SCALE MODEL EXPERIMENTS ON NOISE REDUCTION BY ACOUSTIC BARRIER OF A STRAIGHT LINE SOURCE

Masaru KOYASU and Mitsuyasu YAMASHITA

Kobayashi Institute of Physical Research, Kokubunji, Tokyo (Japan)

(Received: 2 April, 1973)

SUMMARY

Noise reduction by an acoustic barrier of a straight line source is examined with the aid of scale model experiments. The line source used in these experiments is an incoherent line source mechanically radiating broad band noise. From the experimental results a curve can be deduced which shows a relation between sound attenuation and Fresnel number N. This curve shows values lower than those of Maekawa's data by 3～5 dB, which are presented for a point source. On the other hand, it agrees fairly well with Rathe's experimental results, measured near the tracks of a railway line, and also shows a similar tendency to the curve calculated by Kurze and Anderson for an incoherent line source.

INTRODUCTION

One of the practical ways of reducing noise from road traffic, a railway, a factory, etc., is to construct an acoustic barrier near to the source.

Many experimental and theoretical studies have been carried out on the effect of noise reduction by an acoustic barrier. Maekawa's results, in particular, are widely used for the design of an acoustic barrier, but this can be applied in the case of a point source. However, in the practical situation, there are often many cases where the dimensions of the noise source are significant. In such cases, the noise source is usually regarded as an aggregate of manu point sources. For each point source, noise reduction by an acoustic barrier can be estimated from the figure published by Maekawa, and then the sound pressure levels corresponding to all point sources are summed up at the receiving point. However, it is fairly difficult to simulate the practical noise source as an aggregate of the point sources. In addition, it would be difficult to estimate the noise propagation over the complicated surfaces

---

Applied Acoustics(6)(1973)-Applied Science Publishers Ltd, England, 1973-Printed in Great Britain

and obstacles presented by, for example, buildings, undulating land, etc. For these problems, it would be useful to apply a method based on model experiments.

In this report, model experiments on noise reduction by an acoustic barrier of a straight line source will be described.

EXPERIMENTAL STUDY OF NOISE REDUCTION BY ACOUSTIC BARRIER OF A LINE SOURCE

1. *Line source*

Details of the line source used for the model experiments are shown in Fig.1. it consists of a stainless steel channel of C shape, in which there are metal partitions at intervals of 30mm, thus diving the channel into many sections. The same number of small balls are loosely contained in each section. It is driven back and forth in an axial direction by an electric motor, thus the steel balls strike the walls of the channel and radiate broad band noise, Furthermore, the frequency of movement of the channel is adjusted to 2 Hz and has an amplitude of 25mm.

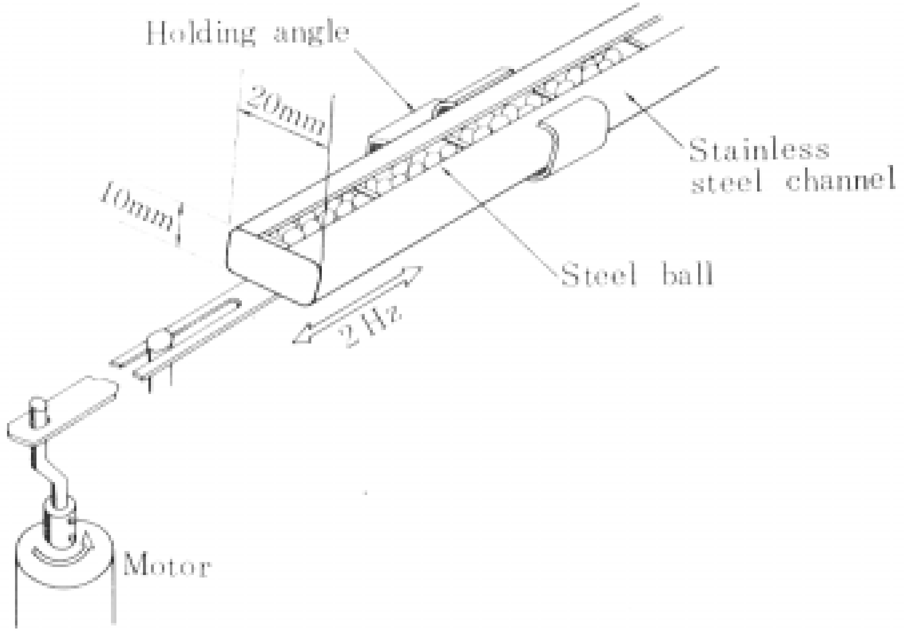

Fig. 1. Details of the incoherent line source used in model experiments.

