

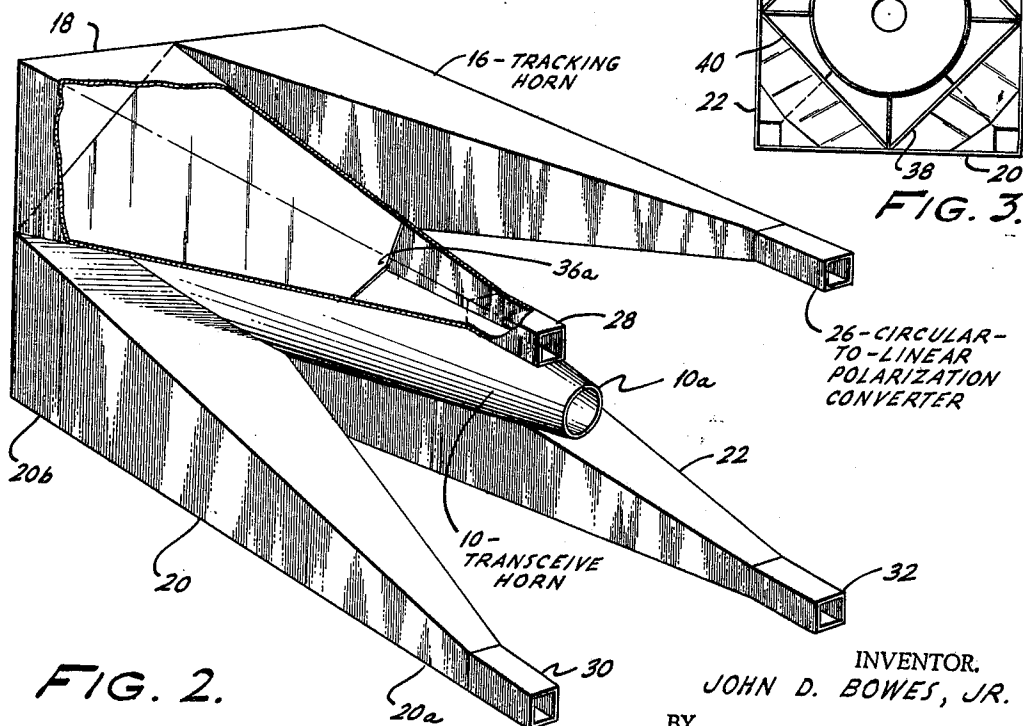
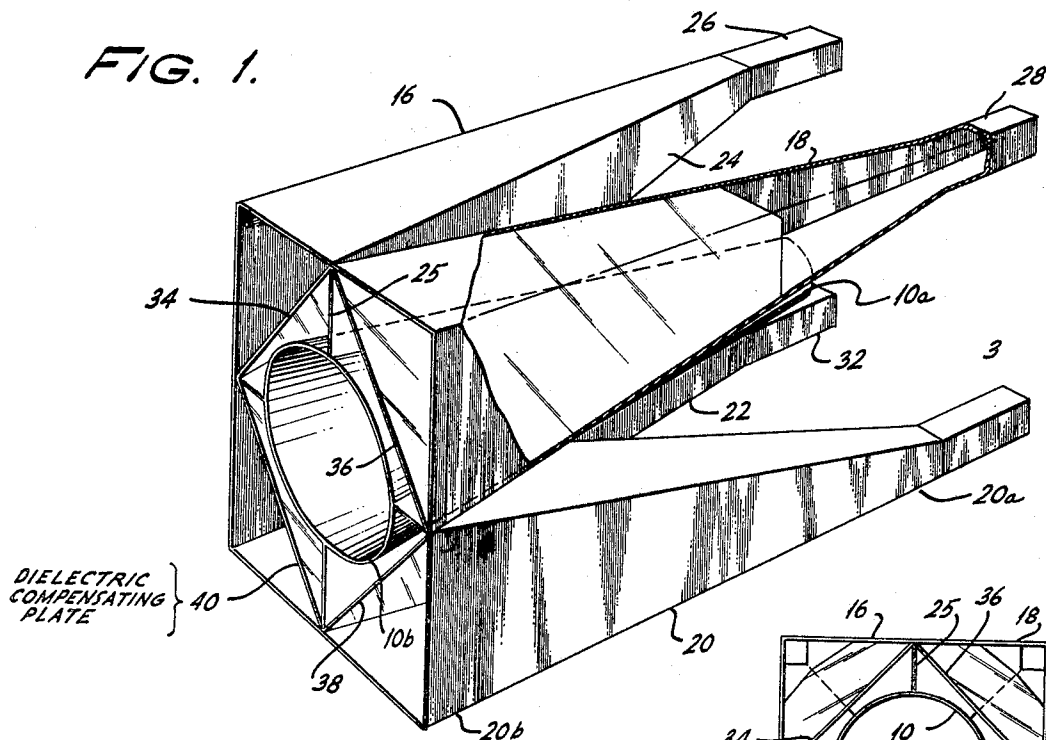
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TRANSCIVE AND TRACKING ANTENNA HORN ARRAY

