Sept. 22, 1970 J. L. PALMER 3,530,482

PARTITIONED HORN ANTENNA WITH PATTERN SHAPING ADJUSTMENT

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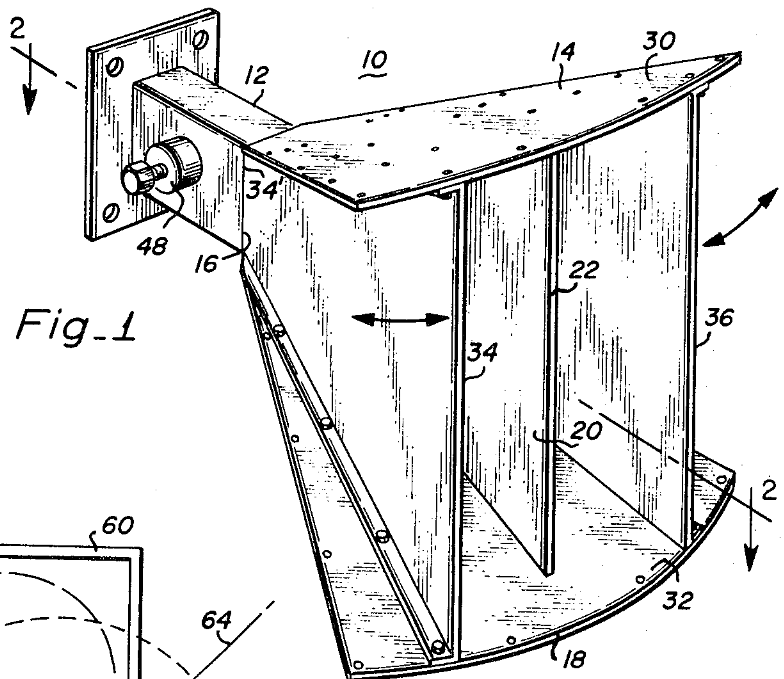