The noise radiated from each part of the channel has random characteristics in phase. Directivity characteristics in the plane normal has random characteristics in (channel) are nearly non-directional, as shown in Fig.2. Frequency characteristics of the radiated noise are affected by the materials and dimensions of the device, especially of the channel and balls. Figure 3 shows the frequency characteristics of

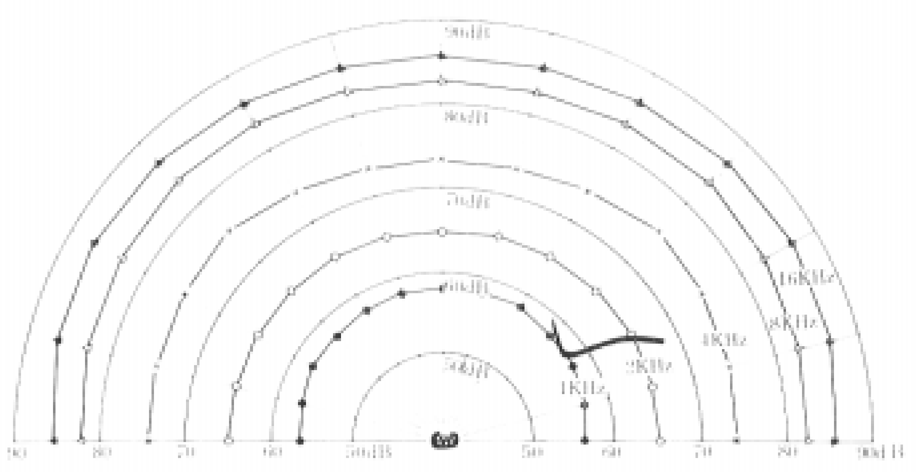

Fig. 2. Directional characteristics in a plane normal to the longitudinal axis of the line source (measured at a distance 1 m from the line source. One - third octave band).

noise for the device used in this ecperiment. In addition, the variation of sound pressure level measured for the direction normal to the source is shown in Fig.4. In this case, the lenght of the source is about 3.8m. For the range less than 1.8m from the source, sound pressure level decreases by approximately 3 dB for every twofold increase in distance. Thus, such a source would be regarded as a line source of infinite lenght for this reason.

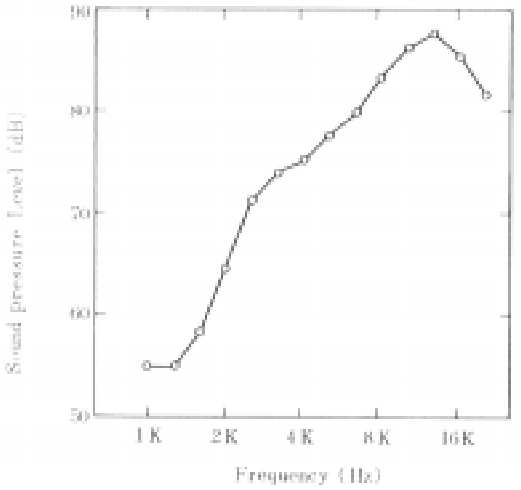

Fig. 3. Frequency characteristics of noise radiated from the line source (measured at a distance 1 m from the line source. One - third octave band).