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TRANSCIVE AND TRACKING ANTENNA HORN ARRAY

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ABSTRACT OF THE DISCLOSURE

Transceive and tracking antenna horn array utilizing circular center horn surrounded by four adjacent square outer tracking horns, each outer horn having a sector removed to accommodate center horn and each outer horn containing a diagonal dielectric plate to compensate for removed sector.

This invention relates to antennas and more particularly to an array of antenna horns for performing transmit/receive (transceive) and tracking functions.

In order to communicate with a satellite from a ground station, a transceive antenna system is required for prime communications, and a tracking antenna system is required in order to obtain direction-related signals to enable any misorientation of the antenna with the satellite to be corrected. Heretofore, transceive and tracking antenna systems have used a rectangular center horn for transmitting and receiving the main communication signal to and from the satellite and four outer tracking horns spaced around the center horn for providing four different versions of the signal for tracking purposes. Appropriate antenna reflectors were provided to focus the received signal into a concentrated beam directed at the center horn, with a portion of the less-concentrated part of the received signal surrounding the concentrated beam being collected by the outer horns. Representative horn arrays of the above type are shown in U.S. Patents 2,929,056 to Page (Mar. 15, 1960) and 3,045,238 to Cheston (July 17, 1962).

Prior art horn arrays of the above type had various difficulties associated therewith, namely: (1) the radiated signal pattern had large sidelobes, resulting in transmitted signal loss and low received signal-to-noise ratio, (2) empty spaces around the center horn caused a partial loss of the less-concentrated part of the received signal, thereby decreasing tracking efficiency, and (3) the centers of phases of the outer horns were relatively widely spaced from each other, which also resulted in inefficient tracking.

Arrangements have also been proposed, as typified in Patent 2,677,055 to Allen (Mar. 27, 1954), in which the transceive and tracking antenna horn array consists of four adjacent rectangular outer horns surrounding a circular center horn. However these arrangements, while eliminating some of the difficulties of the aforementioned arrays, suffered from the inability to couple and receive a large amount of signal energy efficiently through the center horn. In addition, they were unable to track accurately because the outer horns were unable to receive a circularly polarized signal due to the presence of the removed sector which accommodated the center horn.

The horn array of the present invention overcomes the disadvantages of the aforementioned prior art arrangements. Accordingly several objects of the present invention are: (1) to provide an antenna horn array which has an improved radiation pattern with smaller sidelobes than prior art arrangements, (2) to provide a horn array in which a maximum of the less-concentrated part received signal surrounding the focused beam thereof is collected and

utilized by the outer tracking horns, (3) to provide such an arrangement in which the centers of phases of the tracking horns are closely spaced, thereby resulting in improved tracking, (4) to provide such an arrangement in which large amounts of power can be transceived efficiently by a center horn, and (5) to provide such an arrangement in which the outer tracking horns can receive a circularly polarized signal. Other objects and advantages of the present invention will become apparent from a consideration of the following description thereof.

SUMMARY

According to the present invention a transceive and tracking antenna horn array utilizes a conical center horn surrounded by four adjacent square outer horns, each of which has a sector removed so that the four outer horns can closely surround the center horn. Each of the four outer horns has a dielectric plate fitted diagonally between opposing corners thereof in order to provide electrical compensation for the removed sector thereof.

DRAWINGS

FIG. 1 shows a perspective front view of the antenna horn array of the invention, FIG. 2 shows a perspective rear view thereof, and FIG. 3 shows a front view thereof.

