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Hayes Middlesex, UB4 0HB(GB)(54) **End fire aerial.**

(57) An end-fire aerial (6) includes a broadside aerial array (7), for example a horn antenna. A block (9) of dielectric foam material extends outwards from the array (7), in a direction perpendicular to the array. The block (9) is designed to be of such dimensions, and of a suitably low dielectric constant such that it produces an end-fire gain.

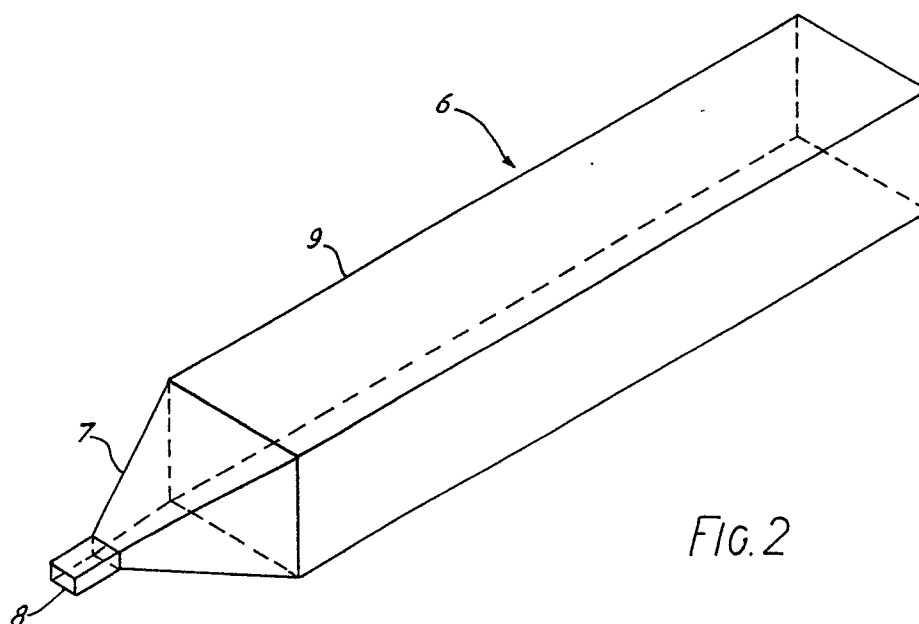


FIG. 2

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END-FIRE AERIAL

This invention relates to aerials and in particular to aerials for use in the microwave/millimeter region.

The main requirements of an efficient aerial are that it is highly directional and has good radiation pattern characteristics over a broad bandwidth.

A well known type of aerial is the conventional horn aerial. Such an aerial is typically pyramidal in shape and formed from aluminium, with a waveguide attached to the apex of the pyramid. These aerials typically have a gain of around 20dB along their preferred reception direction i.e. along their main axis. However such aerials suffer from a severe disadvantage, namely that uncontrolled currents scatter at the horn edges and flow back along the walls. The effects of these currents can be seen by studying the E-plane pattern for such an aerial. This pattern reveals the presence of high side lobes of more than 10dB on either side of the main lobe which has a 20dB gain and which represents the preferred reception direction. Thus the radiation pattern in the E-plane has side lobes of less than 10dB below the main lobe, whereas 25 to 30dB is desirable. This has the obvious effect of reducing the aerial's directivity. The substantial weight of conventional aluminium horn aerials is also a disadvantage in many applications.

Improvements have been made to horn aerials to overcome these problems, for example corrugating the surface of the aluminium horns to reduce surface currents and thus side lobes; alternatively there is copper plating of dielectric-foam horns and corrugating of the surface, this also reducing surface currents, such aerials having the additional advantage of being light-weight. However, while both such types of aerials have improved directivity due to the virtual removal of side lobes, their gain (at about 20db) is not greatly improved and so they do not possess the degree of directivity desired.

Dish aerials are another well-known type of aerial, being highly directional and very efficient, but unfortunately expensive to manufacture and comparatively large and cumbersome.

It is therefore an object of the present invention to provide a low cost aerial for use in the microwave/millimeter region, which possesses a high gain and directivity while at the same time being of light-weight and simple construction.

