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L. J. EYGES

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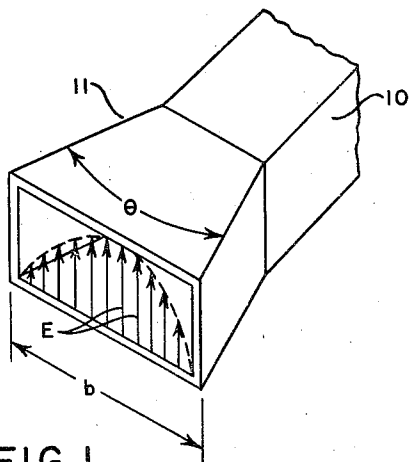


FIG. 1

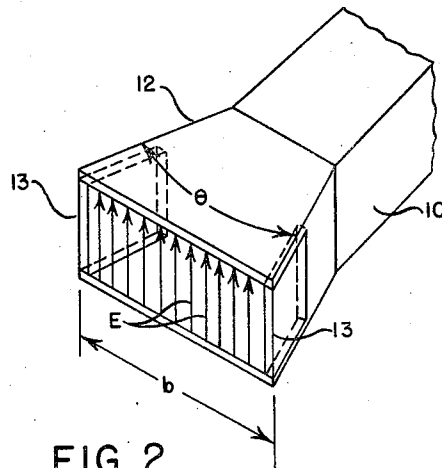


FIG. 2

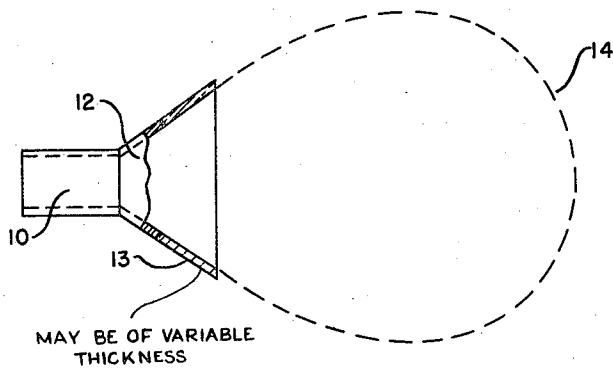


FIG. 3

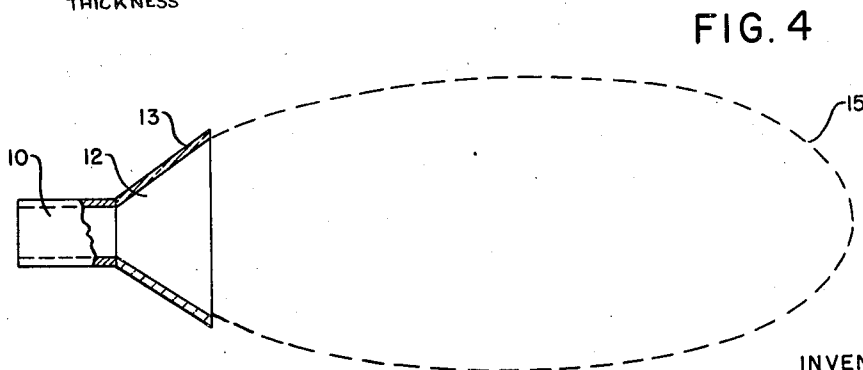


FIG. 4

INVENTOR
LEONARD J. EYGES
BY
William D. Hall
ATTORNEY

UNITED STATES PATENT OFFICE

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ANTENNA

Leonard J. Eyges, Cambridge, Mass., assignor, by
mesne assignments, to the United States of
America as represented by the Secretary of War

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This invention relates to radiant energy antennas and particularly to a directive antenna utilizing a wave guide horn antenna.

A horn antenna, often referred to as a horn radiator, may be regarded as a hollow pipe wave guide having its open end flared to a mouth of suitable proportions, in order to match the guide to the outside medium and to radiate electromagnetic energy with considerable directivity. Horn radiators are very practical for directive radiation at microwave lengths, because although such horn radiators may be large compared to the operating wavelengths, they do not involve unduly large physical sizes.