Fig_1

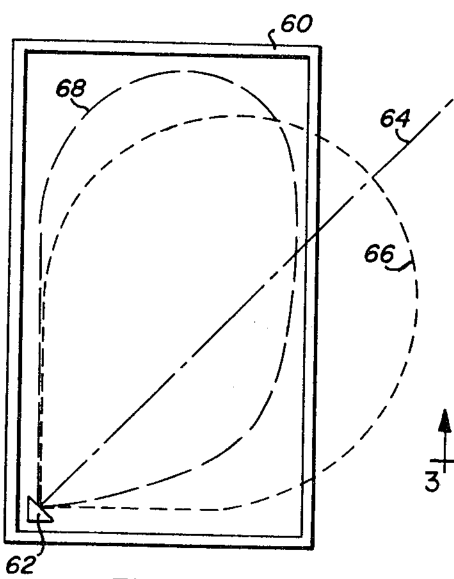

Fig_4

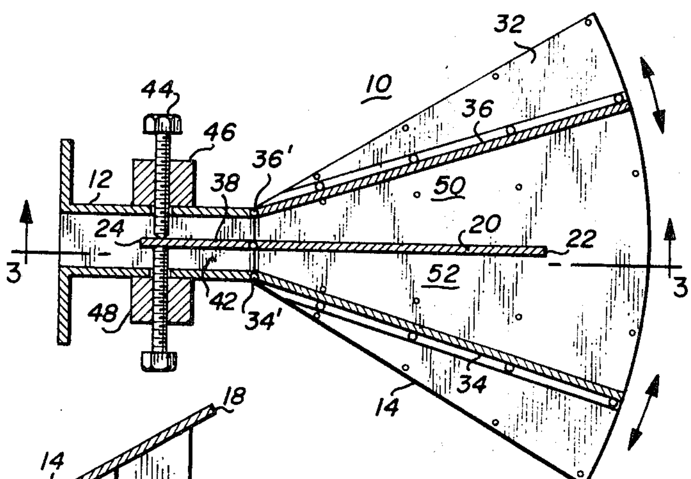

Fig_2

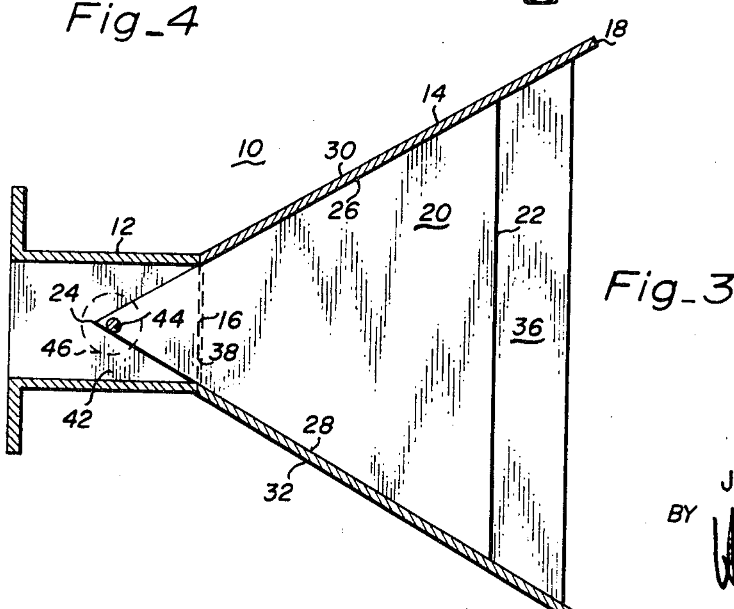

Fig_3

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PARTITIONED HORN ANTENNA WITH PATTERN SHAPING ADJUSTMENT

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U.S. Cl. 343—786 8 Claims

ABSTRACT OF THE DISCLOSURE

An electromagnetic antenna structure in which a partitioned horn is coupled to the end of a waveguide for radiating electromagnetic energy. The partition across the horn has a tongue extending into waveguide and deflectable perpendicular to itself to differentially change the wave energy respectively delivered to the partitioned horn portions for changing the radiation pattern. For added shaping of the radiation pattern, the horn has variable flare side walls.

STATEMENT OF THE INVENTION

This invention relates to electromagnetic antenna structures and, more particularly, to a horn antenna for controlling and varying the shape of the radiation pattern, and especially for forming highly asymmetric radiation patterns.

DESCRIPTION OF THE PRIOR ART

Even though most electromagnetic antenna structure applications benefit by symmetric radiation patterns, there are applications where this is not the case and where it becomes desirable, and oftentimes even necessary, to fit the radiation pattern to a highly unsymmetric shape. One such application is encountered in microwave intruder detection systems, such as described in my copending application Ser. No. 604,430 filed Dec. 23, 1966, now Pat. No. 3,383,678, in which the perimeter of the secure area is determined by the radiation pattern. While there may be situations where a symmetric radiation pattern is desired, such as would be required for a substantially square room having space in one of the corners for accommodating the antenna structure, the usual case involves a room having a cross section other than square and/or having no available space at the axis of symmetry, if there be one, for placing the antenna structure. For this and other obvious reasons, an electromagnetic antenna structure, capable of providing highly unsymmetric radiation patterns and having the capability of controlling the pattern within wide limits, is highly desirable.

For economic reasons, it is also desirable that such electromagnetic antenna structures be readily and easily adjustable since each user of such a microwave intruder system will have, ordinarily, a different area to be made secure. Accordingly, it is desirable to provide an antenna structure which includes means for shaping the radiation pattern to conform to the user's special area requirements.

