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3,146,449

SLOT FED HORN RADIATOR WITH PROTECTIVE RADOME HAVING
POLARIZATION AND RESISTANCE WIRES
EMBEDDED THEREIN

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2 Sheets-Sheet 1

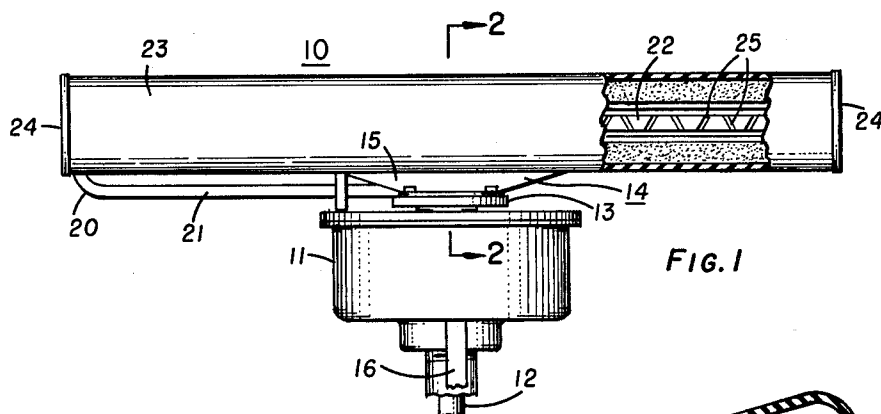


FIG. 1

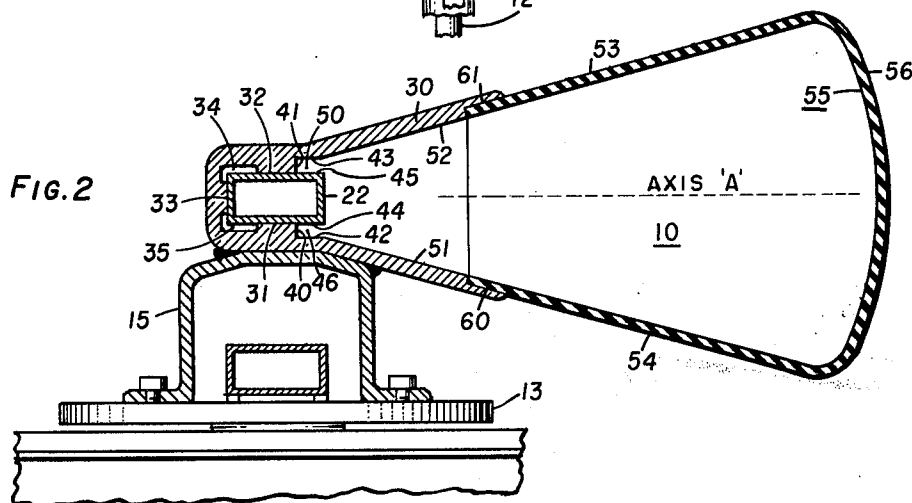


FIG. 2

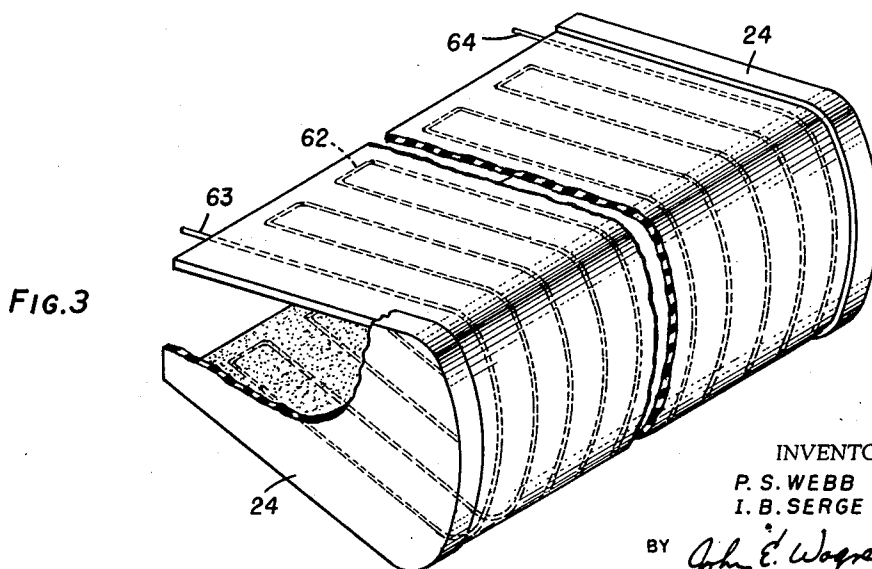


FIG. 3

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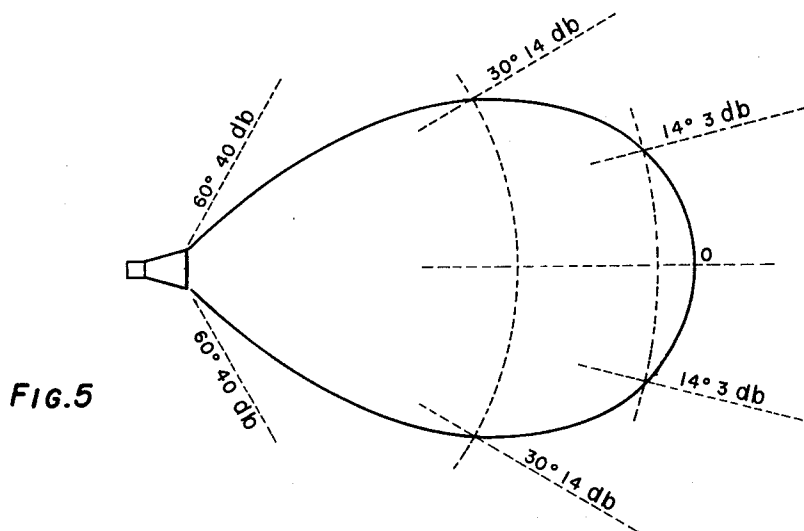
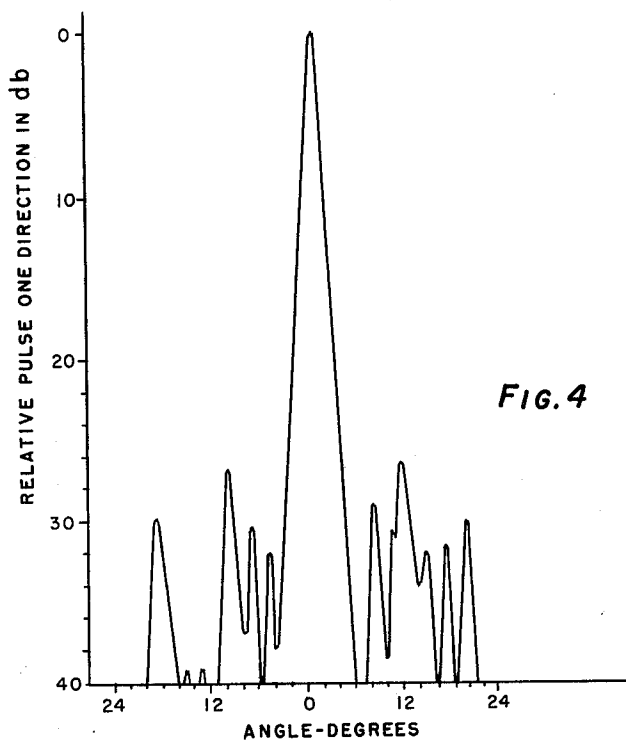
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SLOT FED HORN RADIATOR WITH PROTECTIVE RADOME HAVING POLARIZATION AND RESISTANCE WIRES EMBEDDED THEREIN

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This invention relates to microwave antennas and more particularly to edge-slotted waveguide radiators.

The waveguide transmission line is a structure which is recognized as easily adapted as a microwave antenna when a plurality of the slots extend transverse to a face of the waveguide, and microwave energy is fed into one end of the waveguide. It is a well known practice to control the radiation by varying the angle of orientation or position of successive slots with respect to the current paths in the waveguide walls and thereby vary the degree of coupling of the slots.

The slotted waveguide also has the advantage of simplicity and relatively small size, but suffers from two disadvantages in that it is not completely weather-sealed and consequently is not directly adaptable to marine or aircraft application, and furthermore has a rather wide vertical pattern.

