# United States Patent [19]

**Munson**

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[54] **DIRECTIONAL ANTENNA SYSTEM WITH CONICAL REFLECTOR**


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[52] **U.S. Cl.** ..... **343/814**, 343/815, 343/840

[51] **Int. Cl.** ..... **H01q 21/12**

[58] **Field of Search** .....343/812–817, 840



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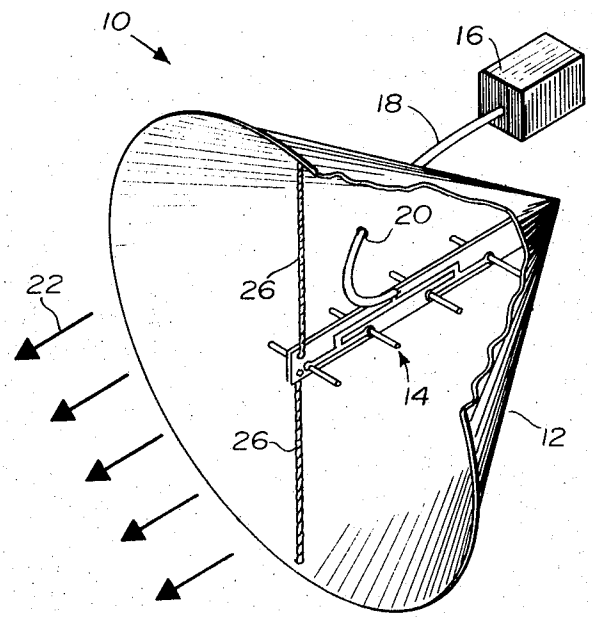
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[57] **ABSTRACT**

A directional antenna system is disclosed and generally includes a passive conical reflector and an active feed assembly comprising a plurality of effective half-wave dipoles or element radiators and extending perpendicular thereto. The dipoles are simultaneously excited by in-phase signal energy so as to produce electromagnetic wave energy which is directed to the conical reflector and reflected therefrom in a direction parallel with the axis thereof.


**2 Claims, 5 Drawing Figures**



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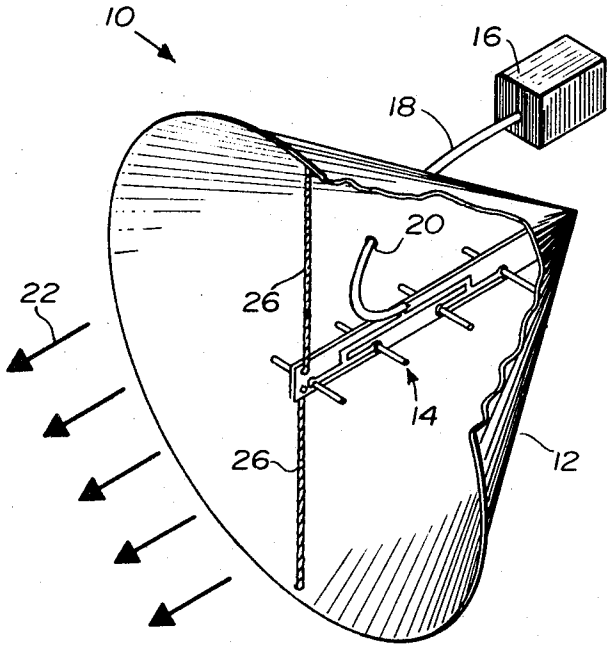