Prior art antenna structures of the electromagnetic horn type, which were capable of controlling or adjusting the radiation pattern, were those which had variable flare angle side walls, one such antenna being described in U.S. Letters Patent 2,456,323. The described antenna comprises a rectangular horn body having angularly adjustable side walls which are rotatable about a knife edge of the throat of the horn to provide the different flare angles, and thereby control the radiation pattern. Even though this prior art antenna structure does provide means for generating asymmetric radiation patterns, the range of

patterns obtainable is quite limited. Further, and more importantly, changing the flare angle primarily causes a rotation or angular shift of the axis of symmetry, and the symmetry of the pattern about the shifted axis is maintained to some degree. Further, very unequal or small flare angles of the side walls causes the formation of objectionable side lobes which require expensive partitions or other means for their reduction to a tolerable size.

OBJECTS OF THE INVENTION

It is therefore a primary object of the present invention to provide an electromagnetic antenna structure which includes means for shaping the radiation pattern through a large range of patterns without appreciable mismatch between the feedline and the radiator.

It is a further object of the present invention to provide an electromagnetic antenna structure which includes means whereby practically any type of asymmetric radiation pattern may be produced.

It is another object of the present invention to provide a method of generating asymmetric radiation patterns.

It is still another object of the present invention to provide a means and a method for illuminating any selected space with electromagnetic energy in such a manner that the field intensity of the energy illuminating the selected space is substantially constant over the space perimeter.

SUMMARY OF THE INVENTION

In accordance with a preferred embodiment of the present invention, there is provided an electromagnetic antenna structure having a horn body for a radiator and a septum, disposed substantially at right angles to the plane of electric field polarization of the electromagnetic waves, for dividing the horn into two horn portions. Attached to the septum, and forming a coplanar extension thereof, is a tongue which passes through the throat of the horn into the feed waveguide. The tongue is movable in the direction parallel to the plane of polarization, and is engaged by a tongue deflection means which deflects the tongue either to one or the other side of the horn throat to thereby differentially change the respective amounts of wave energy communicated to the two horn portions. The two horn portions, having differentially different and controllable amounts of energy fed into each portion, will provide radiation patterns characteristic of such energy distribution. For increased interaction between the wave energy from the two horn portions, the septum is terminated well inside the horn; the shorter the septum, generally, the blunter and thicker the resulting radiation patterns. For still more control in shaping the radiation pattern to fit a selected perimeter space, the side walls of the horn body may be made adjustable whereby the flare angle can be changed, and thereby change also the angular width of the radiated electromagnetic energy pattern.

BRIEF DESCRIPTION OF THE DRAWINGS

Further objects and advantages of the present invention will become apparent to those skilled in the art to which the invention pertains as the ensuing description proceeds.

The features of novelty that are considered characteristic of this invention are set forth with particularity in the appended claims. The organization and method of operation of the invention itself will best be understood from the following description when read in connection with the accompanying drawings in which:

FIG. 1 is a perspective view of the antenna structure of the present invention;

FIG. 2 is a cross-sectional view through the center of the waveguide taken parallel to the plane of electric field polarization of the wave energy;

FIG. 3 is a view taken along lines 3—3 of FIG. 2; and

FIG. 4 is a schematic radiation pattern diagram useful in connection with the explanation of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing, there is shown an antenna structure 10 which includes a rectangular waveguide 12 having one end portion connected to the throat 16 of a rectangular horn 14 having a mouth 18. Rectangular waveguide 12 is dimensioned for propagating substantially linearly polarized electromagnetic waves therethrough, either for feeding or for being fed by horn 14. The other end of waveguide 12 is conventionally connected, through a coupler or similar device, to a wave energy source or a receiver, or both.

Waveguide 12 has a narrow and a wide dimension, the narrow dimension being parallel to the electric field vector, also known as the E-plane, and the wide dimension being parallel to the magnetic field vector, also known as the H-plane. As far as the horn is concerned, its E-plane is defined as a plane through the axis of waveguide 12 and parallel to the electric field E which extends across the narrow dimension of the waveguide. The horn's H-plane is defined as a plane through the axis of the waveguide and parallel to the magnetic field H which extends across the wide dimension of the waveguide 12.