According to the present invention there is provided an end-fire aerial comprising a broadside aerial array and an elongate member of dielectric material extending outwards from the broadside aerial array in a direction perpendicular to the array, the dimensions and dielectric constant of the elongate member being such that the elongate

member constitutes an end-fire array.

The dielectric material is preferably dielectric foam material. In one embodiment of the invention the broadside aerial array comprises a horn antenna.

In an alternative embodiment of the invention the broadside aerial array comprises a flat plate array.

Preferably, the dielectric material is foamed polyethylene.

Three end-fire aerials in accordance with the invention will now be described, with reference to the accompanying drawings, in which:

Figure 1 (a) is a view of a conventional horn aerial;

Figure 1 (b) shows a typical E-plane radiation pattern for such a conventional aerial plotted on circular graph paper;

Figure 2 is a perspective view of a first aerial in accordance with the invention;

Figure 3 shows an E-plane pattern typical of the form of aerial shown in Figure 2;

Figure 4 is a schematic cross-sectional diagram showing the passage of a wave through the aerial of Figure 2;

Figure 5 is a graph of the expected field intensity at the end of the aerial of Figure 2;

Figure 6 shows a second aerial in accordance with the invention; and

Figure 7 shows a third aerial in accordance with the invention.

A conventional horn aerial is shown generally at 1 in Figure 1. It is typically formed from aluminium and has a waveguide 2 attached to its apex. Radiation extends mainly along the axis of the aerial with its E-field component in the direction shown. Such an aerial is often referred to as a broadside aerial since its end can be considered as equivalent to a parallel array of dipole sources substantially in-phase, with radiation extending mainly perpendicular to the array - a 'broadside' array. The gain of such an aerial i.e. the amount of energy extracted from the field due to radiation travelling along the main axis is similarly referred to as "broadside" gain, the higher the gain of an aerial the greater its directivity.

Figure 1(b) shows an E-plane radiation pattern for such an aerial. For an ideal aerial the pattern should follow the dotted line 3 i.e. there should be only one lobe, representing the fact that the aerial is receptive only to radiation travelling primarily in the direction of the aerial's main axis. However, in practice there is a main lobe of gain 20dB and several side lobes represented by the solid line 4

and since the side lobes are less than 10dB below the main lobe, when 25 to 30db is desirable, such an aerial clearly has poor directivity. The presence of side lobes is due to uncontrolled currents scattering at the horn edges and flowing back along the walls, this also causing back radiation, represented by the line 5 on Figure 1(b). In addition to its poor directivity the aerial shown on Figure 1(a) is also relatively heavy, since it is formed from aluminium, and this substantial weight is a disadvantage in many applications.

The aerial of the present invention shown generally at 6 in Figure 2 overcomes the above mentioned difficulties. It comprises a horn 7 with a waveguide 8 and block of foamed plastic material 9. Typically the foam block measures (externally of the horn 7) 570 mm x 120 mm x 105 mm; the horn mouth 95 mm and 119 mm, the horn edge 145 mm and the waveguide has internal measurements 22.86mm x 10.16mm i.e. WG 16. The foam block is made from polyethylene which has a relative dielectric constant of 1.03, but polystyrene or any other dielectric with a suitable dielectric constant could equally well be used.

Aerial 6 is produced by moulding foam material to the shape of block 9, and horn 7 then coating the horn end of the moulded foam with metal by any appropriate method. The waveguide 8 is of a conventional construction.

Figure 3 shows the E-plane radiation pattern typical of an aerial shown in Figure 2. The graph is a plot of relative power (linear) against angle (deg) on linear graph paper, so the 'peaks' on this graph can be compared to the 'lobes' on the graph of Figure 1(b). The measurements were made at 12.5 GHz over a 15% bandwidth and the gain of the aerial was calculated as being 26.3 dB, which is considerably higher than the 20dB gain obtained from the horn aerial alone. In addition, a study of E-plane beam pattern of Figure 3 shows that side peaks (comparable to side lobes on circular paper) are very low. Thus, the aerial 6 has a much higher directivity than a conventional horn aerial, because it has a higher gain and because by its construction it has substantially eliminated the presence of side lobes in its E-plane radiation pattern.

