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Proceedings of Symposium on Ultrasonic Electronics, Vol. 34 (2013) pp. 277-278
20-22 November, 2013

A New Technique for Forming Linearly High-Intensity Aerial Ultrasonic Waves
強力空中超音波を線状に形成する新たな手法

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1. Introduction

Research and development efforts have been made on many application technologies using high-intensity aerial ultrasonic waves[1-3]. We developed a new linearly convergence source of high-intensity aerial ultrasonic wave (at a frequency of 20 kHz to 50 kHz) which comprises a striped-mode rectangular vibrating plate and parabolic reflectors. The new converging method that we propose can converge effectively along a straight line the ultrasonic waves radiated by the vibrating plate. In addition, the reflectors used to converge the radiated ultrasonic waves have a much simpler construction than the conventional ones.

2. Structure of linearly converge aerial ultrasonic source

The conventional ultrasonic source having a structure as shown in **Figure 1** has been used to produce aerial ultrasonic waves converging along a straight line[4]. The rectangular vibrating plate (made of duralumin) is vibrated in the stripe-mode to radiate ultrasonic waves from its back and front faces having four main lobes[5].This source is equipped with the emission direction converters which comprise plural insulating plates and parabolic reflectors. The ultrasonic waves are converged on the axis y by adjusting the phases of the ultrasonic waves radiated from between the insulating plates of the emission direction converters.

On the other hand, the ultrasonic source as shown in **Figure 2** uses the new method to converge the ultrasonic waves radiated by the stripe-mode rectangular vibrating plate along a straight line. This ultrasonic source comprises two reflectors that are constituted by the parts of a cylindrical parabolic respectively. Therefore, it is necessary to install the vibrating plate and the reflecting plates in an appropriate positioning relationship in order to ensure that the ultrasonic waves radiated by the vibrating plate converge into the focus of the cylindrical parabolic. The reflector is sized so that it covers the whole faces of the vibrating plate, and has a striped pattern of concaves and convexes on its surface as shown in the figure. The widths of the concaves and convexes are equal to the pitch between the nodal lines in the stripe-mode. The depths of the concaves and convexes are designed so that the ultrasonic waves converge into the focus of the cylindrical parabolic in the same phase relationship.

3. Characteristics of new ultrasonic source

First, the basic characteristics of the linearly convergence ultrasonic source made on the experimental basis will be described. A longitudinal vibration system of the ultrasonic source as shown

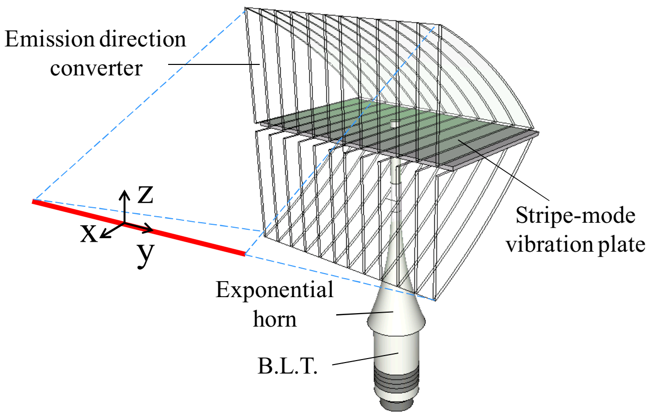

Fig. 1 Schematic view of conventional sound source.

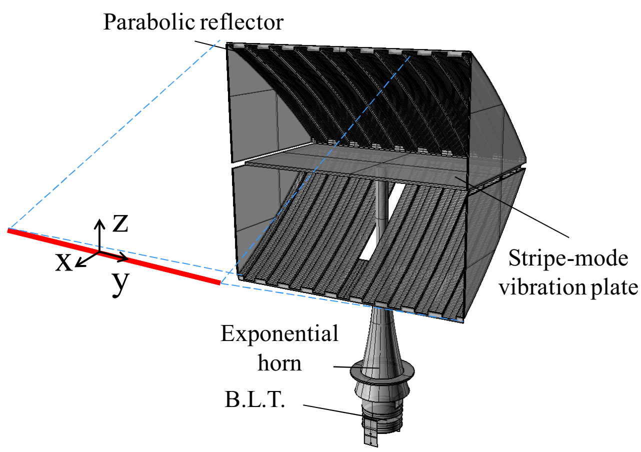

Fig. 2 Schematic view of new sound source.

