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SCANNING HORN-REFLECTOR ANTENNA

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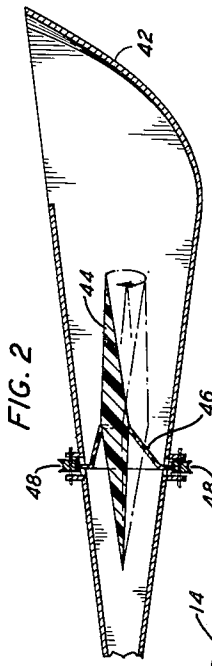

FIG. 2

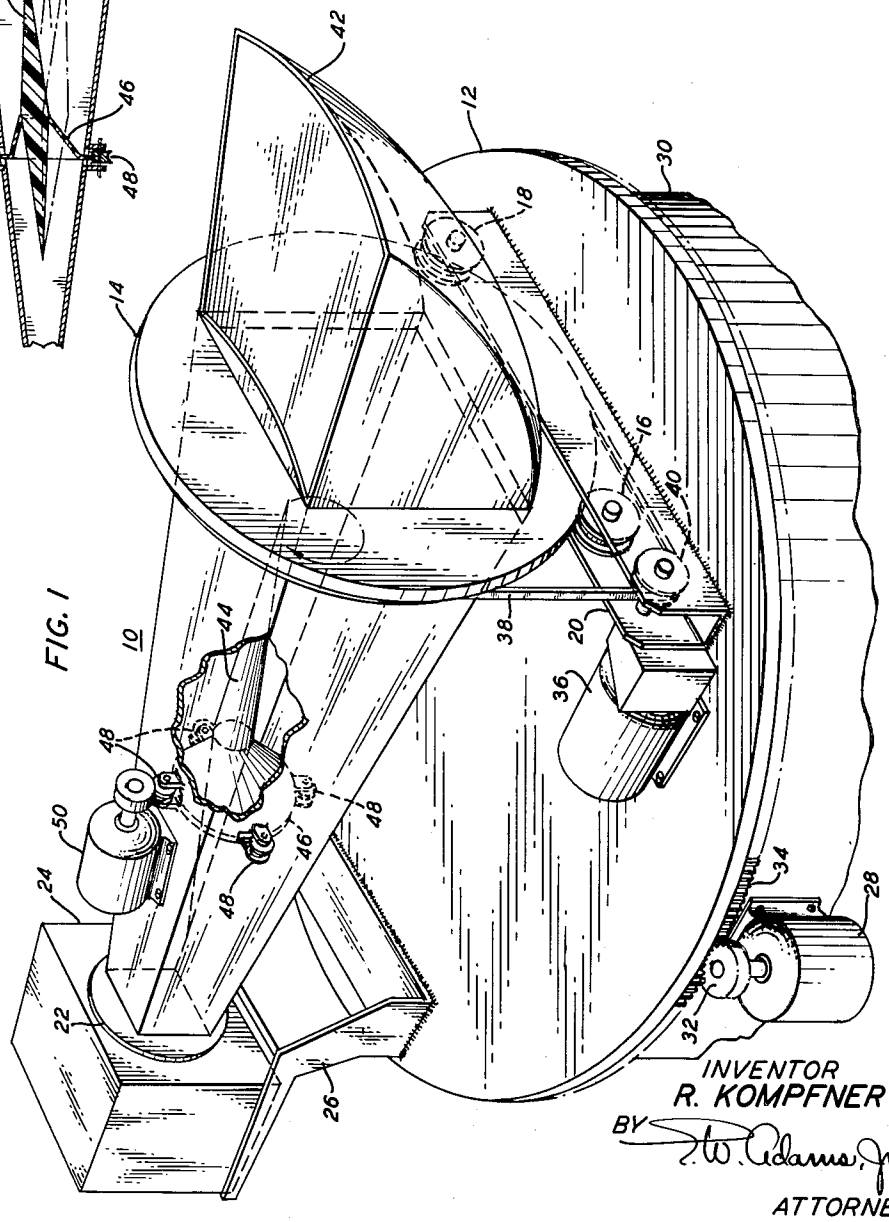

FIG. 1

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SCANNING HORN-REFLECTOR ANTENNA

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This invention relates to microwave antennas and more particularly to horn-reflector antennas suitable, by virtue of an easily adjustable radiation pattern, for use as scanning or tracking antennas.

