Dec. 27, 1966 S. E. MILLER 3,295,136

ANTENNA SYSTEM WHEREIN BEAMWIDTH VARIATION IS ACHIEVED BY CHANGING APERTURE AREA OF PRIMARY ANTENNA

Original Filed July 9, 1963

FIG. 1

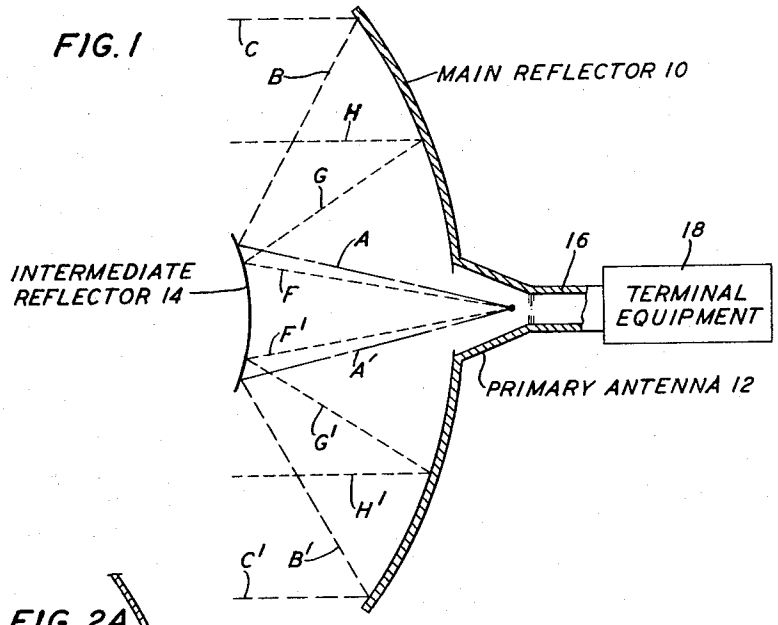


FIG. 2A

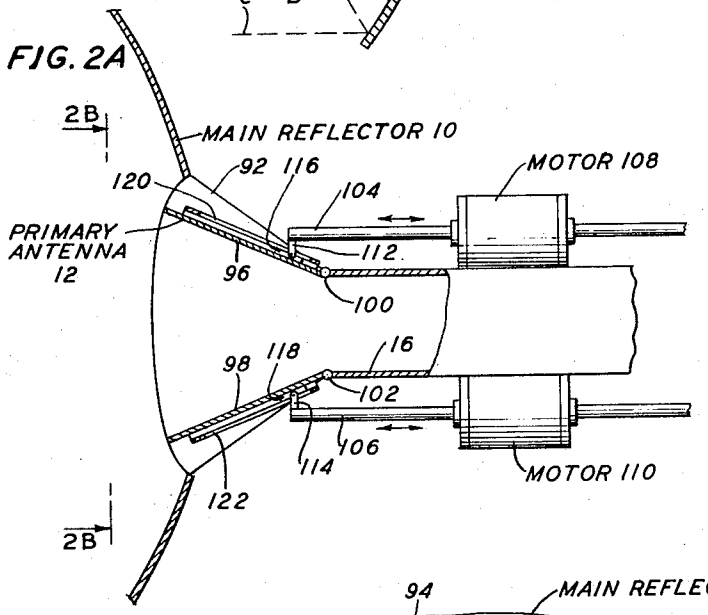
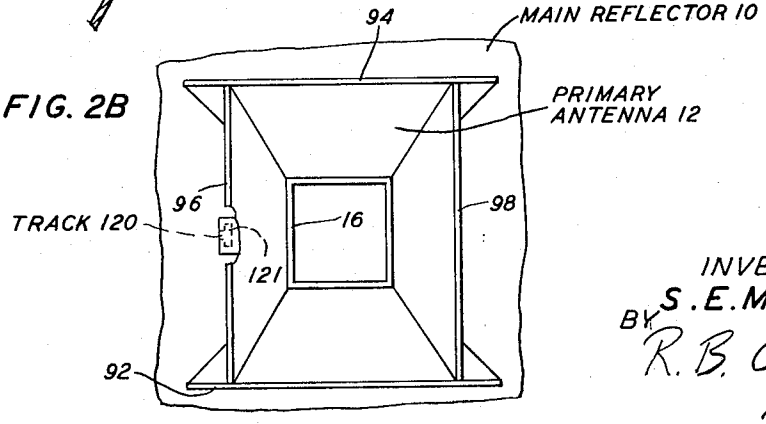


FIG. 2B



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ANTENNA SYSTEM WHEREIN BEAMWIDTH VARIATION IS ACHIEVED BY CHANGING APERTURE AREA OF PRIMARY ANTENNA

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4 Claims. (Cl. 343—781)

This application is a division of application Serial No. 293,610, which was filed July 9, 1963, now Patent No. 3,254,342.

The present invention relates to antenna systems, and more particularly, to a variable-beamwidth antenna system of the type having a passive reflector and an active feed therefor.