An explanation as to why the aerial of the invention has a much higher gain than a conventional horn aerial can be given, with reference to Figure 4. Energy radiates from the horn aperture 10 into the dielectric foam extension section 9 of the aerial 6. When it reaches the foam/air interface at 11 it either propagates across the boundary (θ_1 less than the critical angle) and is radiated or is totally internally reflected (θ_1 greater than the critical angle). The internally reflected wave 12 is accompanied by an evanescent (non-radiating) surface wave 13 which propagates along the interface

until it reaches the far end 14 of the aerial. Radiation then takes place from an effective aperture 15 at the far end of the aerial. Because the field distribution associated with the surface wave extends beyond the foam 9 into the surrounding air, this effective aperture 15 is larger than the aperture 10 of the horn 7 alone and since the gain of the aerial is known to be proportional to its aperture, the gain of the aerial shown in Figures 2 and 4 is greater than that of a horn aerial alone.

Figure 5 is a graph of the expected field intensity at the end of the aerial of the invention, obtained from a computer field modelling programme. This shows how the effective aperture is increased by inclusion of the foamed section 9, the sinusoidal field distribution being extended become more uniform and more efficient.

The gain of the aerial is dependent on both cross-sectional area and length and hence a constant gain can be obtained from a variety of different length/area combinations; this enables dimensions to be optimised to suit a particular application or to minimise visual impact. Alternatively, the gain of the aerial can be altered by varying the dimension of the dielectric material along the length of the aerial or by varying the dielectric constant of the material along the length or across the width of the aerial. Foamed plastic materials are ideal in this respect since their dielectric constants will be proportional to their densities and this can easily be varied during production to achieve the desired-effects.

Variants to the horn shown in Figure 2 can be produced. For example, a conical version of such an aerial is shown in Figure 6. The horn can be corrugated to improve efficiency still further. Whilst it is particularly convenient to form the horn 7 from a metalised portion of the dielectric foam, it will be appreciated that the horn 7 may take the form of a conventional metallic horn, for example of aluminium, either filled with an extension of the block 9 or bonded to the block 9.

Figure 7 shows a third example of an aerial according to the invention. In this example the dielectric part 20 of the aerial 21 is fed by a broadside aerial in the form of a flat-plate antenna array 22, and this aerial is highly directional.

It will be seen that all aerials shown in Figures 2, 6 and 7 can be thought of as end-fire aerials exhibiting enhanced broadside gain.

Thus the present invention provides an aerial which is not only light-weight and cheap to manufacture, but is also more efficient than prior art aerials, possessing much greater directivity and exhibiting much better radiation field patterns.

It will be appreciated that whilst the aerials described herebefore by way of example include a self-supporting block of dielectric foam material, in

some cases it may be advantageous to include a central metallic support through the block. It also may be advantageous to coat the block with a thin protective dielectric skin. It has been found that the provision of such a support or skin does not significantly effect the performance of the aerial.

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Claims

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1. An end-fire aerial (6) characterised in that it comprises a broadside aerial array (7), and an elongate member (9) of dielectric material extending outwards from the array in a direction perpendicular to the array, the dimensions and dielectric constant of the elongate member being such that the elongate member constitutes an end-fire array.

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2. An end-fire aerial according to Claim 1 in which the broadside aerial array comprises a horn antenna (7).

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3. An end-fire aerial according to Claim 1 in which the broadside aerial array comprises a flat plate array (22).

4. An end-fire aerial according to any one of the preceding claims in which the dielectric material is a dielectric foam material.

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5. An end-fire aerial according to Claim 4 in which the dielectric foam material is a plastic foam material.

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6. An end-fire aerial according to Claim 5 in which the plastic foam material is polyethylene.

7. An end-fire aerial according to Claim 5 in which the plastic foam material is polystyrene.

8. An end-fire aerial according to any one of the preceding claims in which the broadside aerial array (7) comprises an extension of the elongate member of dielectric material coated with an electrically conductive layer.

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9. An end-fire aerial according to any one of the preceding claims in which the broadside aerial array (7) has corrugated walls.