Horn 14 has a pair of oppositely flared top and bottom walls 30 and 32 (the term top and bottom referring to FIG. 1) which are substantially perpendicular to the horn's H-plane, and a pair of oppositely flared side walls 34 and 36 which are substantially perpendicular to the horn's E-plane. Extending across the interior of horn 14, between oppositely flared top and bottom walls 30 and 32, and substantially perpendicular to the horn's E-plane, is a partitioning means 20, also referred to as a septum, which has an outer end 22, an inner end 24, and a pair of side edges 26 and 28.

Oppositely flared top and bottom walls 30 and 32 are generally fixed with respect to one another and the horn, as contrasted with side walls 34 and 36 which may be constructed to be pivotally supported for providing adjustable flare angles. Septum side edges 26 and 28 are usually fastened respectively to the horn's top and bottom walls 30 and 32. Extending through horn throat 16 is a tongue 38 which forms an extension of septum 20, and which extends, at least some small distance, into waveguide 12. Tongue 38 is provided with a pivotal means either by flexure of the tongue material itself or by means of a hinged joint located in the plane of the tongue at the intersection of the tongue and the septum. Tongue 38 can be seen to divide the narrow dimension of waveguide 12 into waveguide portions 40 and 42, each communicating with one of the two horn portions 50 and 52 defined on opposite sides of septum 20. It is evident that the amount of wave energy supplied to horn portion 50 depends on the height of waveguide portion 40 and, similarly, the amount of wave energy supplied to horn portion 52 depends on the height of waveguide portion 42.

There is further provided a tongue engagement means, including a dielectric screw 44 which engages tongue 38 and suitable threaded bosses 46 and 48 on either side of waveguide 12 for threadingly receiving dielectric screw 44 so that rotation of dielectric screw 44 deflects tongue 38 either towards one or the other wide side wall of waveguide 12. It is readily seen that deflection of tongue 38 in one direction increases the height of waveguide portion 40, and decreases the height of waveguide portion 42 and thereby the energy respectively delivered to horn portions 50 and 52. Deflection of tongue 38 in the other direction produces the opposite effect. Any deflection of tongue 38 changes the height of waveguide portions 40 and 42 differentially, and thereby the energy delivered to horn portions 50 and 52. This tends to minimize reflections in the region of the tongue 38 and the throat 16 which would be encountered if one or the other of the waveguide portions 40 and 42 were blocked.

Referring now to FIG. 4, there is shown by way of example, a space 60 which is to be secured by a microwave intruder detection system. The antenna structure 62 of the detection system, which may be in the form of the antenna illustrated in FIG. 1, is located at the lower left-hand corner. With a conventional antenna structure, or with the antenna structure of the present invention with a centrally disposed septum and a tongue adjusted to supply equal amounts of energy to the pertinent horn portions, the axis of the radiation pattern would be the axis of symmetry 64, and the radiation pattern would take the form illustrated at 66. This is, of course, the ordinary symmetric radiation pattern which can be thickened and thinned by changing the flare angle of the side walls. It is readily seen that this particular pattern 66 is not suitable to protect area 60, and that no amount of tilting of the antenna would fit pattern 66 into the perimeter of the area 60.

In accordance with the present invention, the antenna pattern is changed to pattern 68 by deflecting tongue 38 in such a manner that the right portion 52 of horn 62, as seen by looking along axis 64, receives less energy than the left portion 50. By adjusting screw 44 in this manner, pattern 68 is readily obtained. Pattern 68 is the locus of all points having the same electric field intensity in the plane of polarization.

It will be readily appreciated that there are a number of modifications to the structure of FIGS. 1–3 which will provide essentially the same results. For example, septum 20 need not be rigidly attached to the horn top and bottom walls as shown, it being sufficient if the outer end is fixed with respect to these walls. If only outer end 22 is fixed, the entire partition may be deflected about a line passing through the outer end. Further, tongue 38 may be pivoted about an axis adjacent the throat of the horn, or may be deflected about this axis, the latter being more economical to construct. Further, even though tongue 38 has been illustrated as being of triangular shape, it may take any shape, including those of a rectangular or semicircle, as long as suitable to differentially distribute wave energy between the two horn portions.