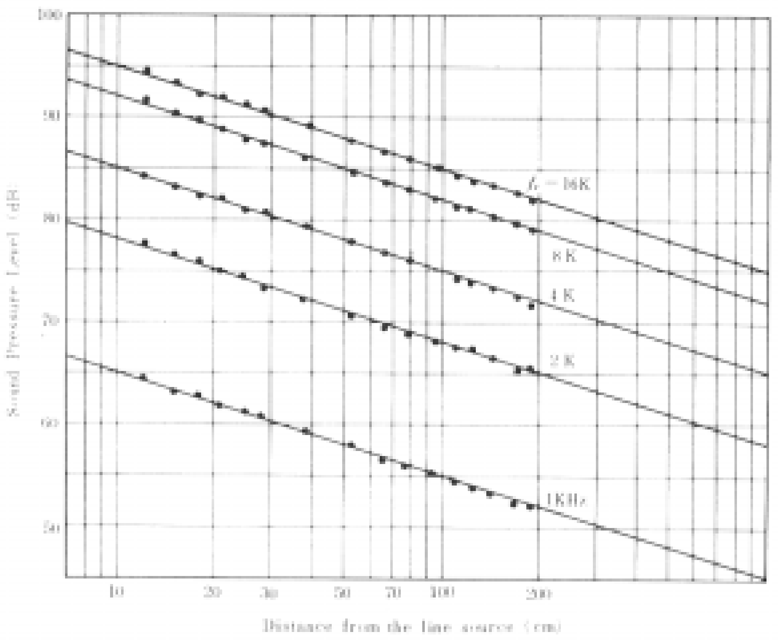

Fig. 4. Sound pressure level as a function of distance from the line source.

2. *Experimental procedure*

Experiments were carried out in an anechoic room. The acoustic barrier used for the experiments was made from plywood having a thickness of 20 mm, and shaped so that the upper edge was similar to a knife edge.

The experimental set-up of the line source, the barrier and the microphone are shown in FIg.5. The acoustic barrier had a lenght regarded as infinite and was put parallel to the line source. In this arrangement, noise from the source was supposed to reach the other side of the barrier only by the diffraction at its upper edge.

For the measurements of sound pressure level, a in condenser microphone was used. This was moved along a guide rail suspended from the ceiling and was operated by remote control. Direction of the microphone movement was fixed normal to the line source.

The measurements of sound pressure level were carried out at the centre frequencies of 1000, 2000, 4000, 8000 and 16,000 Hz, by inserting a one-third octave band filter in the receibing apparatus. The variation of sound pressure level according to the movement of the microphone was recorded on a graphic level recorder.

The height of the acoustic barrier is 16 cm and is fixed at a distance of 14,, 28, 35, 42, 56 or 70 cm from the source.

Alternatively, the same kind of experiments were carried out by using a point source instead of a line source. For a point source, the driver unit of a horn loudspeaker was used, driven by one-h\third octave band noise. This experiment was

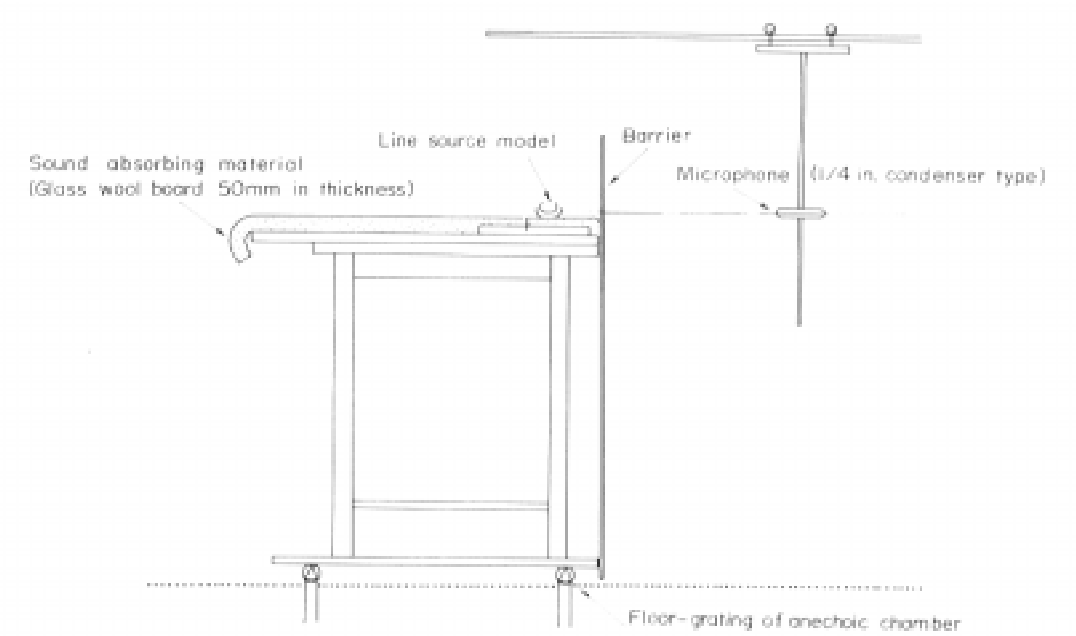

Fig. 5. Experimental set - up.

intended to study the process of approximation involved in replacing a line source by an array of point sources.