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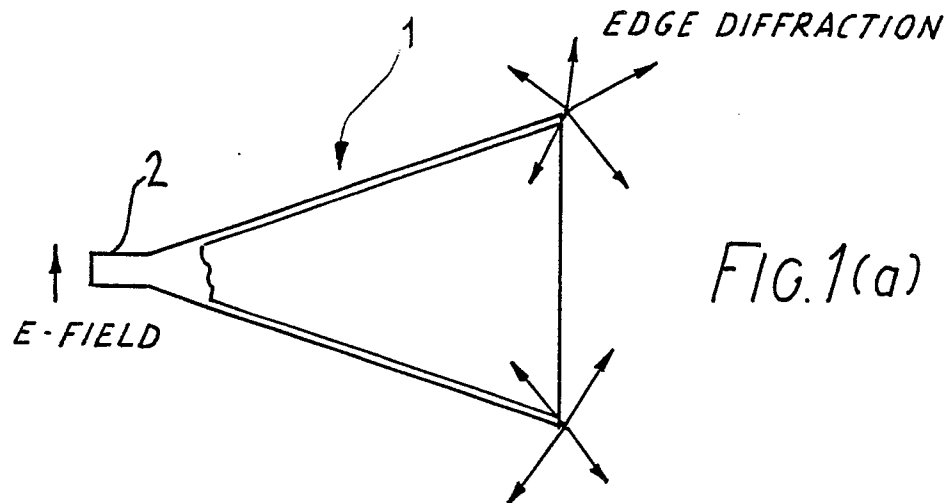


FIG.1(a)