It is the general object of this invention to provide a microwave antenna of simple design and easily fabricated and which exhibits a high degree of directivity in both the horizontal and vertical planes. For the purpose of this specification, horizontally polarized energy will be considered that which is aligned in the same direction as the array itself, and vertically polarized energy will be defined as that which is perpendicular to the horizontally polarized energy as defined.

It is a further object of this invention to provide a slotted waveguide antenna which is sealed from the elements and which affords practically complete suppression of cross-polarized energy.

These objects are all accomplished in accordance with the teaching of this invention, one embodiment of which comprises an edge-slotted waveguide constituting the termination of a microwave transmission system and the basic radiating element. The waveguide is positioned within a recess in an elongated member constituting the main support of the antenna structure and having a pair of flaring portions forming the root of a horn for the slot array. The length of the horn is extended by a dielectric radome member including internally metalized side walls and sealing end domes.

One feature of this invention relates to the elongated unitary member constituting the main support of the antenna and defining the horn.

Another feature of this invention evolves from the support member including portions at the root of the horn for suppressing cross-polarized energy emitted from the waveguide slots. For the purpose of the present specification, when applicants refer to "cross-polarized energy" it is vertically polarized energy which is intended.

Still another feature of the invention relates to the radome structure providing both a weather seal for the antenna and constituting the major portion of the antenna horn.

Still another feature of the invention relates to the presence in the radome of vertically orientated heating wires for maintaining the antenna ice-free in adverse conditions and providing simultaneously additional cross-polarization suppression.

These and other features of the invention may be more clearly understood from the following detailed description and by reference to the drawing in which:

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FIG. 1 is a front view of an antenna and rotor structure incorporating the invention;

FIG. 2 is a transverse section of the antenna along line 2-2 of FIG. 1;

FIG. 3 is an isometric showing of the radome portion of the antenna, FIG. 1;

FIG. 4 is a graphical representation of the horizontal radiation pattern of the antenna, FIG. 1; and

FIG. 5 is a graphical representation of the vertical radiation pattern of the antenna of FIG. 1.

FIG. 1 shows an antenna 10 of this invention designed particularly for marine use. The structure includes a rotor housing 11 containing a rotor motor and mounted on a supporting shaft 12 which may be the foremast of a marine craft. Secured to the upper rotating portion 13 of the rotor is the antenna frame 14 including a channel member 15 best seen in FIG. 2. A waveguide 16 for feeding the antenna 10 extends through the rotor housing 11 to a rotary joint within the channel 15 and unshown in the drawing, through which microwave energy is conducted to a hairpin-shaped, horizontally extending waveguide section 20. The one leg 21 of the hairpin waveguide member 20 visible in FIG. 1 constitutes the feed portion, and the second leg constitutes the radiating portion 22 as seen in the broken away section of FIG. 1. The front of the antenna proper is a dielectric curved window or radome 23 made of low loss material, for example, resin-bonded fiberglass. End caps 24 of similar material seal the ends of the structure.

In the broken away portion of the radome, several slots 25 of the radiating leg 22 of the waveguide may be seen. The slots extend through the entire exposed face of the waveguide leg 22 and are in the order of a small percentage of a wavelength in width. It should be noted in FIG. 1 that the slots 25 do not extend normal to the length of the waveguide 22 but are inclined at slight angles with respect to its longitudinal axis, and each of the slots is at a slightly different angle. This allows each of the slots 25 progressing from the feed end 21 of the antenna to intercept a predetermined portion of the current flowing in the wall of the waveguide leg 22 and consequently to have a controlled amount of radiation. It is well known in the art that a slotted waveguide antenna may have a selected radiation pattern by proper choice of slot-spacing and orientation.

The major component of the current flowing in the waveguide side wall and intercepted by these slots 25 flows across the slots in a direction substantially parallel to the length of the waveguide. The radiated energy therefore is primarily polarized in a horizontal plane. Since the slots are not exactly perpendicular to the length of the waveguide, the energy radiated also has a vertical plane component. This latter energy is desirably suppressed in order that the microwave system radiates and responds only to horizontally polarized energy.

Substantially complete polarization in the horizontal plane is accomplished by features of the structure described in connection with FIGS. 2 and 3.