3. *Experimental results*

In Fig.6, the measured values of sound pressure level were plotted as a function of distance from the point source to the fixed receiving point with the acoustic barrier in position. Here, the positions of the point source were selected (at

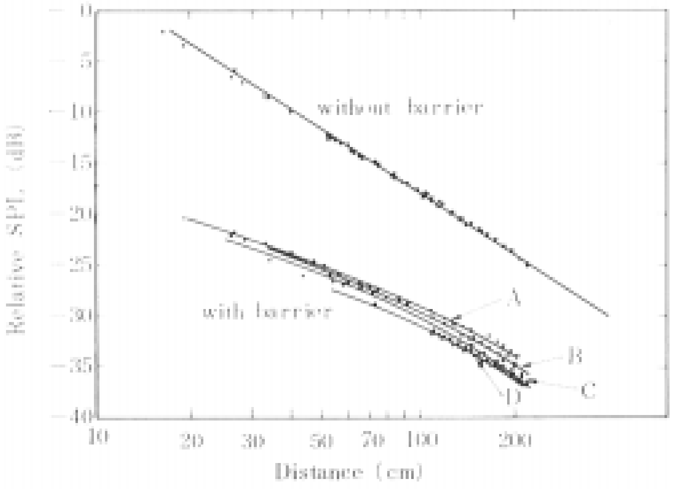

Fig. 6. Relative sound pressure level as a function of distance from each point source (2000 Hz one - third octave band noise).

intervals of 10 cm) on a line parallel to acoustic barrier (Fig.7). The centre frequency of one-third octave band noise used in this experiment was 2000 Hz. The solid curve in Fig.7 shows the estimated values from Maekawa's diagram. As was expected, the measured values were concentrated along this solid curve.

In Fig.8, the measured values of sound pressure levels for each frequency were plotted against the distance from the line source with and without the acoustic barrier. Here, the distance from the source to the barrier was 14 cm.

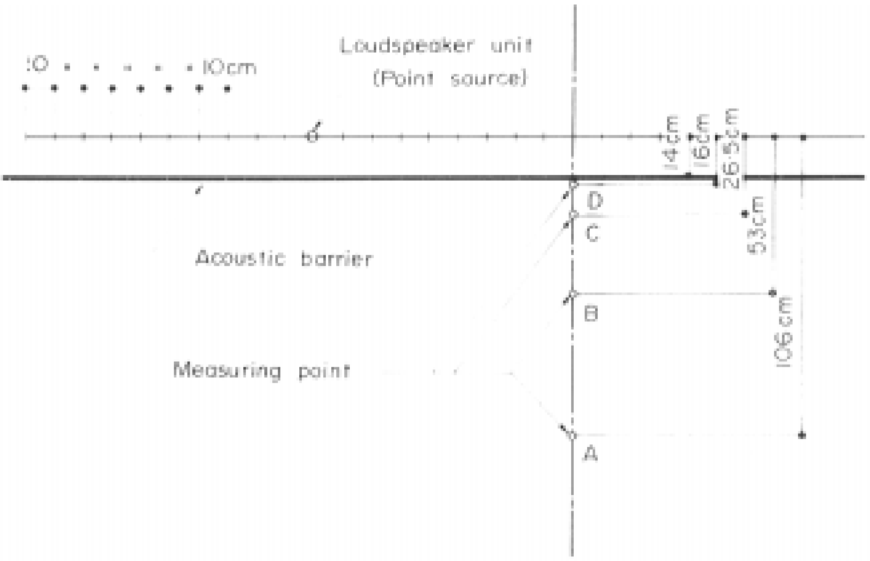

Fig. 7. Positions of the source and the receiving point for the measurement of Fig.6.

The calculated values for an array of point sources are also shown in Fig.8. The calculation was carried out for the case of 40 point sources arranged in a line at intervals of 10 cm. Noise reduction by an acoustic barrier for each point source was obtained from Maekawa's diagram. Experimental values for the line source agree fairly well with the calculated values for an array of point sources.