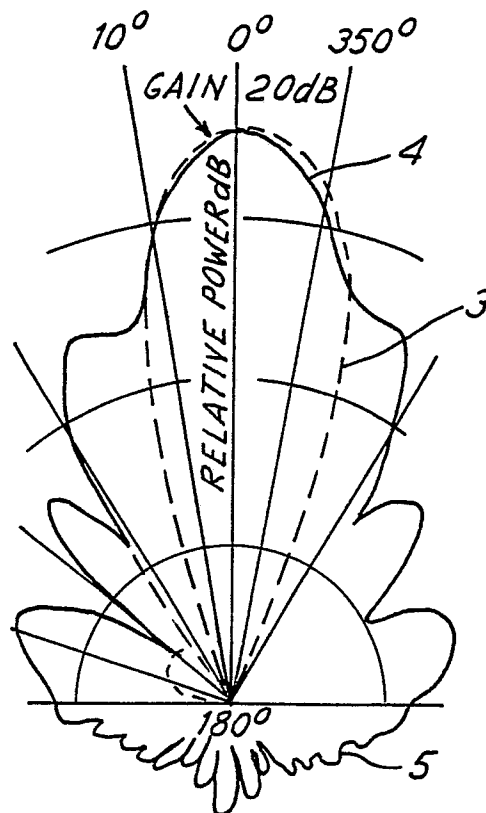
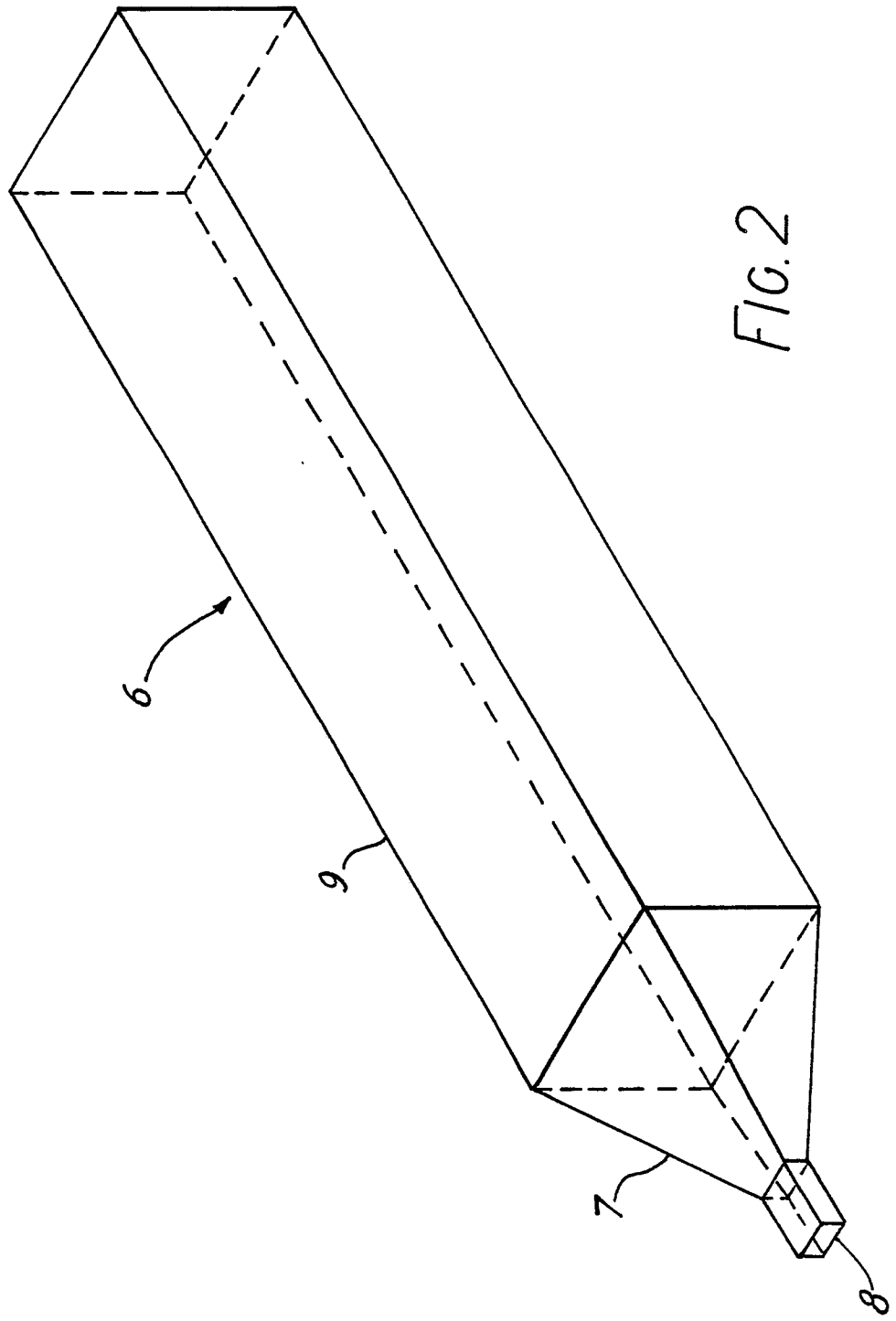