Fig. 1

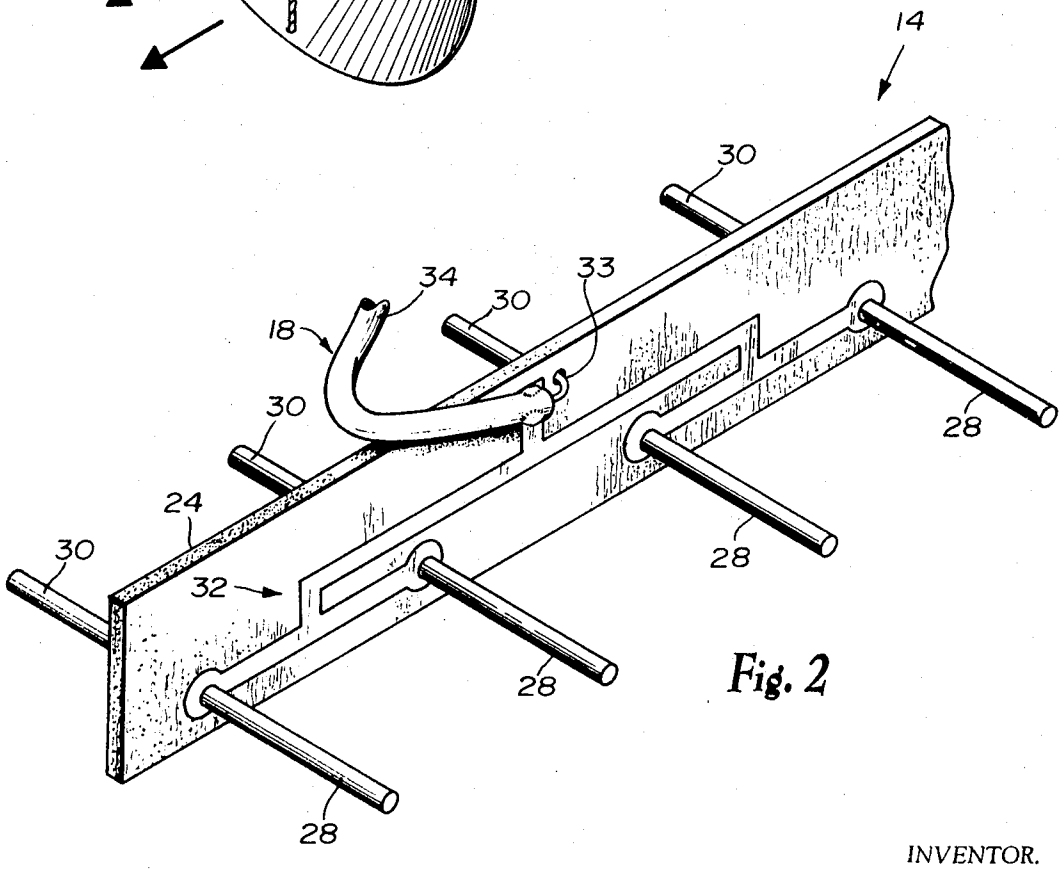



Fig. 2

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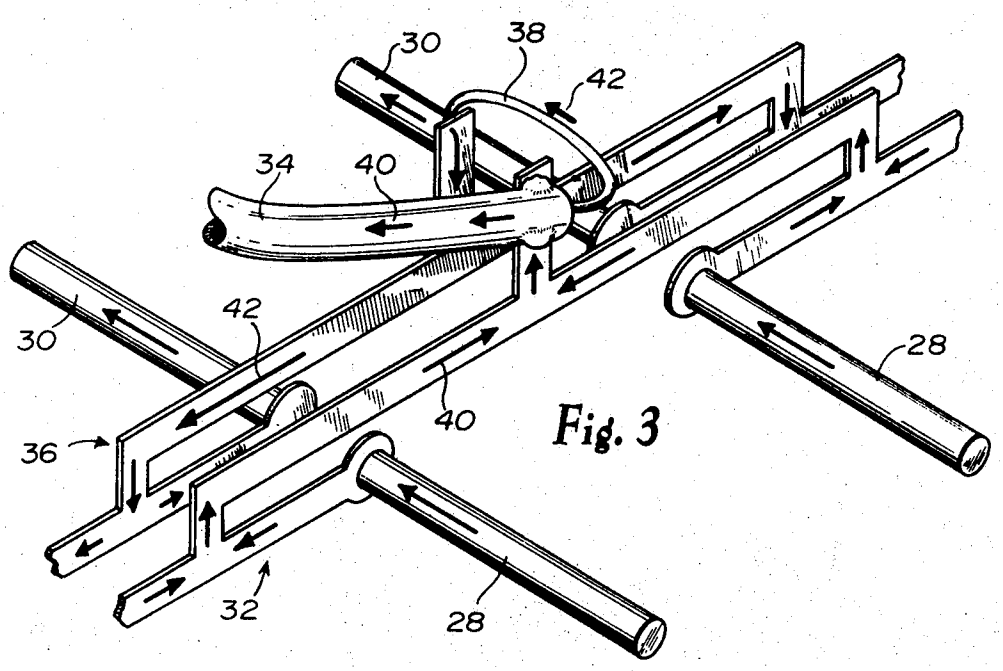