4. *Design diagram for a line source*

From the experimental results for a line source, the sound attenuation by an acoustic barrier was plotted in Fig.9 against Fresnel number N. Here, sound attenuation is defined as the sound pressure level difference with and without acoustic barrier at each receiving point. Fresnel number N is , where was chosen as the path difference between the direct path and the path passing through the top of the barrier from the source and the receiving point. That is, is the maximum value of path differences from each point on a line source to the fixed receiving point.

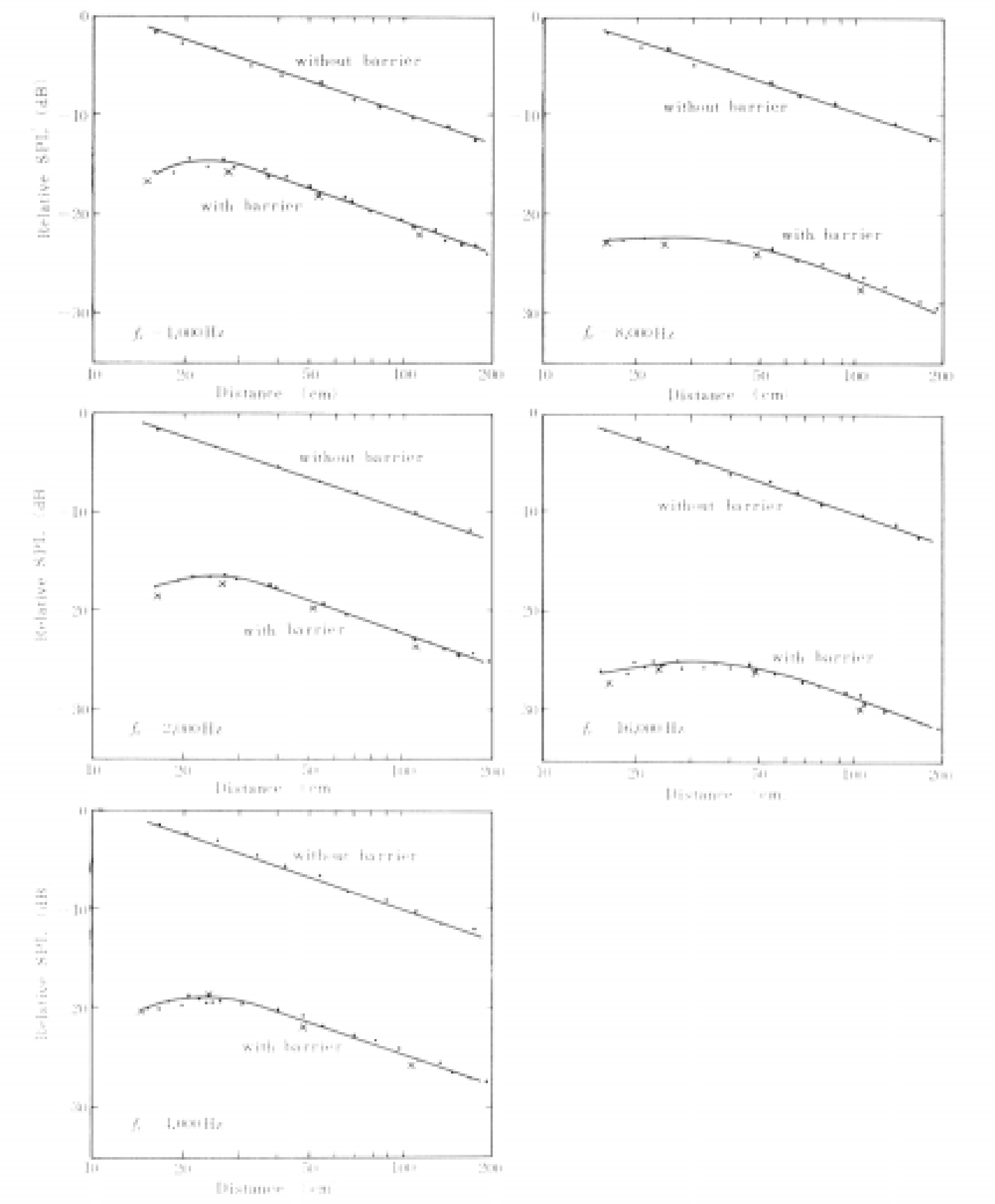

Fig. 8. Relative sound pressure level in shadow zone of the barrie.
●: Experimental values measured with the incoherent line source; ×: Calculated vbalues for any array of point sources.