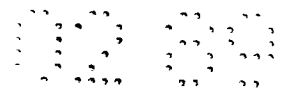
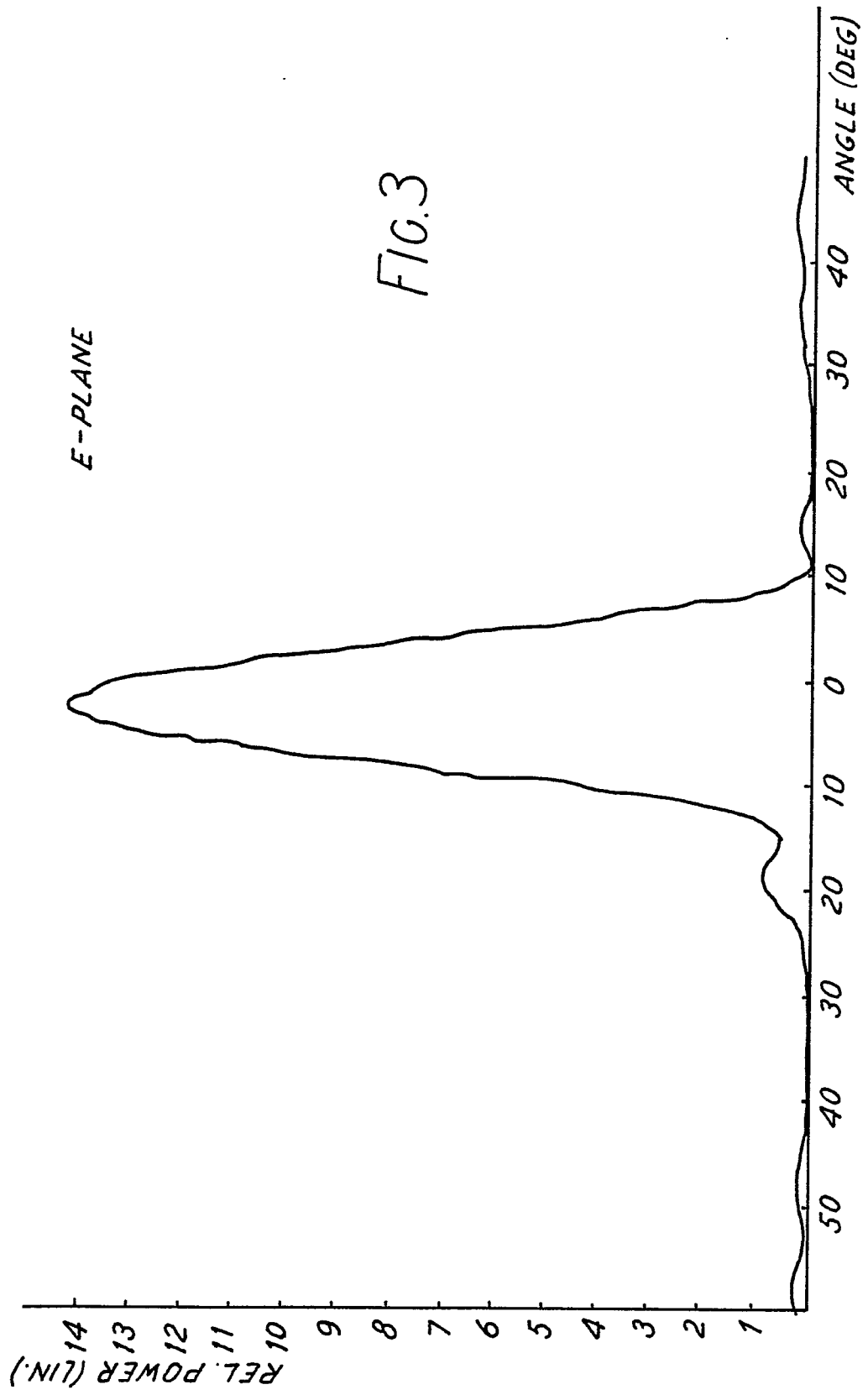
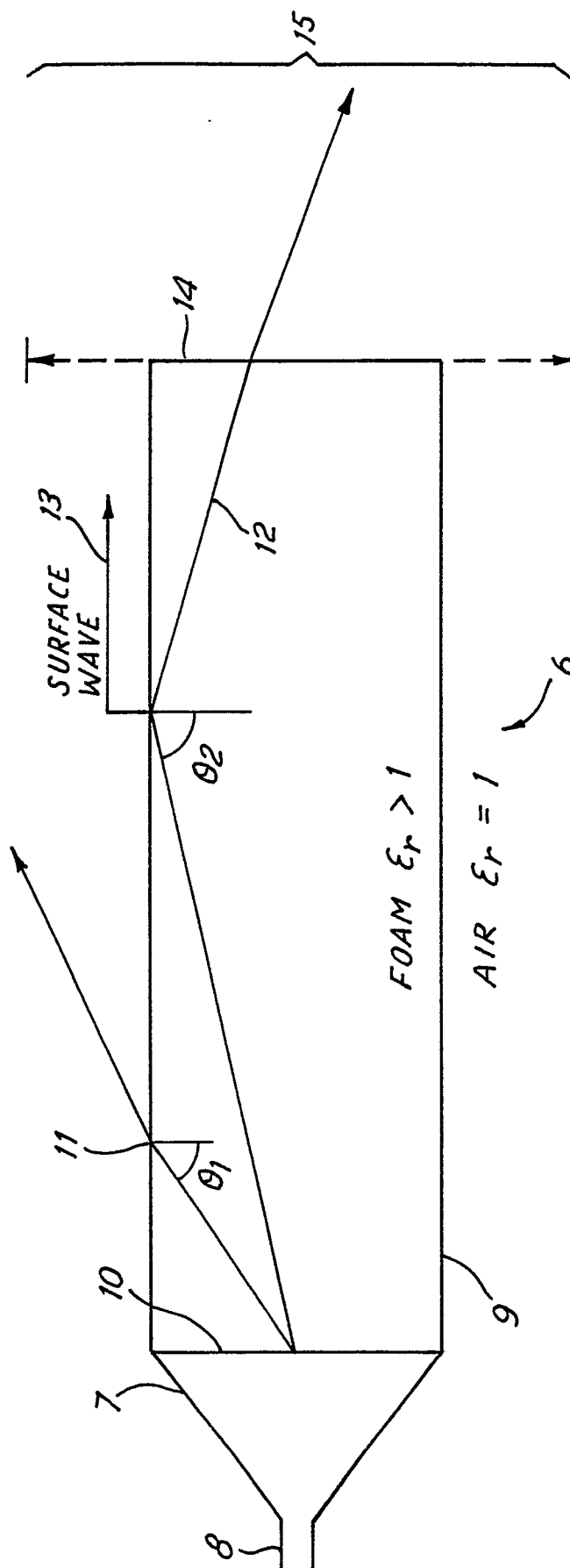
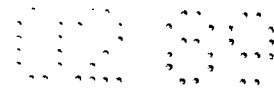
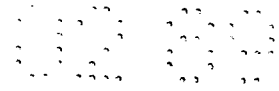


