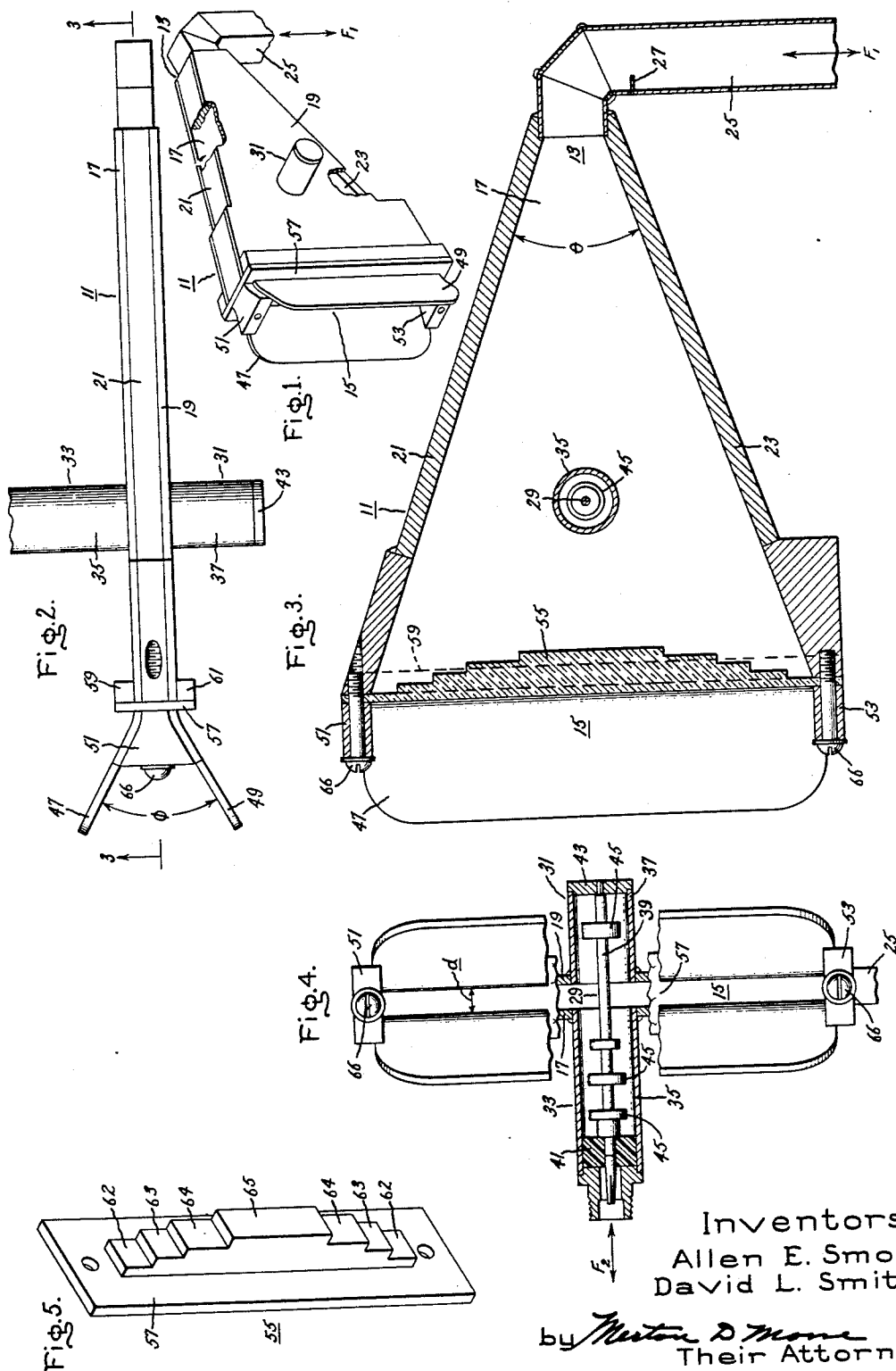


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DUAL FREQUENCY ANTENNA

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1

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DUAL FREQUENCY ANTENNA

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1 Claim. (Cl. 250—33.63)

The present invention relates to horn radiators for ultra-high-frequency wave energy and, more particularly, to such horns adapted for operation with two waves of different frequency values and mutually parallel polarizations.

