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Convergence Property of Aplanatic Straubel Acoustic Mirror Made of Acrylic Resin
アクリル製シュトラウベル反射鏡の集束特性

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1. Introduction

Underwater acoustic imaging technology is effective for marine resource detection, coastal security, and maintenance of seashore facilities. Underwater acoustic lenses and acoustic mirrors made an effort on reducing sound attenuation, aberration, and having stability for water temperature change. In past study, Y. Sato *et al.* designed an aplanatic Straubel AS mirror[1)]. The AS miror is aplanatic back-surface mirror. The AS mirror could correct spherical and coma aberrations in result of calculation. We made AS mirror with acrylic resin and measured the convergence of acoustic field in this report.

2. Experiment

Schematic view of the experimental devices is shown in **Fig. 1**. In the experiment, we used a water tank which has 2 meters wide (*x*-axis), 3 meters long (*y*-axis), and 0.6 meters deep (*z*-axis). A transmitter (RESON TC3029) was put in the center of the mirror and was parallel to the *y*-axis direction. A receiver (RESON TC4035) was put in a movable arm. The mirror could rotate 360°.

We measured sound field distribution around the focus from incidence angle 0° to 15°. We input the sinusoidal burst wave whose pulse length was 5 cycles from a function generator (Agilent 33120A) to the transmitter. The frequency was 500 kHz. The reflected sound pressure was received by the hydrophone, and passed through the amplifier (NF 5307), filter (NF 3628), and A/D converter (ELMEC EC-6904). We measured 10 times at each point to enhance the S/N ratio. We defined the mean square at each point as a measured value. The mirror could be rotated in order to change the incident angle, θ.

Ray trace diagrams and cross-sectional shape of the AS mirror are shown in **Fig. 2**. The AS mirror was made of a hollow acrylic resin. The rays are converged without aberrations when the

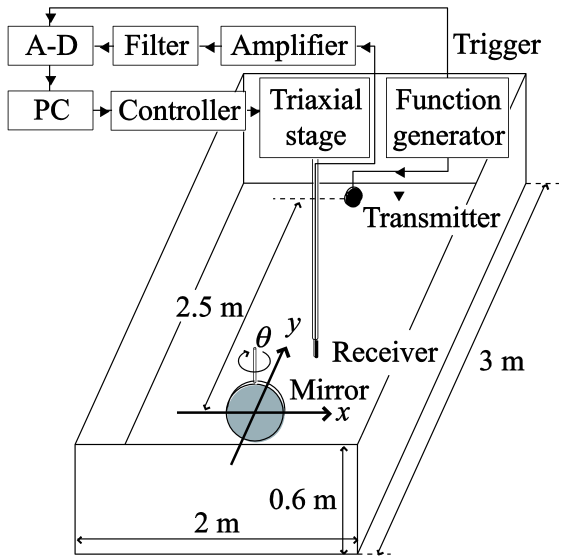

Fig. 1 Schematic view of experimental devices and measuring axes in water tank.

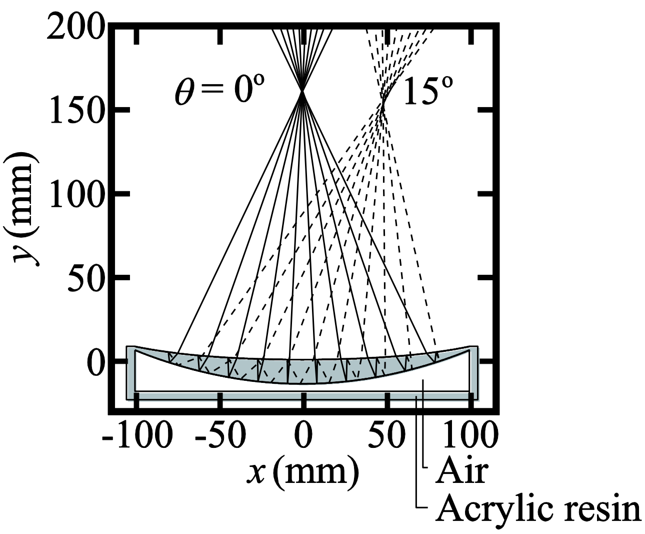

Fig. 2 Ray trace diagrams of incident angle 0° and 15°and cross-sectional shape of AS mirror.