Now referring in more detail to FIG. 2, the antenna proper may be seen as made up basically of a unitary horn-shaped member 30 including a recess bounded by three planar surfaces 31, 32 and 33. The planar surfaces 31 and 32 are opposed and form the vertical positioning boundaries for the waveguide leg 22, and the planar surface 33 constitutes the rear stop for the waveguide. Between the opposed surface and the rear stop are recesses 34 and 35 forming clearance openings between the horn member and waveguide 22. The front edges or step portions 40 and 41 of the opposed surfaces 31 and 32 and the root portions 42 and 43 of the horn, along with the exposed major faces 44 and 45 of the waveguide, define elongated cavities 46 and 50 having a width substantially great

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enough to avoid restricting radiation from the ends of the slots and a depth substantially equal to an odd multiple of a quarter wavelength of the microwave principal radiated frequency, thereby constituting a choke, tending to suppress vertically polarized radiation from the waveguide slots. The flaring portions 51 and 52 of the horn member 30 extend outward from the root of the horn to limit the vertical radiation pattern. The flaring portions 51 and 52 of the horn member 30 extend only a relatively short distance from the slotted front face of the waveguide 22. Extending beyond the horn proper is the radome 23 for the antenna including planar wall portions 53 and 54 forming extensions of the horn and a central dome aperture 55. The ends of the planar wall portions are recessed in steps 60 and 61 at the outer lips of the horn, and the inner surface of the planar side walls 54 and 55 are metalized, for example with aluminum, so as to define a continuous conductive surface. The aperture portion 56 of the radome 55 of course is unmetalized to allow the passage of RF energy therethrough. By shortening or extending the depth of the wall portions 53 and 54, the aperture 56 may be increased or decreased, thereby controlling the beam width. In one specific embodiment the distance from the waveguide slots to the end of the metalized area of the side walls 53 and 54 is approximately six inches. The flare angle of the horn is approximately 30°, and the beam width at the half power points in the vertical plane is approximately 28°.

It can be seen from FIG. 2 that the antenna proper is made up of three basic elements: the edge-slotted waveguide 22 forming the radiator; the horn-shaped support member 30 for the waveguide defining the root of a horn and cross-polarization suppressor; and a radome 53 forming an extension of the horn and dome. The second element of this combination, the horn member 30, is preferably made of an aluminum or magnesium alloy extrusion having the cross-section appearing in FIG. 2. The extrudable shape of member 30 offers a prime advantage of extremely low cost. The critical dimensions of the entire structure are the spacing and orientation angles of the individual slots, and these are obtainable by accurate milling processes available in the art.

The radome forming the extension of the horn is simply a vacuum-formed or otherwise molded resin-bonded fiberglass member having the two planar walls 53 and 54 defining an angle of approximately 30°. The angle of the side walls is not critical, and the only major restriction on the dimensions of the radome 53 is that the surface of the junctions 60 between the support member 30 and the radome side walls 53 and 54 are smooth so as to avoid reflections.

As may be clearly seen in FIG. 2, the antenna 10 is supported by a simple channel bracket 15 secured to the circular plate 13 constituting the rotating member of the rotor of FIG. 1. The channel shape of bracket 15 provides a degree of mechanical protection for the feed leg 21 of the waveguide 20.

In FIG. 3, another aspect of the radome is illustrated by the array of dashed lines indicating the presence of embedded electrical conductors 62 forming a vertically oriented grid across the face of the antenna. The ends 63 and 64 of the conductor 62 extend out of the radome 55 at a suitable point for convenient electrical connection. In practice the conductors are connected to a source of power to provide a heating current in the face of the radome to prevent the icing of the antenna when it is subjected to subfreezing weather. The vertically oriented grid performs an additional function in that it provides further cross-polarization suppression in combination with the chokes 46 and 50 at the root of the horn. This effect is best achieved when the conductors are spaced at minor percentages (significantly less than one-half) of a wavelength apart. The net result of the two forms of cross-polarization suppression in actual practice is that the level of vertically polarized energy radiated is suppressed 40 db.