An object of the invention is to provide a horn radiator operable with electromagnetic waves of different frequency values and mutually parallel polarizations.

Another object of the invention is the provision of an improved horn radiator operable with waves of different frequency values and which is so designed as to prevent waves of either frequency from being supplied from the horn back to the generator of waves of the other frequency. In other words an object of our invention is to provide such a horn having improved means to effect decoupling of the two supply circuits which transmit waves to be radiated to the horn thereby to reduce dissipation of the energy of either frequency in the circuit through which the other frequency is supplied.

Another object of the invention is the provision of an improved horn radiator operable with waves of different frequency values and which is so designed as to prevent waves of either frequency from being supplied from the horn to the translation apparatus of the other frequency. More specifically, an object of our invention is to provide such a horn having means to effect decoupling of the two circuits connected to said horn for supplying to and receiving therefrom waves of ultra-high-frequency energy, thereby to reduce dissipation of the energy of either frequency in the circuit of the other frequency.

In the design of radar apparatus for marine navigation, for example, it has been determined that, for certain purposes, e. g., narrowness of beam, increased directionality and improved definition and resolution, operation at a relatively short wavelength, say 3 centimeters, is desirable. However, for other reasons, for example, a more favorable wavelength-to-object ratio with respect to heavy rain, fog, and other adverse weather elements, it is desirable to operate the radar at a longer wavelength, say 10 centimeters.

The longer wavelength of operation has been found to be effective in open sea voyage giving reliable operation during storms, with relatively good performance with respect to sea return. In harbor travel or in narrow channels the long wavelength lacks required resolution that is available primarily with the shorter wavelength.

The present invention provides a horn radiator that can be used with transmitter and receiver equipment operating at the shorter and longer wavelengths so that, by suitable switching arrangements, the unitary horn radiator can be selectively connected to one or the other of a pair of transmitting and receiving apparatuses, in accordance with the requirements presented.

Heretofore, single horn radiators have been described for operation at two different frequencies, but such radiators have required mutually perpendicular polarizations for insuring isolation of the waves of one frequency value from the source or receiver of the waves of the

2

other frequency value. In prior-known dual-frequency horns operable with two frequencies and parallel polarizations, relatively complicated radiator structures are required for isolation, and such structures as have been described suffer an inherent defect in that undesired directivity patterns are provided thereby.

It is, accordingly, a further object of our invention to provide a novel and improved dual-frequency horn radiator which can be operated with waves of widely differing frequencies and mutually parallel polarizations, the directivity pattern of said radiator having a sharply defined maximum in a predetermined direction and relatively low-valued side lobes in directions other than said predetermined direction.

Briefly stated, in accordance with one aspect of our invention, we effectively isolate the waves of one frequency from the sources or receivers of waves of the other frequency by wave-filtering means associated with the transmission-line apparatus coupling the radiator to the said sources or receivers, thereby to provide a radiator that is simple and compact in construction and which, at the same time, provides the above-mentioned desirable directivity characteristic.

For additional objects and advantages, and for a better understanding of the invention, attention is now directed to the following description and accompanying drawing. The features of the invention which are believed to be novel are particularly pointed out in the appended claim.

In the drawing, Fig. 1 is a perspective view of a preferred embodiment of our invention drawn to a reduced scale; Fig. 2 is a plan view of the apparatus shown in Fig. 1; Fig. 3 is a sectional view taken along the line 3—3 of Fig. 2; Fig. 4 is a front elevational view of our horn radiator, with parts broken away; and Fig. 5 is a perspective view of a dielectric lens forming part of the radiator.