DESCRIPTION

As shown in the three views thereof, the transceive and tracking antenna horn array of their invention comprises a circular conical center horn 10 having a relatively small apex portion 10a and a relatively large flared portion 10b. Surrounding the center horn are four outer tracking horns 16, 18, 20 and 22, each of which has a relatively small square apex portion, such as portion 20a of horn 20, and a relatively large flared portion, such as portion 20b of horn 20. The flared portions are not completely square but have an arcuate sector in lieu of one corner thereof in order to accommodate the flared portion 10b of the circular center horn. The four tracking horns and the center horn may be formed individually and then may be assembled so that the four tracking horns adjoin or lie closely to each other and the center horn at their forward or flared ends. The outer walls of the tracking horns will thus define an outer square and their arcuate segments will define an inner circle which accommodates the center horn. Alternatively the tracking horns can be partially formed without arcuate segments and then attached to the center horn so that the flared end thereof will also serve as the arcuate segments of the tracking horns. The outer or full walls of the tracking horns are perpendicular to the front plane formed by the flared ends of all five horns. The inner or partial walls of the tracking horns, such as wall 24, are not perpendicular to said front plane but are angled as shown to produce the taper of the tracking horns. At the front of the array the inner walls of adjacent horns desirably abut one another as shown so as to define four segments, such as segment 25, which perpendicularly connect the outer square defined by the outside walls of the outer horns with the outside surface of the center horn. Coupled to the rear or apex end of each of the outer horns are four circular-to-linear polarization converters 26, 28, 30 and 32 which may be of conventional form. Tracking circuitry (not shown) is coupled to the outputs of the polarization converters.

According to the invention, four dielectric compensating plates 34, 36, 38 and 40 are fitted within the outer horns. As shown in the cutaway views of horn 18 in FIGS. 1 and 2, each of the dielectric compensating plates extends between the diagonally opposite corners of its respective outer horn and runs along its respective horn from the flared portion to the point where the arcuate segment vanishes from a cross section to form a

square horn cross section. To provide good matching between the horns and the polarization converters, each of the dielectric compensating plates has a pointed section, such as section 36a of plate 36, which extends through the end of the arcuate portion into the square portions of these horns. Each of the dielectric compensating plates should have a dielectric constant of from 2 to 3. Dielectric materials suitable for this purpose are those sold under the trade names "Rexolite" and "Plexiglas."

The dimensions of the center and outer horns are governed in the usual fashion in inverse proportion to the frequencies of the transmitted and received signals. In one operational embodiment of the invention the signal transmitted through the center horn ranged from 7.9 to 8.4 GHz. and the signal received by the center horn and the four outer horns ranged from 7.25 to 7.75 GHz. In this embodiment the dimensions of each side of the flared portion of each outer horn was about 3 inches. Thus the outer square had a dimension of about six inches on a side. In another embodiment of the invention wherein the transmitted and received signals were on the order of 3-4 GHz., the dimension of a side of the flared portion of each outer horn was about 12 inches.

Since the transmitted and received signals are both supplied and received at the apex portion 10a of the center horn, it is necessary to separate these signals and couple them to separate transmit and receive waveguides (not shown) so that they can be processed by a transmitter and a receiver (not shown). One suitable arrangement for this purpose utilizes an orthogonal mode transducer coupled to the end of the apex portion 10a. One output of the orthogonal transducer is coupled to one terminal of a 90° hybrid section via a 90° twist waveguide section and the other output of the orthogonal mode transducer is coupled to another terminal of the 90° hybrid section via a phase adjusting waveguide section. One end of a "transmit" waveguide is coupled to a third terminal of the 90° hybrid section via a received signal frequency rejecting filter, and one end of a "receive" waveguide is coupled to the fourth terminal of the 90° hybrid section via a transmit signal frequency rejecting filter. The other ends of the transmit and receive waveguides are coupled to a transmitter and a receiver, respectively.

The signals received by the tracking horns, after translation through the polarization converters 26, 28, 30 and 32, are coupled to error signal circuitry (not shown) which generates horizontal and vertical error signals for driving positioning controls which correct the orientation of the antenna with respect to the satellite. In one embodiment a vertical error signal was synthesized by subtracting the sum of the output signals from horns 16 and 18 from the sum of the signals from horns 20 and 22. A horizontal error signal was synthesized by subtracting the sum of the signals from horns 16 and 22 from the sum of the signals from horns 18 and 20.

The most advantageous antenna reflector arrangement for the horn array is a Cassegranian system (such as shown in FIG. 25-10 on p. 25-12 of the "Antenna Engineering Handbook," by Jasik, McGraw-Hill, 1961) in which the signals travel from the horn array to the satellite (and vice versa) via a hyperboloid subreflector and a circular paraboloid main reflector. The orientation of the entire assembly, including the horn array, subreflector, and main reflector, will be aimed at the satellite by means of a servomechanism arrangement which is driven by the aforementioned vertical and horizontal error signals.

OPERATION

In operation, the transmitted and received signals are supplied through the center horn ring in a circular polarization mode in convention fashion. Since the center horn is circular, it will produce smaller sidelobes than a rec-

tangular center horn and accordingly less scattering will result, providing more efficient transmission and reception.

