ACOUSTIC HORN ANTENNA WITH CORRUGATED LENS

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A horn-lens antenna with different main lobe widths in the azimuth and elevation planes is described. The acoustic lens with a hemispherical surface is formed by bent planar acoustic waveguides. The antenna characteristics are given.

In Ref. 1, horn-lens antennas with an axisymmetric directional pattern are described. Receiving antennas with different main lobe widths in the azimuthal and elevation planes are often required to solve a number of applied acoustics problems. For example, for an investigation of near-ground sound wave propagation and in bistatic acoustic meteorological radars whose space resolution can be improved by using a narrow beam in the elevation plane, while for consistent signal reception on exposure to wind and temperature refraction, the required main lobe width of the directional pattern in the azimuth plane depends on the magnitude of refraction effects, and is normally no less than 10°–15° (Ref. 2).

To solve this problem, use may be made of a planoconvex lens wherein sound is focused by a set of bent planar acoustic waveguides[3], as shown in Fig. 1.

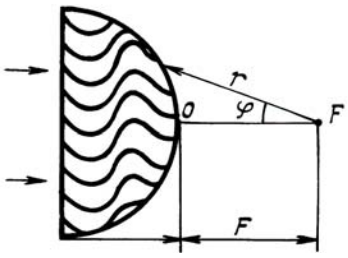

FIG. 1. The corrugated acoustic lens

Note that an effective refractive index equal to a relative increase in the path length in the waveguide is obtained in this case. The bends of the corrugated surface are most easily shaped into semicylinders. The resulting refractive index is equal to $n = \pi R/2R = 1.57$, where R is the radius of the cylinder surface.

If a sinusoidal surface profile were employed, the index of refraction would be calculated through determination of the sinusoid arc distance, which would lead to an elliptic integral that could not be expressed in terms of elementary functions and must be computed numerically. In our case the acoustic lens is formed by a set of semicylinders with small plane initial parts, while the surface skirting the plate edges is a hemisphere. As the plate slabs have a complex configuration, their patterns were cut using a semigraphical method for calculating the evolvent of intersections of the cylindrical surfaces with the sphere. The radius of curvature of the cylindrical corrugated surface was taken to be 20 mm.

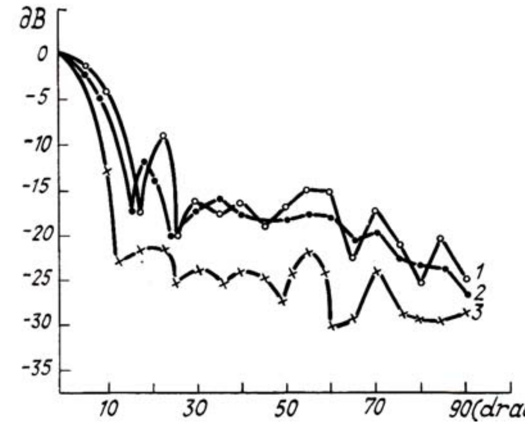

FIG. 2. The directional pattern of the antenna at 6 kHz. 1 – horn without lens, 2 – directional pattern in azimuthal plane, 3 – directional factor pattern in elevation plane

The proposed lens has a 400 mm aperture and a ~ 400 mm focal length. The corrugated lens bounded by the spherical surface fails to provide precise tautochronism thereby causing a lower amplification of the arriving signal as compared to lenses based on circular waveguides[1]. The corrugated lens was tested together with a conical horn 400 mm high and 400 mm in diameter. The lens on-axis gain is about 8 dB at 6 kHz. The directional pattern of the horn-lens antenna was measured in two planes in the receive mode. The measurements were carried out using a Model PSI-202-00001 precision pulsed sound-level meter with a MV-102 microphone. The directional factor pattern at 6 kHz is illustrated in Fig. 2.

The experiments demonstrated quite good characteristics of the corrugated lens antenna. Though inferior to the circular waveguide lens antennas in performance, other things being equal, the corrugated lens antenna may be applicable for solving certain acoustics problems owing to its peculiar directional pattern.

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