In some applications for an antenna system of the type having a passive dish reflector and an active feed therefor it is desirable to have the capacity to vary the beamwidth of the principal lobe of the radiation pattern of the antenna system, so that a single antenna structure can be employed alternatively to perform two functions. As an example of such an application, a single antenna system capable of producing both a broad beam and a narrow beam, alternatively, can be employed in a radar system respectively for acquisition and tracking of a target. Dual use of a single antenna system under appropriate circumstances can result in conservation of space and equipment.

Dish antenna systems have been designed that cause variations in beamwidth by changing the contour of the main reflector surface. Although not too difficult in small dish reflectors, this technique when employed to vary the beamwidth of huge dish reflectors, such as are becoming commonplace in modern long-range communication systems, creates structural problems of a high order due to the extensive area of the reflector surface that must be moved to change the contour of the reflector.

It is also a practice to vary the beamwidth of a dish antenna system by moving the feed away from the focus of the dish reflector, i.e., by defocusing the system. The beamwidth of an antenna system is fairly insensitive to defocusing, however, and large displacement of the feed from the focus is necessary to vary the beamwidth appreciably. Providing for such large displacement can involve structural problems equal in severity to those encountered in distorting the contour of the reflector.

In addition to the structural complications introduced by designs that permit variation of beamwidth of an antenna system, the radiation pattern of the antenna system is often adversely affected. For example, the wide-angle sidelobes of the radiation pattern may increase, detracting from the effectiveness of the principal lobe.

It is, therefore, the object of this invention to vary the beamwidth of an antenna system of the type having a passive reflector and an active feed therefor over a broad range of values without large displacement of the feed, movement of an extensive area of the reflector surface, or introduction of adverse effects in the radiation pattern of the antenna system.

In accordance with this object, in an antenna system of the type having a passive reflector and an active feed therefor, variation of beamwidth is accomplished by changing the extent of coupling between the reflector and the feed, i.e., by changing the area of illumination of the reflector when the antenna system is considered in a transmitting mode. The beamwidth of a dish

antenna system may thus be changed since it is a well-known fundamental in the microwave antenna art that such beamwidth is inversely related to the area of illumination of the dish reflector.

A Cassegrainian feed is employed in one embodiment of the invention in which the primary antenna radiation pattern is changed. This can be accomplished by varying the aperture area of the primary antenna, which changes the area of illumination of the intermediate reflector and, in turn, changes the area of illumination of the dish reflector. The primary antenna comprises a pyramidal horn opposite walls of which are hinged to pivot at the throat of the horn. Movement of the unhinged ends of these walls varies the aperture area of the primary antenna.

The above and other features of the invention will be more fully understood from the following detailed description considered in conjunction with the drawings in which:

FIG. 1 is a plan view partially in section of an antenna illustrating the principles of the invention; and

FIGS. 2A and 2B are sections of plan and front elevations, respectively, of a primary antenna structure whose aperture area is controllable.

In FIG. 1 an antenna system is shown comprising a main reflector **10**, shown as of parabolic shape, and a Cassegrainian feed having a primary antenna **12** and an intermediate reflector **14**. Intermediate reflector **14** is attached to main reflector **10** by spars, not shown, in conventional fashion. Main reflector **10** can take, for example, the shape of a concave paraboloid or a parabolic cylinder. If a paraboloidal main reflector is employed, beamwidth variation in either one or two planes might be desired, depending upon the application at hand. If a concave parabolic cylinder is defined by the surface of main reflector **10**, beamwidth variation generally would be confined to a single plane, viz., to the plane passing through main reflector **10** upon which a parabola is projected. The arrangements described hereinafter are applicable either to vary beamwidth in a single plane or in two planes.

The antenna system of FIG. 1 will be described operating in the mode of transmission. It will be understood, as in antenna operations generally, that reciprocity applies and that the antenna system receives electromagnetic waves in a fashion reciprocal to that of the described mode of operation. The extent of coupling between feed and reflector is described in the parlance of the antenna art as the area of illumination of the reflector by the feed, connoting operation as a transmitter. When this terminology, i.e., area of illumination, is used in the course of the detailed description of the following arrangements and in the claims it shall not be taken as limiting the antenna system to operation as a transmitter.

Waveguide **16** in FIG. 1 connects terminal equipment **18** to primary antenna **12**. Rays A and A′ represent the outer limits of the electromagnetic wave radiated from primary antenna **12** toward intermediate reflector **14** and are reflected therefrom within the limits indicated by rays B and B′. Rays B and B′, in turn, impinge upon and are reflected from main parabolic reflector **10** as rays C and C′ to form the outer ray limits of the ultimate antenna beam. The distance between rays C and C′ represents the area of illumination of main reflector **10**, which area is inversely related to the beamwidth of the principal lobe of the far field radiation pattern of the antenna system.

It will now be assumed that the characteristics of primary antenna **12** are changed so that its radiation pattern limits are represented by rays F and F′ which impinge upon intermediate reflector **14** and reflect there-

from within the limits represented by rays G and G'. Rays G and G' reflect from main parabolic reflector **10** as rays H and H', forming the outer ray limits of the ultimate antenna beam. It is apparent from comparison of the distance between rays H and H' with the distance between rays C and C' that a change in the area of illumination of main parabolic reflector **10**, and consequently in antenna beamwidth, can be accomplished by controlling the beamwidth of the radiation pattern of primary antenna **12**.