As stated, the received signal will be focused into the flared end 10b of the center horn. A less-concentrated part of the received signal surrounding the focused beam will be collected by the four outer tracking horns. The amount of signal collected by each tracking horn will be equal when the array is aimed correctly and unequal when the array is not aimed correctly. When the array is aimed incorrectly an appropriate error signal will be produced which will cause the orientation of the array to be corrected, as aforementioned.

Since the four outer horns completely surround the center horn without leaving any "vacant space" around the outside of the center horn, a maximum amount of the less-concentrated part of the signal surrounding the focused beam will be captured by the outer horns, thereby supplying a maximum amount of signal to the tracking circuitry, so that high tracking efficiency results. Tracking will also be aided because the tight packing of the outer horns around the center horn will cause the centers of the phases of the outer horns to be closely spaced.

According to the invention, the arcuate sector of each outer horn which accommodates the center horn is compensated for electrically by the presence of a respective one of the dielectric compensating plates 34, 36, 38 and 40. Each dielectric plate delays the component of the electric field in its tracing horn which is parallel to the dielectric plate. This component of the electric field has a higher than normal phase velocity as a result of the removed sector and the dielectric plate provides a compensating delay. The dielectric plates thereby allow the outer tracking horns to operate with any sense of linear or circular polarization. Thus the tracking function can be effected accurately.

While there has been described what is at present considered to be the preferred embodiment of the invention it will be apparent that various modifications and other embodiments thereof will occur to those skilled in the art within the scope of the invention. Accordingly, it is desired that the scope of the invention be limited by the appended claims only.

I claim:

1. A transceive and tracking antenna horn array, comprising:

- (a) a conical center horn having a circular rear end of relatively small diameter and a circular front end of relatively large diameter,
- (b) four outer horns positioned around said center horn, each outer horn having a small rear end and a relatively large front end, the front end of each horn having a partially rectangular cross section defined by first and second mutually perpendicular outer walls which meet at a first corner, a first inner wall perpendicular to and abutting said first outer wall to form a second corner, a second inner wall perpendicular to and abutting said second outer wall to form a third corner, and a tapered arcuate inner wall joining said first and second inner walls, said tapered arcuate inner walls of said four outer horns together defining an opening generally conforming to the front end of said center horn, and
- (c) four dielectric compensating plates, each positioned in one of said outer horns and extending from the second to the third corners thereof.

2. The array of claim 1 wherein a circular-to-linear polarization converter is coupled to the rear end of each of said outer horns.

3. The array of claim 1 in which said inner walls of said outer horns abut the outside surface of said center horn and abut each other in four pairs so that the front ends of said outer walls of said outer horns form a rectangle with the abutting ends of said inner walls forming

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four segments, each perpendicularly connecting said outer rectangle to said inner horn.

4. The array of claim 1 wherein the front surface formed by the front ends of said center horn and said four outer horns is planar, each of said outer horns has a square cross section, except for said arcuate inner wall thereof, and the two outer walls of each of said outer horns are perpendicular to the front surface of said array and are planar from said front to said rear ends thereof.

5. The array of claim 1 wherein each of said compensating plates has a dielectric constant from 2 to 3 and extends from the front to the end of its arcuate segment of its respective horn along said second and third corners thereof.

6. A transceive and tracking antenna horn assembly, comprising:

(a) four outer rectangular horns, each having a relatively small apex portion and a relatively large flared portion, each of said flared portions having an arcuate sector in lieu of one corner thereof, said four horns being positioned so that the four arcuate sectors generally define a circular opening surrounded by said four horns with the outside surfaces of said four horns generally defining a rectangle.

(b) a circular center horn having a relatively small apex portion and a relatively large flared portion, said flared portion being positioned in said circular opening, and

(c) four dielectric compensating plates, each extending

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across a respective one of said outer horns between the diagonally-opposite corners thereof.

7. The array of claim 6 wherein said center horn and said outer horns are joined together in a unitary structure with the arcuate sectors of said outer horns and the flared portion of said center horn being unitary.

8. The array of claim 6 wherein a circular-to-linear polarization converter is coupled to the apex ends of each of said four outer horns.

9. The array of claim 6 wherein the apex ends of said four outer horns are square and the flared ends thereof are square, except for said arcuate sectors, whereby the outside surfaces of said outer horns generally define a square.

10. The array of claim 6 wherein each of said compensating plates has a dielectric constant from 2 to 3 and extends along its respective horn from the start of the arcuate portion to the flared portion thereof.

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