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in Fig. 2 comprises a bolt-clamped Langevin-type transducer (B. L. T.), an exponential horn and a vibration transmission rod. Ultrasonic waves are aerially created by the transverse vibrating plate (width: 89mm, length: 167mm, thickness: 2mm, material: aluminum alloy plate). It has 18 nodal lines, and the nodal line pitch is 9.57mm. The reflectors installed on the back and front faces of the vibrating plate are made of chemical wood, and designed and manufactured so as to ensure the ultrasonic waves radiated by the vibrating plate are converged into a point 140mm distant from the opening of the ultrasonic source. The frequency to drive the ultrasonic source is 50.80 kHz.

Figure 3 shows the sound pressure distribution on the axes x and z around the ultrasonic waves converging point.

Figure 4 shows the sound pressure distribution on the axes y. The figures indicate that the ultrasonic waves radiated from the vibrating plate converged at the designed position.

Figure 5 shows the relationship between the electric power supplied to the ultrasonic source and the sound pressure at the converging area. The figure indicates that the ultrasonic pressure increased in the ratio of the 0.5 power of the electric power supplied to the ultrasonic source, and that the ultrasonic wave having a high intensity of about 1000 Pa was produced at the supplied electric power of 7W.

4. Conclusion

We proposed a new method for converging the aerial ultrasonic waves radiated by a stripe-mode rectangular vibrating plate along a straight line, and made an ultrasonic source at frequency of 50 kHz on the experimental basis. As a result, it was found that the new method could well converge ultrasonic waves, and produced the convergent ultrasonic wave having a much higher intensity than those using conventional ultrasonic sources.

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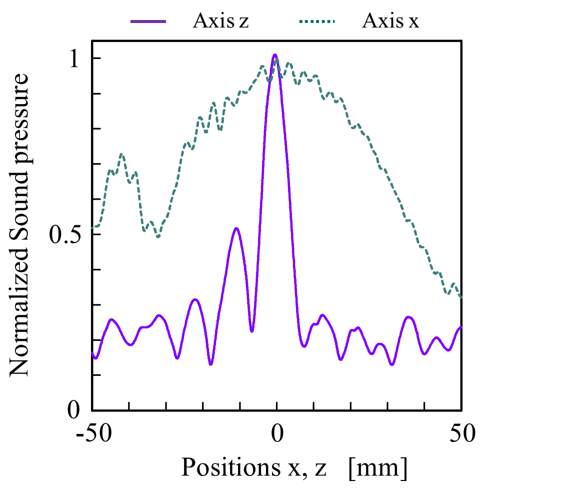

Fig. 3 Distribution of sound pressure along the x-axis and the z-axis.

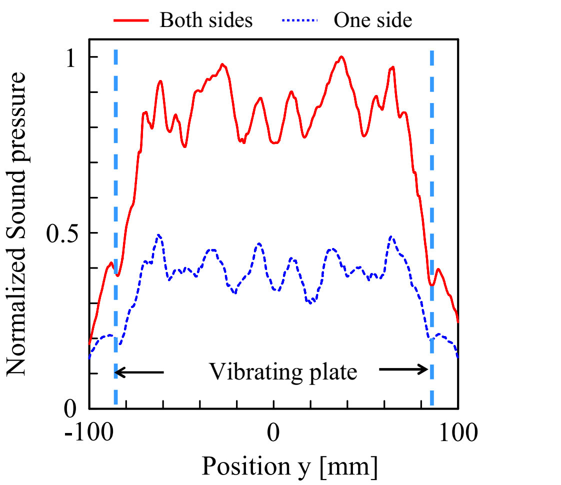

Fig. 4 Distribution of sound pressure along the y -axis.

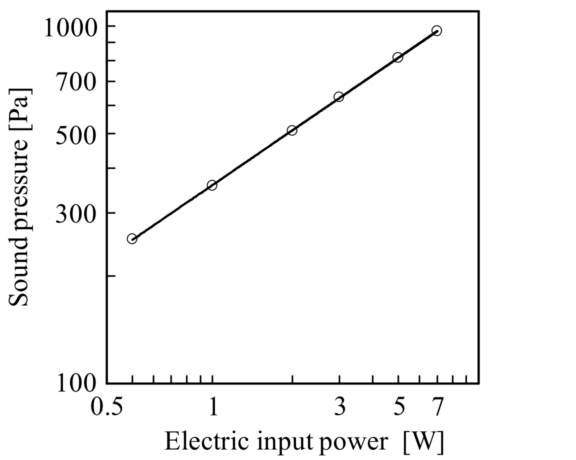

Fig. 5 Relationship between electric input power supplied to sound source and sound pressure in the focused sound field.