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incident angle, θ, is 0° and 15°. The focal length and aperture were 160 mm and 200 mm. The focal length is shortened because receiver array will interrupt incident wave if the array is used.

3. Convergence property

Experimental sound power distributions under incident angle 0° to 15° are shown in **Fig. 3**. The power distributions are normalized by the maximum power of each incident angle. Dot lines in **Fig. 4** show azimuth angle from the mirror. We regard a peak point of sound power as a focal point at each incident angle. The gray colored areas have over half power of each focal point. The gray areas show almost the same shape from 0° to 10°, however, different shape at 15°. It is considered that the gray area is deformed by aberrations. Additionally, gray areas of 5°, 10°, and 15° are not on the dot lines. These displacements are caused by a distortion or inaccuracy in rotation. The distortion is one of the Seidel aberrations and generates the image deformation [2].

Beam patterns of AS mirror are shown in Fig. 4. The beam patterns are normalized by the maximum sound power of incident angle 0°. The beam width is broadened and relative power decreases as the incident angle increases. The causes are thought of as the mirror cannot correct aberration in large incident angle due to short focal length.

4. Conclusion

We measured the convergence of sound field of the AS mirror made of acrylic resin. In the result, the sound pressure showed almost the same shape except for incident angle 15°. The causes were thought of aberration generated by the short focal length. Additionally, the focal points did not appear on accurate locations. The causes were thought of as the rotate angle was not accuracy, and the distortion was generated. We need to set incident angle accurately, and design new AS mirror to reduce aberrations, in future work.

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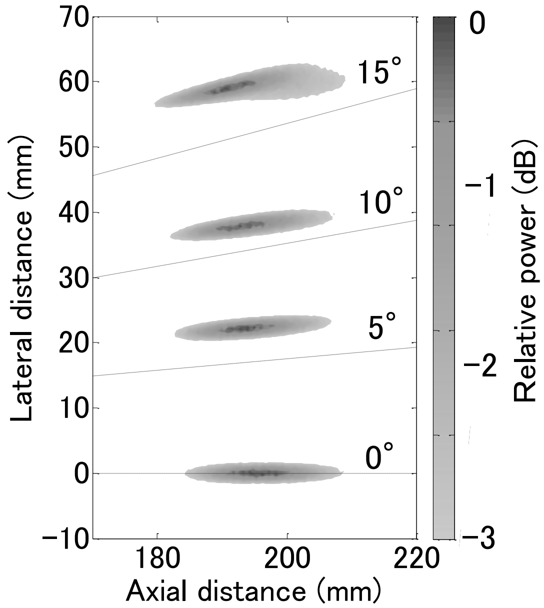

Fig.3 Sound power distributions of AS mirror under changing incidence angle. The gray colored areas have over half power of each focal point. Dot lines show azimuth angle.

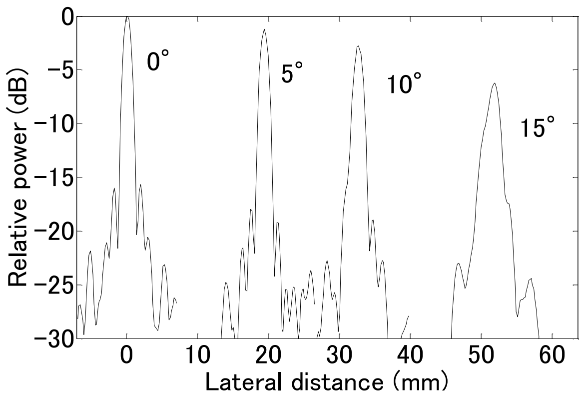

Fig. 4 Beam patterns of AS mirror normalized by the maximum sound power of incident angle 0°.

References

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