Fig. 3

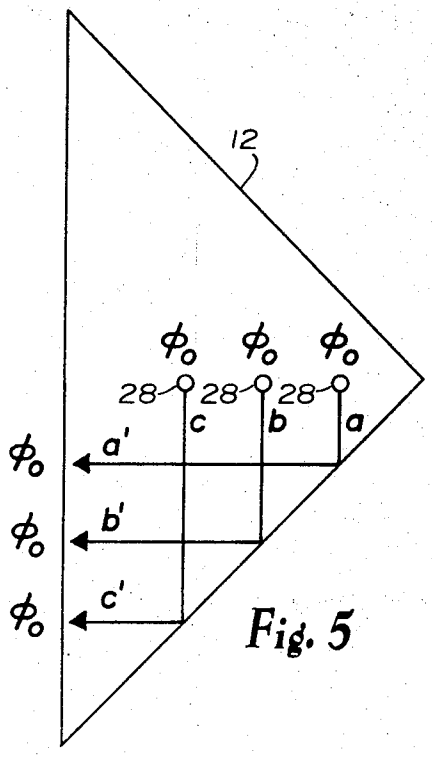



Fig. 5

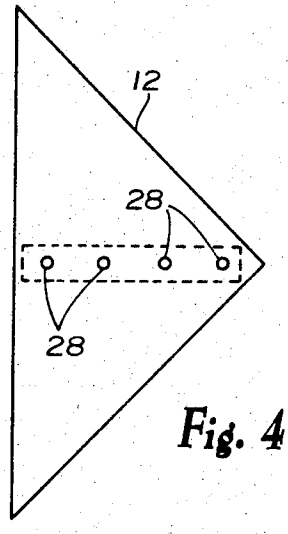



Fig. 4

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# DIRECTIONAL ANTENNA SYSTEM WITH CONICAL REFLECTOR

## BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to antenna systems and more particularly to directional antenna systems of the type which utilizes a passive reflector and active feed assembly.

2. Description of the Prior Art

Directional antenna systems of the general type disclosed herein are used predominantly in line-of-sight communication networks such as, for example, radar installation and other types of tracking stations. The efficiency at which any given directional antenna system operates depends to a great degree upon its gain, that is, the larger the gain of a directional antenna, the more signal energy it is capable of intercepting from its ambient surrounding when operating in a receive mode and the greater proportion of total available signal energy it can direct towards a particular target when operating in a transmit mode.

The gain of such an antenna system, in turn, is dependent largely on the shape and size of the reflector used therewith, as well as the manner in which the reflector is fed. Accordingly, to have an efficient directional antenna system, it is important firstly to provide an appropriately designed reflector and secondly, and just as important, to provide an active feed assembly which most advantageously cooperates with the reflector for producing the largest gain possible.

Perhaps the most commonly used types of directional antennas are the horn reflector and the passive paraboloidal dish reflector having an active feed element located at its focus, both of these reflectors displaying certain operational advantages, however, at the expense of certain disadvantages. For example, while the horn reflector exhibits small wide angle side lobes and therefore is capable, when operating as a receiver, of delivering large signal-to-noise ratio signals to its output terminals, it achieves this desirable result by utilizing a reflector which occupies an extremely large amount of space and which requires an economically prohibitive quantity of material.

The passive paraboloidal dish reflector, on the other hand, provides fairly large antenna gain for the space consumed and the amount of material required for fabrication, but, at the same time, displays poor wide angle side lobe characteristics.

It has been found, in many cases, that the efficiency at which both of these antennas operate is approximately 55 percent, which is substantially lower than that required in today's society of long range communication. In addition, both the horn reflector and paraboloidal dish reflector employ paraboloid-shaped reflecting surfaces, each of which requires a doubly curved surface. The necessity for this type of double surface makes these reflectors extremely difficult to fabricate, especially the larger reflectors used more and more in current communication systems. Moreover, to achieve the dimensional tolerances for both degrees of curvature which are required to obtain the directional characteristics sought in present applications, elaborate and time consuming manufacturing practices have been necessary.

