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A New Point-Convergence Type Aerial Ultrasonic Source with a Stripe-Mode Vibrating Plate

縞モード振動板を用いた新しい点集束型空中超音波音源

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1. Introduction

A source of point-convergent ultrasonic wave (at a frequency of 20 kHz to 50 kHz), which converges the aerial ultrasonic waves radiated by a stripe-mode rectangular vibrating plate into one point, can produce the ultrasonic waves of very high intensity. Therefore, it is used in various applications[1,2]. However, this ultrasonic source comprises the reflectors having a slightly complex structure to converge ultrasonic waves. Also, it uses only a part of the ultrasonic waves radiated by the vibrating plate due to the principle of converging ultrasonic waves. This paper proposes a new point-convergence-type aerial ultrasonic source that presents a better ultrasonic wave converging characteristic by combining a stripe-mode vibrating plate with reflectors having a simple structure.

2. Structure of point-convergence type aerial ultrasonic source

The rectangular vibrating plate (made of duralumin) is vibrated in the tripe-mode to radiate ultrasonic waves from its back and front faces having four main lobes[3]. The ultrasonic source having a structure as shown in **Fig. 1** is used to produce these ultrasonic waves converging into one point[4]. This source is equipped with the emission direction converters which comprise plural insulating plates and parabolic reflectors and are installed on the back and front faces of the source. The ultrasonic waves are converged into the point O by adjusting the phases of the ultrasonic waves radiated from between the insulating plates of the emission direction converters. For an example, the ultrasonic source presents the characteristic that produces a convergent ultrasonic wave having a very high intensity of about 168 dB at the frequency of 20 kHz and the supplied power of 50 W.

On the other hand, the ultrasonic source as shown in **Fig. 2** uses a new method to converge the ultrasonic waves radiated by the stripe-mode rectangular vibrating plate into one point. This ultrasonic source comprises two reflectors that are constituted by the parts of the rotated paraboloid 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 paraboloid. 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

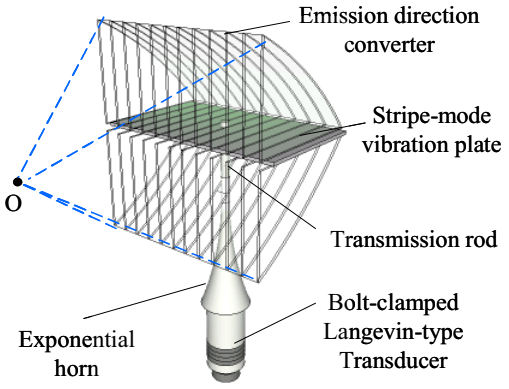

Fig.1 Conventional type point convergence aerial ultrasonic source.

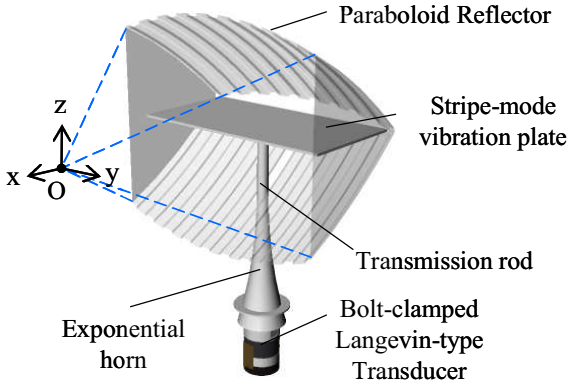

Fig. 2 New type point convergence ultrasonic source.

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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 paraboloid in the same phase relationship.

3. Characteristics of new ultrasonic source

Here, the characteristics of the point-converging ultrasonic source made on the experimental basis will be described. A longitudinal vibration system of the ultrasonic source as shown in Fig. 2 consists of a bolt-clamped Langevin type transducer, an exponential horn and a vibration transmission rod. Ultrasonic waves are aerially created by the transverse vibration plate (width: 89 mm, length: 167 mm, thickness: 2 mm, material: aluminum alloy plate). It has 18 nodal lines, and the nodal line pitch is 10 mm. 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 both faces of the vibrating plate are converged into a point 120 mm 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, y and z around the ultrasonic waves converging point. The figure indicates that the ultrasonic waves radiated from the vibrating plate converged into the point almost at the designed position.

Figure 4 shows the relationship between the electric power supplied to the ultrasonic source and the sound pressure at the converging point. 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 very high intensity of about 7000 Pa was produced at the supplied electric power of 5 W. For comparison, the figure also shows the convergent ultrasonic wave characteristic of the conventional ultrasonic source using the same vibrating plate.

4. Conclusion

We proposed a new method for converging the aerial ultrasonic waves radiated by a stripe-mode rectangular vibrating plate into one point, 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 produce the convergent ultrasonic wave having a much higher intensity than those using conventional ultrasonic sources.

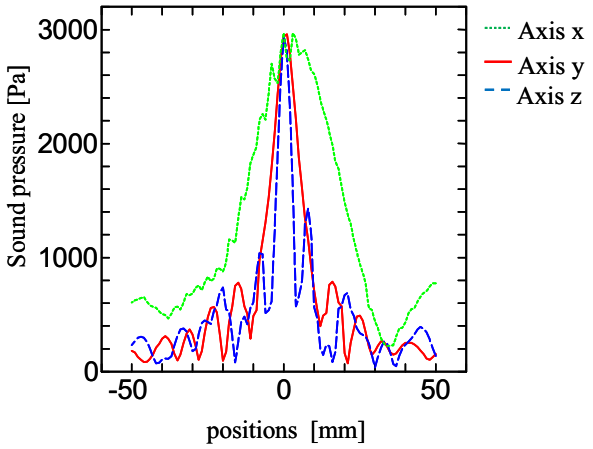

Fig.3 Distributions of sound pressure in vicinity of the converging point.

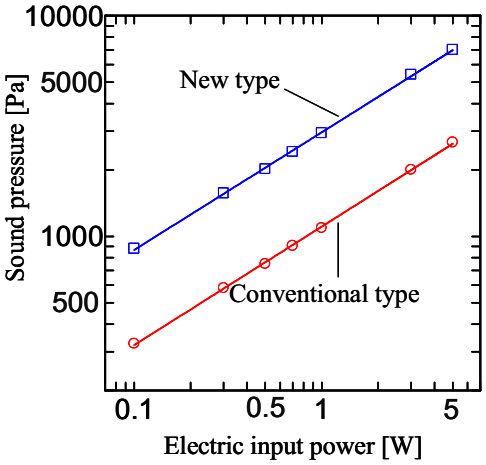

Fig.4 Relationship between sound pressure in the focused sound field and input power supplied to the sound source.

References

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