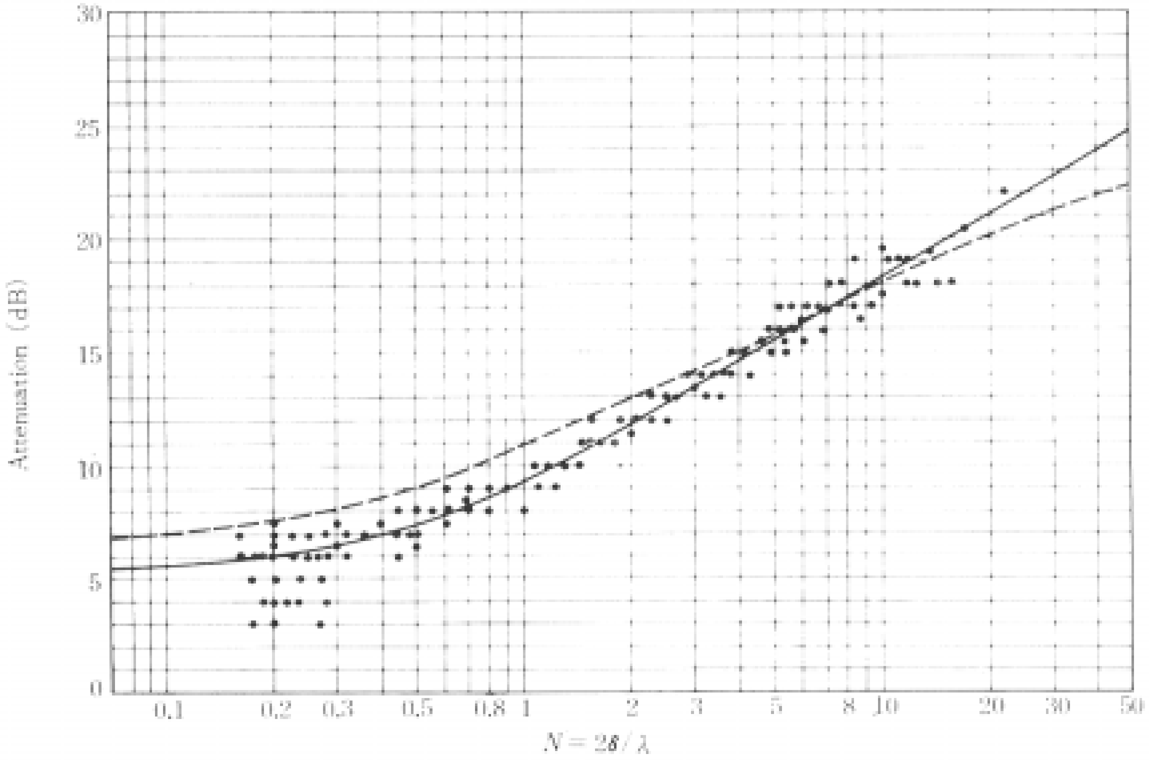

Fig.9. Sound attenuation by an acoustic barrier versus Fresnel number N for an incoherent line source.
●: Our experimental results; – —: Calculated by Kurze and Anderson.

In Fig.9, plotted values results for every combination of the distance from source to barrier, of the distance from source to receiving point, and of frequency. In spite of these different conditions, the relation between sound attenuation and Fresnel number N can be represented by the curve, as shown in Fig.9.

DISCUSSION

Figure 10 shows a comparison between the experimental curve obtained in this study and the results of other stuides.

Sound attenuation for a line source shows values lower than those of Maekawa's data (which are for a point source), by 3～5 dB.

Kurze and Anderson calculated sound attenuation by an acoustic barrier for a coherent line source, by applying Keller's theory of light diffraction. They also calculated the sound attenuation for an incoherent line source. This result agrees fairly well with our experimental result.