All of the aforestated problems, such as fabrication, the large quantity of material consumed in manufacture and the large amount of space consumed by the aforestated antennas have accounted for the most recent technical variation in directional antenna systems which is the utilization of a conical or cone-shaped passive reflector. While this type of reflector has the potential of eliminating many of the disadvantages of the horn and paraboloidal dish reflectors, the conical reflector has not lived up to this potential mainly due to the inability to provide an effective active feed assembly which, as stated above, is just as important in achieving the desired end as is the reflector. It has been found that these feed assemblies not only operate in a rather poor fashion, but also are highly expensive to construct, thereby negating any savings that may be attributed to the passive reflector.



## SUMMARY OF THE INVENTION

The present invention overcomes the aforementioned disadvantages, as well as other disadvantages, by providing a directional antenna assembly which is effieient in operation, simple in design and economical to manufacture. Generally, the antenna assembly, constructed in accordance with the present invention comprises a support member positionable along the axis of a passive reflector, at least one elongated electrically conductive first element mounted to the support member and axially extendable away therefrom, at least one elongated electrically conductive second element mounted to said support member, insulated and lengthwise offset from said first conductor; and means for electrically feeding the conductive elements.

It is accordingly an object of the present invention to provide a new and improved directional antenna assembly which overcomes the aforementioned disadvantages of the prior art.

Another object of the present invention is to provide a new and improved directional antenna assembly which operates in an efficient manner and which, at the same time, is simple in design and economical to produce.

Still another object of the present invention is to provide a directional antenna assembly utilizing a new and improved active feed assembly which is efficient in operation, simple in design and economical to produce.

Yet another object of the present invention is to provide a directional antenna assembly of the last-mentioned type including a conically shaped passive reflector in combination with said new and improved feed assembly.

Still another object of the present invention is to provide a new and improved directional antenna assembly which operates with great efficiency and at high gain and which produces an electromagnetic wavefront displaying extremely low side lobes.

Yet another object of the present invention is to provide a new and improved directional antenna system including a passive conical reflector and an active feed assembly, the latter of which operates effectively as a plurality of centerfed half-wave dipoles laterally spaced along the axis of the reflector and extending perpendicular thereto, so as to provide a cylindrical radiation pattern which deflects off the inside surface of the reflector in a direction parallel with the reflector's axis.

These and other objects and features of the present invention will become more apparent from a reading of the following descriptions.

## A BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a partially broken away perspective view of a directional antenna assembly constructed in accordance with the present invention;

FIG. 2 is an enlarged perspective view of a portion of an active feed assembly which comprises part of the directional antenna assembly of FIG. 1;

FIG. 3 is an enlarged perspective view of a portion of the feed assembly of FIG. 2 with the dielectric support member removed therefrom;

FIG. 4 is a diagrammatic cross-section of the conical reflector and feed assembly of FIG. 1 and specifically illustrating the electromagnetic radiation pattern emanating from the feed assembly; and

FIG. 5 is an enlarged view of FIG. 4 specifically showing the manner in which the electromagnetic waves emanating from the feed assembly cooperate with the inner surface of the conical reflector.

## DETAILED DESCRIPTION

Turning now to the drawings, wherein like components are designated by like reference numerals throughout the various figures, a directional antenna assembly **10**, constructed in accordance with a preferred embodiment of the present invention, is illustrated in FIG. 1 and includes a conical or cone-shaped passive reflector **12**, of the unfurlable type in some applications, having a right-angle or 90° apex, that is an apex at which the axis of the reflector forms an angle of 45° with the reflector's conical surface. In this regard, it is to be understood that a reflector having an apex of any desired angle may be provided. However, it has been found that a 90° apex provides excellent directivity. An active feed assembly **14** is situated along the axis of and within reflector **12** and is connected to a transmitter and/or receiver device **16** by a coaxial cable **18** which extends through an aperture **20** provided through the surface of the reflector. Assembly **10** and particularly reflector **12** is supported by conventional means (not shown) which may include a conventional drive assembly for rotating the entire assembly, if desired.