The horn-reflector antenna as disclosed in Patent 2,416,675 to A. C. Beck et al., March 4, 1947, has received wide acceptance as a broadband microwave antenna and has been used primarily as the transmitting and receiving antenna of broadband radio relay systems. In such applications, the radiation pattern of the antenna is fixed and the antenna is physically oriented in such a way as to concentrate the radiation pattern very precisely in the direction required for transmission to or reception from the next station of the relay system. It has been found, however, that the horn-reflector antenna, in addition to its other desirable properties, is capable of operation as an extremely low-noise receiving antenna. The relative freedom from back lobes in the antenna pattern fits the antenna for use in receiving signals from sources presenting a low-noise temperature. Thus, such antennas may profitably be used in radio astronomy and similar applications. In such use, the horn-reflector antenna may be considered as a low-noise temperature source of microwave energy and is particularly suited for use in connection with maser and similar low-noise amplifiers which are practicable only when the applied signal is from a low-noise temperature source.

In radio astronomy and related applications, however, the horn-reflector antenna, which heretofore has been employed primarily in fixed mounts, is called upon to track a moving object. If such tracking is to be accomplished automatically, as is extremely desirable, a source of tracking error signal is required. While this might be furnished by a separate system of some sort, the most attractive arrangement is that in which the radiation pattern of the antenna may be shifted slightly on a periodic basis to provide for so-called lobing of the radiation pattern. The slight difference in incoming signal, which occurs when the antenna is not directed exactly at the source thereof, provides an error voltage which may be utilized in a servo system of conventional configuration to direct a moving signal source.

It is therefore the object of the present invention to improve the horn-reflector antenna to permit its use as a scanning or tracking antenna.

In accordance with this object, the conventional horn-reflector antenna, which consists of a feed horn located at the focus of a paraboloidal reflector, is modified by mounting a dielectric body generally on an axis intersecting the axis of the feed horn and between the feed horn and the reflector. Means are provided for rotating the dielectric body about the horn axis to produce a variable differential delay in the microwave energy as it travels from the feed horn to the reflector. From another point of view, the dielectric body may be considered as a means for adjusting the focus of the reflector with respect to its normal position at the center of the mouth of the feed horn for reception of a wave tilted so that it would otherwise not arrive at the focus. In any event, the radiation pattern of the antenna is swept in a generally circular path providing the lobing action desired.

The above and other features of the invention will be considered in detail in the following specification taken in connection with the drawing in which:

FIG. 1 is a perspective view partially broken away, illustrating the general configuration of a scanning antenna according to the invention; and

FIG. 2 is a partial sectional view taken on the vertical median plane of the antenna of FIG. 1.

The scanning antenna of the invention is shown in FIG. 1 as it may be arranged for use in radio astronomy or like applications. Here, the axis of the antenna horn is shown as horizontal rather than vertical so that the antenna pattern may be in a vertical plane and the antenna may be employed in scanning the sky or tracking objects therein. Thus, a horn-reflector antenna structure 10 of essentially the same configuration as that shown in the patent referred to above is mounted with its horn axis horizontal and is supported on a rotatable platform 12. To this end, the large end of the horn-reflector assembly is mounted in a disc 14 through which it extends and this disc is supported for rotation upon rollers 16 and 18 which, in turn, are journaled in a frame 20 mounted on platform 12. The small end of the antenna is supported in a smaller disc 22 which is journaled for rotation in the front face of an equipment enclosure 24, supported upon a bracket 26, also mounted on turntable 12.

The equipment enclosure 24 is shown schematically in FIG. 1 and may include, in addition to the support for the antenna, mounting and shelter for at least the initial input stages of the radio receiver or transmitter, or both, to be used with the antenna. Such an arrangement is of particular practicability with the horn-reflector antenna since the antenna is of essentially square cross-section and may be fed with any desirable polarization from a circular wave guide. This permits short waveguide runs to the input stages of the receiver and only a single rotatable connection or joint is required between the antenna itself and the receiver.

A motor 28 is shown as mounted on a base 30 upon which platform 12 is journaled and provision is made for rotating platform 12 by way of a pinion 32 which engages a rack 34 secured to platform 12. In addition, a second motor 36, mounted on platform 12, is arranged to rotate the antenna about its horizontal axis by means of a belt or chain drive 38. This belt extends over disc 14 and also over a drive pulley 40 which is driven through reduction gearing by the motor. It will be recognized that through rotation of platform 12 and rotation of antenna 10 about its horizontal axis, any location within a hemisphere centered at the center of platform 12 may be covered by the radiation pattern of the antenna.