In order to prevent the two horn segments 50 and 52 from exhibiting separate, unjoined radiation patterns having a blank or dead region along horn centerline 64, outer end 22 of septum 20 should be spaced inwardly from horn mouth 18. The shortened septum permits energy from each segment of the horn to spill into the other at the outer end and thus to fill in the blank or dead region. It has been found experimentally that the optimum filling of the radiation pattern is obtained by spacing the outer end 20 inwardly from the mouth of the horn a distance of between 10% and 25% of the axial length of the horn.

While the above detailed description has shown, described and pointed out the fundamental novel features of the invention as applied to various embodiments, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated may be made by those skilled in the art, without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. An electromagnetic antenna structure comprising:

waveguide means for propagating electromagnetic waves having a substantially linear, transverse, electric field polarization;

an electromagnetic horn body having a throat and a mouth, the throat of said horn body being coupled to one end of said waveguide means;

at least one wave-energy partitioning means disposed within said horn body substantially perpendicular to the plane of said electric field polarization serving to partition said horn body, said partitioning means having inner and outer ends respectively adjacent to said throat and mouth, said inner end being movable in a direction substantially parallel to the plane of said electric field polarization and said outer end being fixed with respect to said mouth; and

deflection means engaging said inner end to deflect said inner end in a direction parallel to the plane of electric field polarization to thereby differentially change the space between opposite side walls of said horn body and said partitioning means and thereby the wave energy supplied to either side of said partitioned horn body for effecting a desired alteration of the normal electric field intensity across the mouth of said horn body in the plane of said polarization.

2. An electromagnetic antenna structure in accordance with claim 1 in which the inner end of said partitioning means is formed by a tongue means which extends into said waveguide means.

3. An electromagnetic antenna structure in accordance with claim 1 in which the outer end of said partition means terminates inwardly of the mouth of said horn body by a distance which is between 5% and 25% of the length of said horn body.

4. An electromagnetic antenna structure in accordance with claim 1 in which said inner end of said partitioning means is formed by a flexible tongue portion extending from the main body of said partitioning means into said waveguide means, the main body of said partitioning means being fixed with respect to said horn body.

5. An electromagnetic antenna structure in accordance with claim 4 in which said deflection means comprises a non-conductive device which threadedly engages said flexible tongue portion.

6. An electromagnetic antenna structure in accordance with claim 1 in which said horn body includes variable flare side walls for altering the field intensity across the mouth of said horn body, and thereby altering the shape of the radiated electromagnetic energy field.

7. An electromagnetic antenna structure comprising:

waveguide means for propagating substantially linearized polarized electromagnetic waves;

an electromagnetic horn body having a throat and a mouth, the throat being coupled to one end of said waveguide means;

septum means immovably disposed in said horn body substantially perpendicular to the plane of said polarized waves to form a partitioned horn, said septum means having an outer end substantially adjacent and inside the mouth of said horn body and an inner end substantially adjacent the throat of said horn body; and

means for differentially changing the amount of wave energy exchanged between said waveguide means and each segment of said partitioned horn, said means for differentially changing the amount of wave energy comprises a tongue means coupled to the inner end of said septum means and extending into said waveguide means and means for moving said tongue means in a direction parallel to the plane of said polarized waves.

8. An electromagnetic antenna in accordance with claim 7 in which said horn body includes variable flare side walls to alter the field intensity across the mouth of said horn body, and thereby to alter the shape of the radiated electromagnetic energy field.

References Cited

UNITED STATES PATENTS

2,415,807	2/1947	Barrow et al.	343—786
2,519,603	8/1950	Reber	343—786
2,743,440	4/1956	Riblet	343—786
2,918,673	12/1959	Lewis et al.	343—778
3,171,129	2/1965	Nowarowski et al.	343—786
3,218,580	11/1965	Zanichkowsky	343—786
3,234,559	2/1966	Bartholoma et al.	343—779

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