of radiator elements with graded energization and consequent power division and feed system problems.

The invention will be described with reference to the accompanying drawing, wherein:

Figure 1 is a schematic diagram of a prior art antenna system including parabolic reflector means,

Figure 2 is a schematic diagram of an antenna system in accordance with the present invention, and

Figure 3 is a perspective view of an antenna system embodying this invention.

Referring to Figure 1, a typical prior art antenna comprises a half wave doublet 1 disposed at the focus of a reflector 3 in the shape of a parabola of rotation. In order to minimize direct forward radiation, with consequent loss of sharpness of the beam, an auxiliary reflector 5 is provided near to and in front of the radiator 1.

It is sometimes supposed that the operation of a system such as that of Figure 1 is closely analagous to that of a searchlight in producing a beam of light. However, this is not the fact, principally because the usual searchlight reflector has a diameter of millions of wavelengths, while the reflector used with a radio antenna is ordinarily less than one hundred wavelengths in diameter. This results in interaction between the radiator and reflector, since the radiator is large enough to intercept an appreciable fraction of the beam produced by the reflector, and also because there is appreciable direct radiation from the source which forms an interference pattern with the energy from the focusing reflector.

The distance F is generally chosen so that direct radiation from the primary radiator in the forward direction is in phase with the energy from the reflector, this arrangement usually having the most favorable antenna pattern. If the distance is chosen to be 3λ at a particular operating frequency an increase in operating frequency of 8 percent will cause the distance F to be $3\frac{1}{4}\lambda$. If the distance 3λ gave the most favorable field pattern the frequency change of 8 percent $F=3\frac{1}{4}\lambda$ results in an inferior pattern because the radiation from the primary radiator and the reflector will now be out of phase in the forward direction. Furthermore, if the radiator is matched to the feed line when $F=3\lambda$ then when $F=3\frac{1}{4}\lambda$ the radiator will present a different impedance to the feed line causing a serious mismatch because the phase of the energy returned from the reflector to the radiator will be opposite for the cases $F=3\lambda$ and $F=3\frac{1}{4}\lambda$. The impedance mismatch caused by the change in frequency will result in standing waves on the feed line and reduced system efficiency.

The above described difficulties can be met to a large extent by designing the reflector to make F one-quarter wavelength at the mean frequency of operation. Then a 20 percent change in frequency will be equivalent to a change of

$$20 \text{ percent} \times \frac{\lambda}{4}$$

or only $\frac{1}{20}$ wavelength, and the variation in impedance will be correspondingly small throughout a wide band of frequencies.

However, this is only a partial solution and in fact no solution at all when it is desired to use a large reflector to obtain a very narrow beam. For example, suppose that the mouth of the reflector is to be 25 wavelengths in diameter, and the focal length one-quarter wavelength. The length of the reflector from vertex to mouth will then be about 156 wavelengths, or over 600 times the focal length. The radiator will be so far inside the mouth that the reflector will no longer operate as a simple parabola at all, owing to diverse polarization of the energy following different paths within the reflector, and to the non-uniform illumination due to the nulls off the ends of the radiator.

According to the present invention, the reflector 7 is in the form of a section of a circular parabola, and does not include the vertex (indicated at 9) of the parabola. A directive antenna 11 is disposed at the focal point of the reflector 9, which may be at any convenient distance from the vertex 9, and is outside the plane of the mouth of the parabola.

The antenna 11 comprises a radiator 13 at the focus of a relatively small auxiliary reflector 15. The focal length of the reflector 15 is approximately one-quarter wavelength, and the reflector 15 is oriented to direct a relatively broad beam over the surface of the reflector 7.

Since the reflector 15 needs only to concentrate the radiation into a beam angle of, for example, 30 degrees by 60 degrees, it has a small mouth opening and may be designed with the relatively short focal length of one-quarter wavelength without introducing polarization difficulties. A cylindrical parabola 15 with the radiator 13 along the focal line obviates this difficulty.

The larger reflector 7 is "illuminated" by the small antenna 11, providing a very sharp beam parallel to the axis of the paraboloid. This beam misses the antenna 11 entirely, so that no energy can be returned from the reflector 7 to the antenna 11. Thus there is no critical relationship to be maintained between the wavelength and the focal length of the main reflector, and efficient operation is obtained throughout a wide frequency band. The directivity is substantially the same as that which would be obtained (but only at the design frequency) with a complete circular paraboloid having a mouth area equal to that of the section 7.

Figure 3 shows the principal details of a typical embodiment of the present invention. The main reflector 7 comprises a screen of "expanded metal" or the like, secured by spot-welding to a supporting structure including curved ribs 17 and 19 mounted on a bracework structure, designated generally by the reference numeral 21. The auxiliary reflector 15 is similarly constructed and supported by the structure 22. In the present illustration, the reflector 15 is in the form of a cylindrical parabola, with its focal line horizontal.

The radiator 13 comprises a horizontal doublet with its element supported by the transmission line 14 by which it is connected to the feed system. A line balance convertor 16 is provided behind the reflector 15 for coupling the line 14 to a coaxial feed line 23. The antenna 11, comprising the radiator 13 and reflector 15, may be of the type described in U. S. Patent No. 2,430,353 issued November 4, 1947, to Robert W. Masters, and entitled Antenna.

The operation of the system of Figure 3 is the same as that of the system of Figure 2. The beam emitted from the reflector 7 is horizontally polarized, since the doublet 13 and the reflector 15 are disposed horizontally.

Although the invention has been described with reference to a specific embodiment thereof, it will be apparent without further illustration to those skilled in the art that it is not limited thereto. For example, the directive antenna 11 may be a directive array, rather than a simple dipole and reflector. The reflector 15 need not be a parabolic, but may even be a flat screen, depending upon the particular design and performance requirements.

Summarizing briefly, the present invention contemplates the use of a reflector in the form of a portion of a paraboloid, with the vertex omitted, "illuminated" by a directive antenna at its focus. The beam formed by the reflector does not impinge on the primary radiation source, thus avoiding impedance variations and enabling broad-band operation.

I claim as my invention:

1. A directive antenna system including a reflector in the form of a portion of a paraboloid, said portion excluding the vertex of said paraboloid, radiator means near the focus of said reflector, and an auxiliary reflector adjacent said radiator means and oriented to direct radiation from said radiator means substantially only to said first-mentioned reflector, said radiator and said auxiliary reflector being located outside the beam formed by said parabolic reflector.

2. A directive antenna system including a reflector having a reflecting surface in cross-section in the shape of a portion of a parabola entirely on one side of the parabola axis and excluding the parabola vertex, means to radiate or receive electromagnetic energy substantially at the focus of the reflector, and an auxiliary reflector arranged to have a radiation pattern with said means which pattern includes substantially only said reflecting surface and excludes substantially all portions outside said surface, said auxiliary reflector being located on the side of the parabola axis opposite the said reflecting portion surface and thereby being located outside the radiation pattern of the system.

3. The system claimed in claim 2, said means to radiate or receive the electromagnetic energy being a dipole, and said auxiliary reflector having a reflecting surface in cross-section in the shape of a parabola with the dipole substantially at its focal point.

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