One of the several uses of a horn radiator is in feeding or illuminating a reflector, for example a paraboloidal reflector, adapted to direct the radiant energy into free space in a desired beam pattern. The radiation field pattern of the horn itself is hereinafter termed the primary pattern, as distinguished from the field pattern of an antenna system utilizing a reflector and a horn feed. In the field pattern of such an antenna system, the gain and the half-power beam width, and the magnitude of undesirable minor lobes, are dependent upon the primary pattern of the horn feed.

The horn radiator disclosed hereinafter is particularly useful in connection with a reflector having a truncated paraboloidal shape. It is desirable that the feed means for such a reflector shall have a primary pattern narrow in a plane perpendicular to the truncating planes, and wide in a plane parallel to the truncating planes. It is further desirable to realize the maximum gain consistent with minor lobe limitations. Achievement of the desired characteristics requires a relatively uniform illumination across the mouth or aperture of the reflector and little spill-over of energy at the edges, and may be accomplished by means of the present invention.

It is an object of the invention to provide a horn radiator having a high gain characteristic.

Another object is to provide a horn radiator having a substantially uniform distribution of E-field intensity across its mouth.

A further object of the invention is to provide a horn radiator of small size relative to prior art horn radiators having comparable radiation characteristics.

Other objects, novel features and advantages of this invention will suggest themselves to those skilled in the art and will become apparent from the following description taken in connection with the accompanying drawing in which:

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Fig. 1 is a perspective view of a prior art horn radiator and the characteristic E-field pattern at its mouth;

Fig. 2 is a perspective view of a horn radiator in accordance with the present invention, and of the distribution of electric field intensity at its aperture;

Fig. 3 is a top view of the horn radiator of Fig. 2, its upper wall in part cut away, and of its characteristic primary pattern; and

Fig. 4 is a similar top view of a modified horn radiator and its corresponding field pattern.

Referring now to Fig. 1, there is shown a section of rectangular wave guide 10 operating in a dominant mode and terminated in a typical prior art horn radiator 11 made entirely of conductive material. The flare of the horn from its throat, at which it joins wave guide 10, to its mouth is in an H-plane and is measured by the angle θ between the narrower walls of the horn as shown. The mouth or aperture is rectangular in shape and its larger dimension is here designated b . The direction and distribution of the E-field across the aperture of this typical prior art horn is as indicated by the several arrows designated E. As illustrated, the E-field vanishes at the horn's enclosing surfaces which lie in planes of the E-field, namely at the narrower walls, and this phenomenon limits or determines the maximum gain possible for a given size of aperture.

In certain other respects, also, such horn radiators as in Fig. 1 have not been entirely satisfactory. The width of the primary beam of this horn radiator depends primarily upon the dimension b of its mouth measured in terms of wavelengths, and to a lesser extent upon the flare angle θ . In order to substantially narrow the beam of the horn, it is necessary to increase b considerably. Thus, for a constant flare angle, the length of the horn must be large for a narrow beam. On the other hand, for a constant b , the flare angle must be decreased to narrow the beam, although the narrowing action here is of lesser effect as previously stated. If flare angle θ is kept constant and b is increased, a horn size is reached at which the beam width is a minimum. As the aperture dimension b is further increased, some of the secondary sources in the wave front at the aperture are out of phase with others and interfere destructively in the forward direction. The effect upon the primary pattern is to produce minor lobes or shoulders on the main lobe. The flare angle may be decreased to reduce the minor lobes, but this necessitates an even longer structure. This type of horn, while electrically satis-

factory in some instances, may be too long and heavy for some uses.

Again, in order to produce a broad beam with the horn shown in Fig. 1, as in some instances may be desirable, it is necessary to increase the flare angle. There then results, however, considerable mismatch between the horn and the outside medium. Furthermore, it is not possible to simultaneously obtain both broad banding and proper impedance match with the horn radiator shown in Fig. 1.