Referring now to Fig. 1 of the drawing, the dual-frequency horn radiator embodying our invention comprises a horn 11 of substantially rectangular cross section, flaring smoothly and continuously from the throat 13 to the mouth or aperture 15. The horn may be fabricated of sheet conducting material such as copper or aluminum, or it may be of other material with the inner walls thereof coated with a suitably conductive surface.

Two of the sides of the horn 11, illustrated as the lateral walls 17 and 19 are parallel and the other two sides, namely the top wall 21 and the bottom wall 23 are flared in the magnetic or H plane of the waves. It will, of course, be understood that the orientation of the horn is optional and that the arrangement described herein is illustrative only, an arrangement with the walls 17, 19 as top and bottom and sides 21 and 23 as the lateral walls being equally effective where it is desired to operate with waves polarized at right angles to the polarization of the waves in the illustrated arrangement.

As shown in Figs. 2 and 3, horn 11 is excited at one of the frequencies of operation, say the higher frequency F_1 , by means of a waveguide 25 through which wave energy at a frequency corresponding to the shorter, say the 3 centimeter wavelength is conducted and launched into the horn. An iris 27 (Fig. 3) of any suitable size and reactance value may be employed, as required, to match the characteristic impedance of the waveguide 25 to the input impedance of the horn for minimizing reflections of energy at the junction of the waveguide and the horn. As will presently appear, the transverse dimensions of the waveguide are selected to provide a below cutoff waveguide for wave energy of frequency corresponding to the lower frequency of operation, while readily propagating energy at the higher frequency.

Referring now to Fig. 4, horn 11 is excited at the other frequency of operation, say the lower frequency F_2 , by

means of a probe 29, which is supported and coupled, at ends thereof, to filter sections 31 and 33 that operate simultaneously to match the impedance of a coaxial transmission line feed (not shown) to that of the horn 11 and to prevent the transmission of wave energy at the higher frequency into the coaxial line. As shown, the probe 29 is introduced into the horn 11 at a point therein at which the dimension in the H-plane is sufficient to support excitation at the lower frequency of operation.

It will thus be seen that the horn 11 is excited by waves of either frequency F_1 or F_2 and, in each case, with horizontal polarization, the direction of electric intensity being normal to the parallel walls 17, 19.

The filters 31 and 33 are designed, in accordance with well-known principles, to provide substantially infinite impedances at the higher frequency of operation F_1 as seen in either direction axially from the probe 29. Also, the impedance looking into the section 31 should be relatively low so that a current maximum occurs at the center of the probe 29. To that end, the filters each may comprise coaxial-line sections having substantially uniform-diameter outer conductors 35, 37 and a common inner conductor 39 coaxially supported therein as by a dielectric bead 41 at the end of filter 33 remote from the probe 29 and conductive shorting disk 43 at the end of filter 31 remote from the probe 29. Portions of the inner conductor having enlarged diameters, as at 45, are suitably designed with respect to diameter and axial length to provide filter characteristics in accordance with the above-mentioned desiderata. The design of such filters, per se, forms no part of the invention and accordingly a fuller description herein of the structure and/or mode of operation are deemed unnecessary.

The vertical primary radiation pattern of the horn is principally a function of the flare angle ϕ between top and bottom walls 21, 23, and the axial length of the horn, while the horizontal primary pattern is determined by the distance d across the narrow dimension of the mouth 15 of the horn. To improve the pattern in the horizontal plane, a mouthpiece comprising a pair of conductive plates 47, 49 are secured together at the opposite ends thereof by wedge-shaped blocks 51, 53, to which the plates are brazed, soldered or otherwise secured, with the planes of the plate 47, 49 defining a predetermined angle of flare ϕ (Fig. 2) which can be determined empirically to provide desired beam width and reduction of side lobes.

Further reduction of undesired side lobes in the vertical radiation pattern is accomplished by means of a stepped dielectric lens 55 that operates, at the same time, to seal the mouth 15 of the horn so that the structure may be pressurized for protection against weather conditions.