As will be seen hereinafter, reflector **12** and feed assembly **14** cooperate to produce and transmitt electromagnetic waves having a plane wavefront propagating in the direction of the reflector's axis, as illustrated generally by arrows **22**. For purposes of description, directional antenna assembly **10** will be considered as a transmitting device as indicated by these arrows, it being readily apparent to those skilled in the art that the same may be used equally well as a receiving device. In this regard, it should be pointed out that assembly **10** may be utilized in many different ways such as, for example, in an outer space or deep space communications system, as well as in ground or atmospheric operations.

Turning to FIG. 2, attention is directed to active feed assembly **14** which includes an elongated rectangular and substantially flat dielectric support member **24** which is longitudinally situated along the axis of and within conical reflector **12**. The support member may be mounted or held in this position by any suitable means. For example, as illustrated in FIG. 1, one end of the support member is soldered to the apex of reflector **12**, while its other end is held in place by a pair of suitable connectors, such as straps **26**, fastened to the outer lip of the reflector.

A first plurality of electrically conductive cylindrical radiating elements **28**, the axial length of each of which is equal or approximately equal to one-quarter wave length at the anticipated operating frequency of assembly **10**, and a second equal plurality of electrically conductive cylindrical radiating elements **30** of the same axial length as elements **28** are suitably mounted by any conventional means to opposite sides of support member **24** and extend outwardly in a direction perpendicular thereto. As illustrated in FIG. 2, radiating elements **28** are equally laterally spaced along the longitudinal axis of support member **24** and in axial alignment with respective radiating elements **30**.

As will be described in more detail hereinafter, each pair of axially aligned elements operate as an effective center fed half-wave dipole for producing the aforestated electromagnetic waves represented by arrows **22**. In this regard, active feed assembly **14** includes a first electrical signal transfer network **32** electrically connecting the mounted ends of radiating elements **28** to the outer conductor **34** of coaxial cable **18**, as illustrated best in FIG. 2. In like manner, a second identical electrical signal transfer network **36** (shown only in FIG. 3) connects the mounted ends of radiating elements **30** to the inner conductor **38** of coaxial cable **18**.

Each network is constructed of a plurality of integrally connected flat and relatively thin conductive leads which are fixed to support member **24** in a flush fashion. The leads are suitably dimensioned (length, width and thickness) so as to match the impedance or coaxial cable **18** to the impedance of each of the radiating elements **28** and **30**. In addition, in order to eliminate many other impedance matching problems, the leads comprising network **32** are positioned on one side of support member **24** in direct alignment with the leads of network **36** positioned on the opposite side of the support member, this being illustrated best in FIG. 3. Further, the paths between coaxial cable **18** and elements **28** and **30** defined by these leads are equal or substantially equal. In this manner, the radiating elements receive equal phase and amplitude signal energy from their respectively connected conductors **34** and **38**.

While electrical signal transfer networks **32** and **36** may be constructed of any suitable conductive material, they are preferably formed from opposite sides of a standard sheet of parallel plate transmission line which, as is well known, is laminated sheet material comprising a dielectric center layer having copper-cladded layers on opposite sides thereof. In this way, by utilizing a conventional printed circuit board technique such as, for example, a photo-etching process, portions of the copper-cladded layers may be removed from the dielectric layer (which dielectric layer is used as support member **24**) so as to provide networks **32** and **36** in both an efficient and economical way.

Turning to FIG. 3, attention is directed to the manner in which each pair of axially aligned radiating elements **28** and **30** operate as an effective center-fed half-wave dipole antenna. Specifically, elements **28** and **30** are excited in the TEM mode by transmitter device **16** which provides outer conductor **34** and inner conductor **38** of coaxial cable **18** with current signals flowing in opposite directions. In this manner, the current which is transferred to each element **28** flows in the

same direction as the current flowing through each element **30**, as generally indicated by respective groups of arrows **40** and **42**. Since, as stated above, the length of each element is approximately one-quarter wavelength, typical half-wave dipole standing waves of current and voltage develop in the radiating elements. Accordingly, for all practical purposes, each pair of axially aligned elements effectively operates as a center-fed half-wave dipole antenna. With each of these effective dipole antennas positioned along the axis of conical reflector **12** in the aforedescribed manner, a cylindrically shaped pattern of electromagnetic waves, generally indicated by dotted lines in FIG. **4**, develops concentrically about the axis of reflector **12** and propagates in a direction perpendicular thereto, as illustrated best in FIG. **5**.