Although the antenna as thus far described is of considerable advantage as a low-noise temperature antenna to be used in tracking celestial objects as in radio astronomy, the fact that some external system must be provided to permit tracking of a moving object is a shortcoming. To eliminate this difficulty, there is provided, in accordance with the invention, a scanning device which is located within the antenna between the feed horn source and the reflector thereof. Generally, a reflector 42 is so located with respect to the source that the focus of the reflector falls at the center of the feed horn and in the plane of the mouth thereof. For the purpose of this discussion, the antenna may be considered as comprising a feed horn located in the plane of disc 22 and a paraboloidal reflector spaced therefrom along the axis of the feed horn and connected therewith by conductive extension of the feed horn walls which form a flaring box of essentially rectangular cross-sections, this box being interrupted only at the right-hand end of its upper surface to permit radiation of waves reflected from reflector 42.

The fixed radiation pattern normally provided by this antenna configuration is caused to sweep by the interposition of a dielectric body 44 in the path between the feed horn and the reflector and by the provision of means

for rotating or otherwise moving the dielectric body to introduce a varying differential delay in electromagnetic waves radiated from the feed horn to the reflector.

In one convenient arrangement as shown in FIGS. 1 and 2, the dielectric body has a longitudinal dimension which is large as compared to its diameter or cross-section in a plane at right angles to the longitudinal dimension and is mounted within the extension of the feed horn in such a way that the longitudinal axis of the body intersects the axis of the feed horn. Because of the presence of the dielectric, the waves traveling from the feed horn to the reflector are more delayed in one portion of the wave front than in another and reach the paraboloidal reflector at different times rather than simultaneously. The net result is the same as that which would be introduced if the feed horn or the reflector were moved so that the focus of the reflector no longer fell at the center of the feed horn. If, now, the dielectric body is caused to rotate or otherwise move about the longitudinal axis of the antenna, the virtual focus of the assemblage will also move and the radiation pattern of the antenna will be correspondingly swept with respect to the normal pattern thereof.

As shown in the drawing, the dielectric body 44 conveniently comprises a pair of right circular cones of altitudes, which are large as compared to their diameters, joined base-to-base and supported with their central axes at an angle to the axis of the feed horn. To this end, a conical structure 46, which may be made of polyfoam or other material of low dielectric constant and has the general form of an oblique cone, is mounted with its base at right angles to the longitudinal axis of the antenna. The dielectric body 44 then is mounted with its axis coincident with the axis of the supporting structure and is accordingly supported with its axis intersecting the longitudinal axis of the antenna. Conveniently, conical structure 46 is supported by rollers 48 which extend through the walls of the antenna shield horn and are so located that conical structure 46 and the dielectric body supported thereby may be rotated within the antenna horn to provide the desired scanning of the antenna pattern. In FIG. 1, an electric motor 50 is externally mounted on the top of the antenna structure and drives one of rollers 48 to provide the desired rotation of dielectric body 44.

While dielectric body 44 has been shown as being a double cone, it will be recognized that a wide variety of shapes may be employed as required to provide a sufficient differential delay of energy traveling from the source to the paraboloidal reflector of the antenna, and further, that a wide variety of materials including both the better known dielectrics and such materials as ferrites may be employed for this purpose. It is advantageous, however, to provide a dielectric body 44, the ends of which are tapered to reduce or eliminate reflections which might otherwise occur by virtue of the introduction of the change in dielectric constant of the transmission medium within the antenna horn. Obviously, it is also desirable that the dielectric body and its supporting structure be of as light a weight as possible to reduce the vibration effects introduced by rotating an unbalanced mass within the antenna structure at relatively high speeds.

What is claimed is:

1. In a scanning antenna system, a horn-reflector antenna having a waveguide feed horn and a paraboloidal reflector spaced from said feed horn along the longitudinal axis of said feed horn and interconnected by a shield horn, and means for varying the radiation pattern of said antenna comprising an elongated body of dielectric material of maximum cross-section less than the corresponding cross-section of said shield horn, means supporting said body within said shield horn including a member of material substantially transparent to radio frequency energy mounted within said shield horn for rotation about the longitudinal axis of said feed horn, said member supporting said body to extend generally between said feed horn and said reflector with the longitudinal axis of the body intersecting that of said feed horn and means external to said shield horn for rotating said member about its axis.

2. In a scanning antenna system, a horn-reflector antenna having a waveguide feed horn and a reflector spaced therefrom along the feed horn axis, and means for varying the radiation pattern of energy radiated from said reflector comprising a member of low dielectric constant mounted between said feed horn and said reflector for rotation about said feed horn axis, a dielectric body which is a solid of revolution tapered at both ends and of higher dielectric constant, the length of said body along its axis being large as compared with its maximum cross-section, said body being supported by said member with the longitudinal axis of the body intersecting the feed horn axis and means for rotating said member about said feed horn axis.

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