FIGS. 2A and 2B disclose a structure for primary antenna **12** that permits regulation of its radiation pattern. Primary antenna **12** takes the form of a pyramidal horn having stationary walls **92** and **94** and movable walls **96** and **98**, pivoted about hinges **100** and **102**. Shafts **104** and **106** are translated by motors **108** and **110**, respectively. The translational motion of shafts **104** and **106** is transferred to walls **96** and **98** by means of interconnecting members **112** and **114**, respectively, and arms **116** and **118**, respectively, which are constrained to motion within tracks **120** and **122**, respectively. As a result, movement of shafts **104** and **106** from right to left pushes the unhinged ends of walls **96** and **98** inwardly, thus contracting the aperture area of primary antenna **12**. Conversely, movement of shafts **104** and **106** from left to right causes arms **116** and **118** to exert force against flanges **121** of tracks **120** and **122**, which is transferred to walls **96** and **98** causing them to move outwardly and dilate the aperture of primary antenna **12**. The effect of change in the aperture area of primary antenna **12** upon the beamwidth of the antenna system far field depends upon the location of intermediate reflector **14** with respect to primary antenna **12**. If intermediate reflector **14** is placed in the near field of the radiation pattern of primary antenna **12**, as taught in U.S. Patent 3,231,893, issued on January 25, 1966 to D. C. Hogg, and assigned to the assignee of this invention, dilation of the primary antenna aperture increases the beamwidth of the wave impinging upon intermediate reflector **14** and, as discussed in connection with FIG. 1, decreases the far field beamwidth. On the other hand, if intermediate reflector **14** is situated in the far field of primary antenna **12**, as is normally the case, dilation of the aperture of primary antenna **12** decreases the beamwidth of the wave impinging upon intermediate reflector **14** and, as discussed in connection with FIG. 1, increases the far field beamwidth.

If it is desired to vary both aperture dimensions of primary antenna **12**, walls **92** and **94** would be hinged and provided with apparatus, similar to that shown for walls **96** and **98**, for moving them. In this case, gaps would exist at the corners of the horn in some conditions, but these gaps would not adversely affect performance if not too large.

Practice of this invention is not limited to a Cassegrainian feed arrangement. A Cassegrainian feed arrangement, however, has many characteristics that enhance the radiation pattern of an antenna system and permits control of the area of illumination of the main parabolic reflector by means of relatively simple mechanical apparatus. Beamwidth control can be accomplished by providing a conventional feed located at the focus of the main parabolic reflector and varying the radiation pattern thereof. This can be done, for example, by providing a horn like that shown in FIGS. 2A and 2B at the focus, directed toward main reflector **10**.

What is claimed is:

1. An antenna system with means for changing the beamwidth of the radiation pattern of electromagnetic waves radiating from said antenna system which comprises a concave reflector having a focus and a vertex, said electromagnetic waves emanating from said concave reflector and having a plane wavefront, a single radiating primary antenna located near said vertex, said radiating primary antenna having its axis coincident with and its radiation pattern directed along the axis of said concave reflector toward said focus, an intermediate reflector having its axis coincident with the axis of said concave reflector, said intermediate reflector being situated to intercept the radiation pattern of said radiating primary antenna, thereby coupling waves between said radiating primary antenna and said concave reflector, and means for changing the aperture area of said radiating primary antenna, thereby controlling the extent of coupling between said radiating primary antenna and said concave reflector to change the beamwidth of the radiation pattern of said antenna system without changing the plane wavefront characteristics and the direction of radiation of the electromagnetic waves emanating from said concave reflector.

2. An antenna system with means for changing the beamwidth of the radiation pattern of electromagnetic waves radiating from said antenna system which comprises a concave reflector having a focus and a vertex, said electromagnetic waves emanating from said concave reflector and having a plane wavefront, a single radiating primary antenna located near said vertex, said radiating primary antenna comprising a pyramidal horn having its axis coincident with and its radiation pattern directed along the axis of said concave reflector toward said focus, an intermediate reflector having its axis coincident with the axis of said concave reflector, said intermediate reflector being situated to intercept the radiation pattern of said radiating primary antenna, thereby coupling waves between said radiating primary antenna and said concave reflector, and means for changing the aperture area of said radiating primary antenna, thereby controlling the extent of coupling between said radiating primary antenna and said concave reflector to change the beamwidth of the radiation pattern of said antenna system without changing the plane wavefront characteristics and the direction of radiation of the electromagnetic waves emanating from said concave reflector.

3. The variable-beamwidth antenna system according to claim **2** in which said pyramidal horn comprises four walls, opposite walls being hinged at the throat of said pyramidal horn, and means for moving the unhinged extremities of said walls to vary the aperture of said horn.

4. The variable-beamwidth antenna system according to claim **2** in which said pyramidal horn comprises four walls, having at least two of said opposite walls hinged at the throat of said horn, and means for moving the unhinged extremities of said hinged walls to vary the aperture of said horn.

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