FIG.1(b)









FIELD INTENSITY AT FAR END OF AERIAL

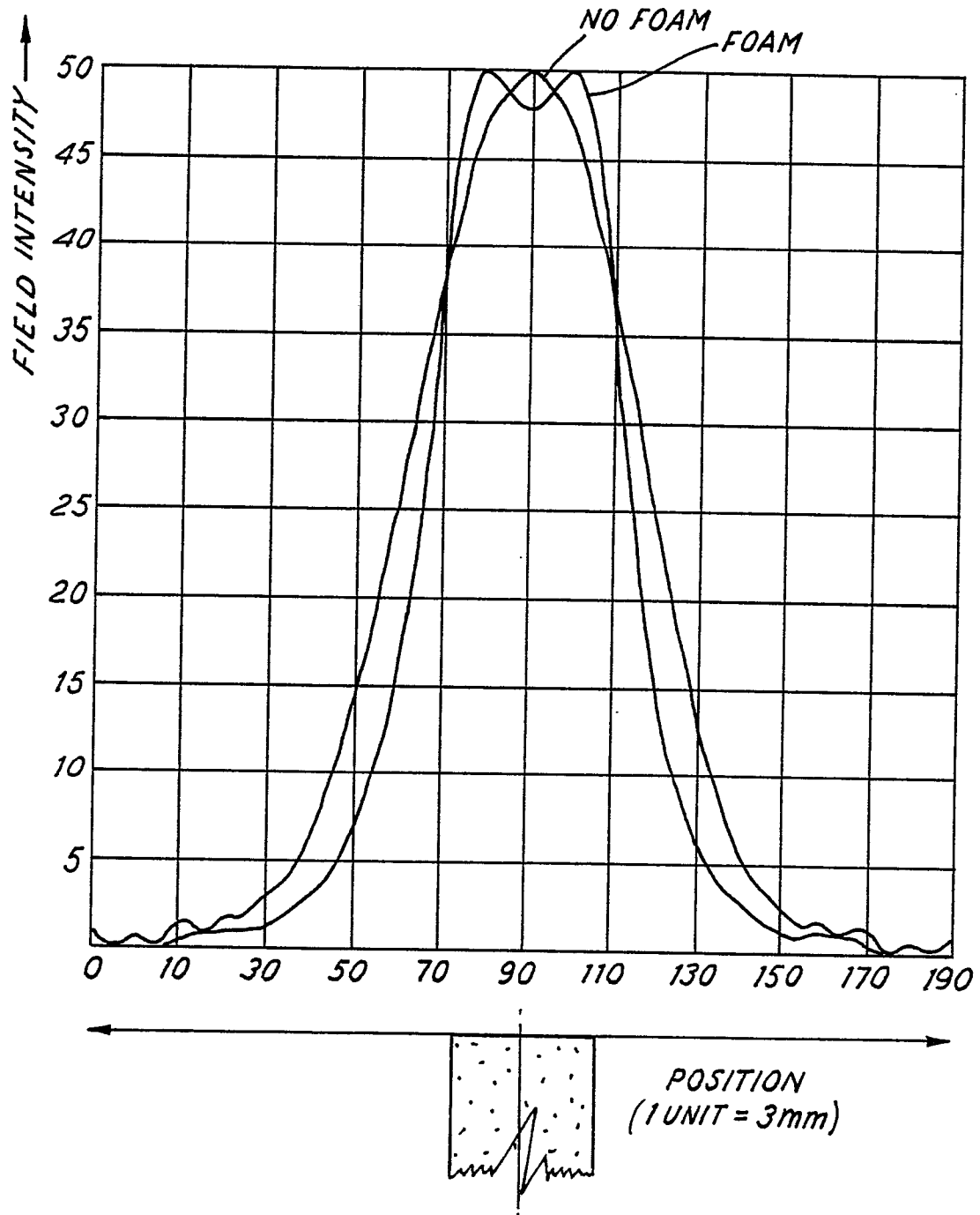


FIG. 5

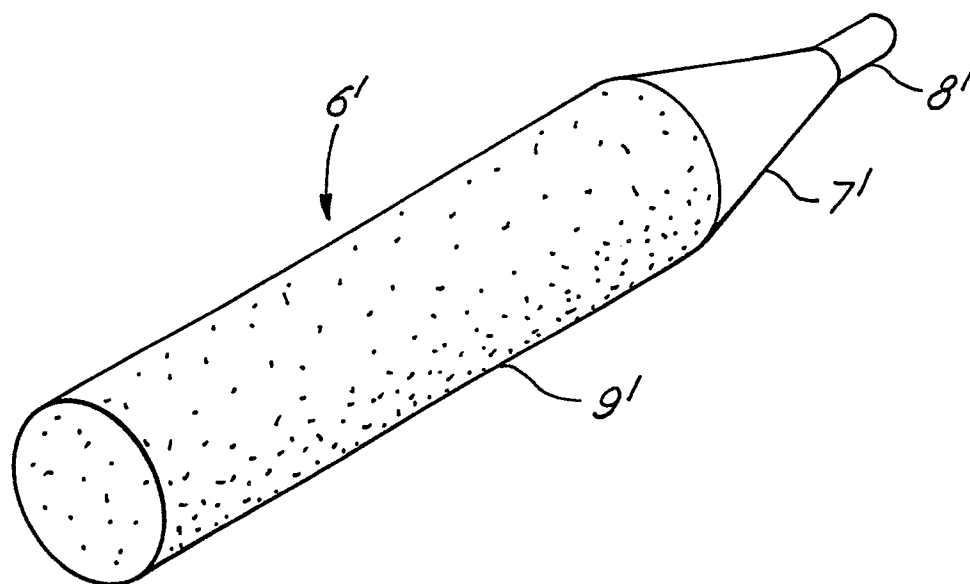


FIG. 6

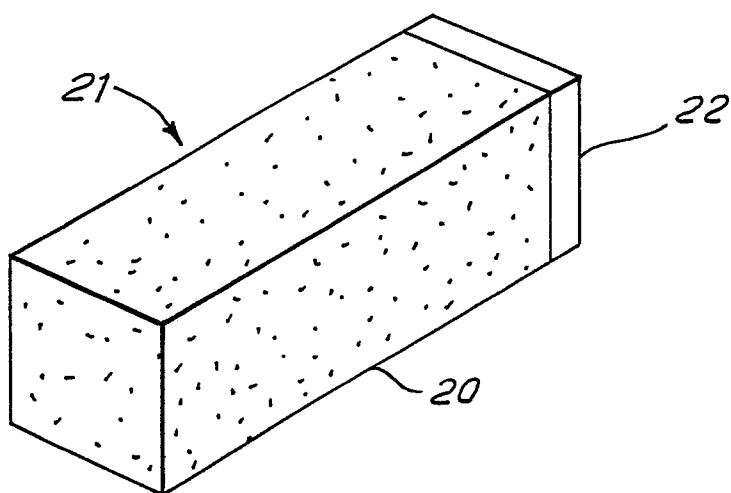


FIG. 7