Rathe measured the effect of an acoustic barrier constructed along a railway line and reported that the measured attenuation showed the values to be lower than

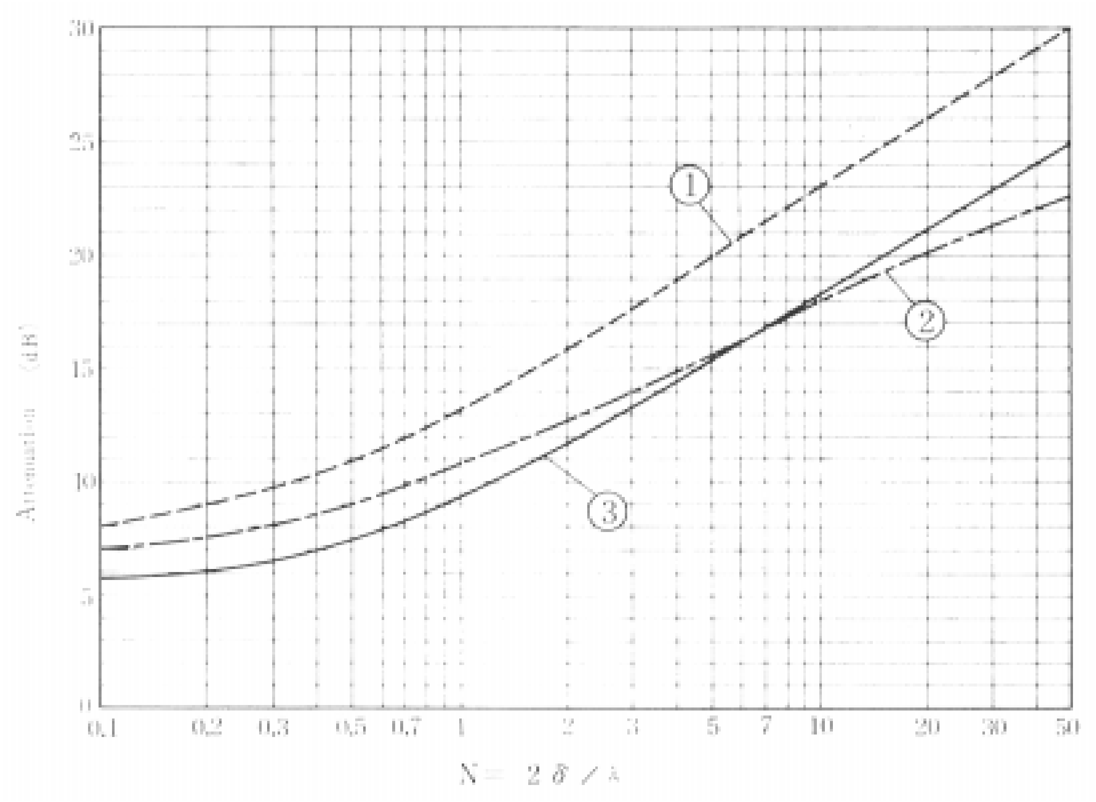

Fig.10. Comparison of different results for sound attenuation by acoustic barrier: (1) Maekawa's result (for a point source); (2) Kurze and Anderson's result (calculated for aline source); (3) our experimental results.

those of the ones calculated from the diagram for a point source. This result would also support our experimental results.

CONCLUSION

Noise reduction by an acoustic barrier has been studied by the use of scale model experiments emplouing a straight line source. The experimental results obtained agree fairly well with the calculated values by replacing a line source with an array of point source.

From these experiments the diagram which shows the relation between sound attenuation by an acoustic barrier for a line source and Fresnel number N was formulated. Sound attenuation for a line source shows values lower than those of Maeawa's data (which were presented for a point source) by 3～5 dB.

The diagram can be applied to estimate the noise reduction by acoustic barrier for a line source, that is, for noise from congested road traffic, the railway, and so on.

The line source employed in this experiment has several advantages, such as stability, easy-handling, coherency and so on. Thus, this source can be effectively spplied to scale model experiemnts.

REFERENCES

1. Z.Maekawa, Noise reduction by screens, Applied Acoustics, **1** (1968), p.157.
2. U.J.Kurze and G.S.Anderson, Sound attenuation by barriers, Applied Acoustics, **4** (1971), p.35.
3. E.J.Rathe, Note on two common problems of sound propagation, *J.Sound Vib.,* **10** (1969), p.472.