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The horizontal and vertical radiation patterns of the antenna of FIG. 1 appear in FIG. 4 and FIG. 5, respectively. In FIG. 4 the ordinate axis is calibrated in radiated power in one direction, measured in decibels. The abscissa is calibrated in degrees in the horizontal plane from the axis of the antenna normal to the center of the waveguide leg 22. It should be noted from FIG. 4 that the beam width at the half-power points is in the order of 2°, giving an extremely narrow beam in azimuth. The first side lobes are both down at least 28 decibels, and the major side lobes down at least 25 or 26 decibels. The narrow beam is accomplished by the orientation of the respective slots 25 as indicated above.

The vertical pattern shown in FIG. 5 indicates that the horn produces a beam width of approximately 28° at the half-power points. This beam width is desirable for navigational applications.

In the description of the invention, reference is made only to a single waveguide array. It is recognized, however, that individual antennas may be stacked vertically. Moreover, the cross-section of the support member 30 may be modified to include two vertically displaced recesses for a pair of waveguides and thereby achieve the same effect. Such a modification illustrates how the single support member 30 both literally and figuratively forms the backbone of this invention. It supports and positions the waveguide radiator, defines the vertical radiation pattern, and also provides cross-polarization suppression. The radome further limits the vertical pattern when it is internally metalized and adds to the cross-polarization suppression by the presence of the properly oriented conductors. The cooperation of these elements with a slotted waveguide provides a simple, relatively inexpensive, and extremely effective microwave antenna.

Although for the purpose of explaining the invention a particular embodiment thereof has been shown and described, other modifications within the spirit and scope of this invention will occur to persons skilled in the art. The scope of this invention is only limited by the appended claims.

We claim:

1. In a microwave antenna including a waveguide section having a plurality of slots constituting a slot array: a support for said waveguide comprising a unitary member having a length at least as great as the length of the slot array and including a recess for positioning said waveguide with the slotted face thereof exposed, said support including a pair of flaring wall portions extending outward from said slot array, the root of said wall portions terminating in a recess bounded on one side by a side wall of said waveguide, said recess having a depth substantially equal to an odd multiple of a quarter wavelength of the principal radiated frequency and thereby constituting a cross-polarized energy suppressor, and a radome of low-loss dielectric material including a pair of planar wall portions constituting an extension of the flaring walls of said support and a central dome portion, at least a portion of said planar wall portions of said radome being internally metalized to constitute an extension of the horn formed by the flaring walls of said support.
2. A microwave antenna comprising: a waveguide section including a plurality of slots extending generally transverse to the length of one face thereof and forming a microwave energy-radiating array, a support for said waveguide section including a unitary member having an elongated recess for receiving said waveguide section and a pair of flaring wall portions embracing the slotted face of said waveguide and constituting the root of a horn,

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a radome of low-loss dielectric material including planar wall portions constituting extensions of the horn defined by said flaring walls of said support, said radome including a central dome portion joining the outermost ends of said planar portions to constitute an aperture,

and a plurality of electrical conductors extending across said central dome portion of said radome in a direction transverse to the length of said slot array, thereby constituting a cross-polarized energy suppressor.

3. The combination in accordance with claim 2 wherein said conductors are embedded in said radome and extend beyond said dome portion into said planar wall portions.

4. The combination in accordance with claim 2 wherein said conductors are resistance wires for heating said radome by the passage of current therethrough.

5. The combination in accordance with claim 2 wherein the inner surface of at least a portion of the planar wall sections of said radome are metalized to constitute an extension of the horn defined by the flaring walls of said support member.

6. A microwave antenna comprising:

a waveguide section including a plurality of slots extending generally transverse to a face thereof and constituting an array of microwave energy-radiating apertures,

and a support for said waveguide section comprising a unitary member having a length substantially equal

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to the length of said slot array and defining a first elongated recess for positioning said waveguide with the slotted face exposed,

said support including flaring walls embracing and extending outward from the slot array,

said support further defining second and third elongated recesses between the root of each of said flaring walls and said waveguide, the second and third recesses constituting microwave chokes for attenuating cross-polarized energy,

and a radome of low-loss dielectric material including a pair of planar wall portions constituting an extension of the flaring walls of said support and a central dome portion.

7. The combination in accordance with claim 6 wherein said second and third recesses are each bounded on one side by nonradiating faces of said waveguide and by respective step portions of said support.

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