Referring now more particularly to Fig. 2, illustrating an embodiment of the invention, a wave guide 10, as before, is terminated by a horn 12 which flares in the H-plane. The horn radiator 12 is made of electrically conductive material as before, except for certain portions of the narrower walls to which the E-field vectors are parallel. Here these E-plane walls are formed of a dielectric material such as polystyrene indicated at 13 to secure a desired distribution of electric field intensity in accordance with the invention.

In operation of the horn illustrated in Fig. 2, the E-field does not vanish at the narrower sides formed of dielectric material, and a substantially uniform distribution of E-field intensity across the aperture may be obtained. The degree of potential uniformity can also be affected by suitable choice of cross-sectional thickness of dielectric 13, since the amount of power carried in the E-plane walls is controlled thereby. The thickness of the dielectric may be non-uniform or variable. As previously indicated, a uniform distribution of E-field intensity across the mouth of the horn produces a beam of greater gain than can be obtained by a field which diminishes to zero at the E-plane walls of the horn.

The pattern of the energy beam radiated from the horn is dependent on the E-field phase distribution and intensity across the mouth of the horn radiator. The dielectric retards the phase velocity of wave energy an amount dependent on the dielectric constant. This results in an appreciable phase difference between that part of the field traveling in the dielectric walls and that part traveling in the center space of the horn radiator. Experiments have shown that with short lengths of dielectric 13 in the horn radiator structure, it is possible to obtain a wide beam as illustrated at 14, Fig. 3. It is also found that as the length of the dielectric 13, and thereby the length of the energy paths through it, are increased, the resultant phase difference between that portion of the field traveling in the dielectric and that traveling in the center space is increased. This results in a highly directive high-gain pattern illustrated at 15, Fig. 4. Thus, by suitable choice of the lengths and thickness of the dielectric walls in the horn radiator structure, a desired directive radiation pattern may be obtained.

It will be seen that the horn radiator having dielectric walls as herein set forth provides relatively high gain, and achieves primary beam patterns to fit specified reflectors, without materially changing the aperture dimension b or flare angle θ , thereby reducing the bulk of a horn type feed for a specified primary pattern.

It will be obvious to those skilled in the art that the horn radiator here disclosed may be associated with other types of transmission lines than

the hollow pipe wave guide here shown. It may, for example, be fed by a coaxial or other type of line. It will also be apparent to those skilled in the art that although the preceding description of the invention has been with particular reference to the horn as an energy radiating means, the characteristics of the horn, properly interpreted, also apply to its use as a wave energy receiving means.

While there has been described what is at present considered to be the preferred embodiment of this invention, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. A horn antenna, comprising two parallel electrically conductive walls and two divergent relatively narrow walls perpendicular thereto, said walls defining a tubular structure flared from a throat end to a mouth end, said throat end being adapted for connection to a transmission line, said narrow walls being formed of electrically conductive material near said throat end and of dielectric material near said mouth end.
2. A horn antenna as in claim 1, wherein said narrow walls formed of dielectric material are variable in thickness.
3. A horn antenna, comprising two parallel electrically conductive walls and two divergent relatively narrow walls perpendicular thereto, said walls defining a tubular structure flared from a throat end to a mouth end, said throat end being adapted for connection to a transmission line, at least a portion of said narrow walls being formed of dielectric material.
4. A horn antenna as in claim 3, wherein said narrow walls formed of dielectric material are variable in thickness.
5. A horn antenna to provide a highly directional radiation pattern comprising two parallel walls and two divergent walls perpendicular thereto, said walls defining a tubular structure flared from a throat end to a mouth end, said two parallel walls and equal portions of said narrow walls proximate said throat end being formed of electrically conductive material, the remaining portions of said narrow walls being formed of dielectric material, the directivity of said antenna being a function of the length of said dielectric material, the power transmitted by said wave guide being a function of the thickness of said dielectric material.
6. The antenna according to claim 1 wherein the length of the dielectric material is predetermined to produce a desired radiation pattern.
7. The antenna according to claim 3 wherein the length of said dielectric material is so chosen as to produce a desired radiation pattern.

LEONARD J. EYGES.

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