Turning to FIG. **5**, attention is directed to the manner in which the cylindrical pattern of electromagnetic energy of FIG. **4** cooperates with conical reflector **12** for transmitting axially propagating electromagnetic waves **22**. This may be illustrated best by randomly choosing three rays of electromagnetic energy, designated *a*, *b* and *c*, emanating from arbitrarily chosen points on active feed assembly **14**. These rays impinge upon, or come into contact with conical reflector **12** at an angle of 45° to its surface, i.e., generally at an angle equal to the angle between the axis and surface of the reflector. The continuation of rays *a*, *b* and *c*, designated rays *a'*, *b'* and *c'*, respectively, are reflected from conical reflector **10** at an angle of 45° to its surface. Therefore, in accordance with geometrical considerations, continuation rays *a'*, *b'* and *c'*, which are analogous to rays **22** of FIG. **1**, propagate in direction parallel to the axis of reflector **12**. In addition, geometrical considerations further establish that the electromagnetic energy path lengths between active feed assembly **14** and a plane perpendicular to the axis of reflector **12** are equal, that is, the path length $a+a'$ equals the path length $b+b'$ which, in turn, equals the path length c+c'. In this manner, since all of the rays radiating from active feed assembly **14** emanate in phase as indicated by the term $\phi_0$ in FIG. **5**, they combine in phase forming wavefront **22**.

With conical reflector **12** and active feed assembly **14** constructed and operated in the aforedescribed manner, it has been theoretically found that directional antenna system **10** operates at approximately 90 percent efficiency with slight spillover and heat losses accounting for the remaining 10 percent. In addition, the electromagnetic waves produced by this system display extremely low level side lobes thereby adding to the efficiency thereof. While the improved manner in which system **10** operates is of great value, it is of even greater value when considering the simple and economic way in which it is constructed and the small amount of space occupied. As an example of the aforestated operation, it has been found theoretically that at an operating frequency of, for example, 2,000 MHz, assembly **10** has shown a gain 1.8 db greater than the conventional parabolic type reflector assembly, after taking into account both heat loss and spillover. It should be noted that at this frequency, the overall length of each pair of axially aligned radiating elements is approximately 2½ inches, which illustrates the small amount of space required by active feed assembly **14**, the cross-sectional maximum diameter of reflector **12** being approximately 4 feet. In this regard, it is to be understood that reflector may be of any desired size depending upon the manner in which it is used.

While system **10** has been described operationally as a transmitting device, it should be readily apparent to those skilled in the art that the same may be used equally well as a receiving device. In addition, although a single embodiment of the present invention has been illustrated and described, it is anticipated that various changes and modifications be apparent to those skilled in the art, and that such changes may be made without departing from the scope of the invention as defined by the following claims.

What is claimed is:

**1.** An active feed assembly for use in a directional antenna system having a passive reflector element such as a conical reflector, said assembly comprising: and elongated support member of thin dielectric material longitudinally positionable long the axis of said conical reflector; a plurality of elongated electrically conductive first elements mounted to one side of said support member and axially extending in a direction substantially perpendicular thereto; a plurality of elongated electrically conductive second elements mounted to an opposite side of said support member, insulated from said first elements and axially extending in a direction substantially perpendicular to said support member; and means for electrically feeding said conductive elements including first and second feed means respectively, electrically connected to said first and second conductive elements, said first and second feed means being thin metallic cladded leads on opposite sides of said thin dielectric support member, each of said feed means being aligned with one another and dimensioned so as to transfer substantially equal phased signals to said first and second conductive elements, respectively.

**2.** A directional antenna system comprising: a passive reflector having a predetermined axis; an elongated support member positioned along the axis of said reflector; means for supporting said member along said axis; and an active feed assembly including a plurality of half-wave dipoles insulated with respect to one another and mounted to said support member and spaced longitudinally along said support member, said active feed assembly including means for electrically feeding said dipoles at equal phase including a plurality of relatively thin and flat conductive leads mounted to said support member and wherein said support member is of dielectric material, said support member and said electrical feeding means each comprising part of a sheet of parallel plate transmission line.

* * * * *