As shown in Fig. 5, the lens 55 is formed with a substantially rectangular base 57 peripherally conformable with and suitably bonded to the surface presented by the ends of the walls 17, 19, 21, and 23 (Fig. 2) of the horn and a pair of struts 59, 61, which are preferably mounted exteriorly of the walls 17, 19 and adjacent the mouth 15 to provide structural support for the walls 17, 19, whereby warping or other distortion of the dimensions of the mouth are minimized.

A primary step 62 (Fig. 5) is formed on the base 57, integrally therewith or suitably bonded thereto, and is dimensioned in length and width to fit snugly into the mouth or aperture 15. Rising from the step 62 and in pyramidal form are successively smaller-area steps 63, 64 and 65 of dielectric material similar to that of which the base and the primary step are formed, to provide a lens of which the thickness of dielectric is greater along the axis of the horn 11 and smaller in the region adjacent the top and bottom walls 21 and 23.

The increased thickness of dielectric provided by lens 55 effectively slows down the center portion of the waves and thus corrects an unduly large curvature of the phase front of the waves that is known to develop in sectoral

or flared horns of the general type described herein. This correction of the curvature, it has been found, effectively reduces the magnitude of the side lobes and thereby improves the directivity of the radiator.

In assembly of the mouth end of the horn, a mouthpiece subassembly comprising the plates 47 and 49 and the blocks 51 and 53 is preliminarily formed, and the lens 55 is bonded in position, as above described. The mouthpiece sub-assembly is then attached to the horn and secured as by screws 66, which pass through aligned openings in the blocks 51, 53, base 57 and upper and lower walls 21 and 23, respectively.

It may be observed that for some desired frequencies of operation corresponding to the frequency F_1 , the length of the probe 29 included within the resonator may be more than a half wavelength. Under such circumstances, the current distribution thereon may become such as to produce undesired distortion of the radiation pattern. Such deleterious effects may be avoided by using quarter wavelength coaxial chokes at approximately quarter wavelength intervals, thereby to reduce the length of the probe.

It will be apparent, to those skilled in the art, that the probe 29 can be made to extend only part way through the horn in which case the filter section 31 can be eliminated. Also, the filter sections can be formed with dielectric beads or series reactance elements in either the outer or inner conductors, or shunt-connected reactance elements can be employed, as desired.

In operation, with the waveguide 25 connected to a transmitter and/or receiver operable at a frequency F_1 and the coaxial line section 33 connected to a transmitter and/or receiver operable at a frequency F_2 , waves of either frequency can be radiated and received by the horn radiator 11, the waves of frequency F_1 being effectively isolated from the transmitter and/or receiver operating at frequency F_2 , and vice versa.

It will be understood that the wavelengths of 3 and 10 centimeters, mentioned herein, are exemplary only and are not intended as limitations of the scope of the invention.

While we have shown and described specific embodiments of our invention, we do not desire our invention to be limited to the particular form shown and described and we intend by the appended claim to cover all modifications within the spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

An electromagnetic horn for propagating waves of two different frequencies, comprising a throat portion and a pair of oppositely disposed sidewalls, waveguide means at said throat portion for launching waves of one frequency into said horn and dimensioned below cutoff for waves of the other frequency, coaxial transmission means coupled through said sidewalls for launching waves of the other frequency into said horn, said coaxial transmission means including a cylindrical outer-conductor member and a coaxially-disposed inner-conductor member, said inner-conductor member having a plurality of spaced enlarged-diameter portions defining with said outer-conductor member filter means adapted to pass waves of said other frequency and to block waves of said one frequency, whereby effective isolation of the respective waves is provided.

References Cited in the file of this patent

UNITED STATES PATENTS

2,364,371	Katzin	Dec. 5, 1944
2,408,425	Jenks et al.	Oct. 1, 1946
2,425,488	Peterson et al.	Aug. 12, 1947
2,438,987	Bailey	Apr. 6, 1948
2,514,779	Martin	July 11, 1950
2,547,416	Skellett	Apr. 3, 1951
2,669,657	Cutler	Feb. 16, 1954