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INCE: 38.2

APPLICABILITY OF ACTIVE NOISE CONTROL SYSTEM AS COUNTERMEASURE AGAINST ROAD NOISE

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INTRODUCTION

Road traffic noise is one of the most serious problems related to road environment in Japan. Road agencies have already adopted various countermeasures against the road traffic noise such as noise barriers, low noise pavement, noise absorption panels and so on. Since these passive methods, however, are effective at the frequency of about 500Hz and more, new technologies for the lower frequencies are required. In this context, we have just commenced studies to develop the active noise control(ANC) system for a practical use as a countermeasure against the road traffic noise.

With respect of the cancellation of sound in a free space, the application of multi-channel ANC system has been proposed[1][2]. But the larger the number of the channels becomes, the less the system would be practical because of the complexity of its algorithm and high cost of the controllers. Therefore we propose a single-channel system which does not require complicated and costly hardware.

This paper presents the results of the preliminary experiments in an anechoic chamber that show the applicability of the Lined Single-Channel ANC (LSC-ANC) system as a countermeasure against the road traffic noise.

DEVELOPMENT OF THE LSC-ANC SYSTEM

As stated above, the purpose of our study is to develop a simple ANC system for a practical use to reduce the road traffic noise. We have basically decided to compose the system of a number of single-channel ANC systems which are located in a row. For the development of the system, there were two problems to be solved: (1)Expansion of noise reduction areas of the individual single-channel system; and (2)Prevention of howling between neighboring single-channnel systems.

In order to solve these problems, we have devised the single-channel ANC system with some(three in this paper) error microphones whose electrical outputs are combined to be used as an error signal. The block diagram of this fundamental unit is shown in Fig.1. The unit is controlled under the Filtered-X-LMS algorithm. Detailed conditions of the controller used in the experiments below as follows: frequency range controlled of 50-800Hz, signal sampling rate of 3kHz and tap length of FIR filter of 128.

First of all, we have conducted a experiment shown in Fig.2 to confirm the effect of the fundamental unit. A primary sound source, a detection sensor, a loudspeaker and one or three error microphone are installed at the same height on a straight line. A loudspeaker as a primary source generated random noise at the frequencies ranging from 100 to 700Hz. Fig.3 and 4 show the noise reduction contours of 250Hz in the case of the single-channel ANC system with one error microphone and with three at a interval of 50cm, respectively. The comparison of the two Figures describes that the fundamental unit has widened the noise attenuation area without lessening the effect.

Fig.5 shows the configuration of three fundamental units arranged at a interval of 1m in a row. This is a example of the LSC-ANC system. Fig.6 shows the noise reduction contours of 250Hz of the system. We could successfully avoid the howling between neighboring units and obtain larger attenuation in the larger area compared with Fig.4. It is also observed that the system have accomplished 10-20dB of sound attenuation at the error microphones of the unit B in the controlled range and 4-10dB at the measuring point No.23, respectively(see Fig.7 and 8).

EFFECT OF REFLECTION BEHIND THE SYSTEM AND ITS COUNTERMEASURE

A lot of buildings are seen along roads in urban areas. They behave as reflective objects. For the practical use of the ANC system, it is necessary to investigate the effect of the reflected sound on the system and to cope with it.

Fig. 9 shows the block diagram of the circuit that we have proposed to eliminate the adverse effect of reflected sound on the error signal. Three supplementary microphones are installed behind the three original error microphones respectively and connected to a delay circuit that generates the reverse of electrical input signal delaying the time of sound propagation between the original and the supplementary microphones.

In the experiments, a reflective panel is installed behind the error microphones at the distance of 1m, 3m or 5m as shown in Fig.10. The effects of the fundamental unit with and without three supplementary microphones are shown in Fig. 11. The effect of reflected sound is negligible and no supplementary microphones are need in the case of a reflective wall at a distance of 5m, whereas at a distance of 1m and 3m the supplementary microphones are effective to reduce the influence of reflection.

CONCLUSION

As a consequence we have obtained the following results: (1)three units of LSC-ANC system located at a interval of 1m in a row achieve noise reduction effects of 4-10dB at the frequencies ranging from 100 to 630Hz and widen the noise reduction areas without howling; and (2) a reflective wall behind the ANC system modeled on roadside buildings has little adverse influence on the effects of the system devising the arrangements of the error microphones.

In conclusion, the LSC-ANC system installed along the road could be applicable to reduce the roadside noise especially coming from a steady sound source such as a tunnel.

REFERECES

[1]P.A. Nelson and S.J. Elliott, *Active control of sound*, Academic Press,1992.

[2]Elliott, S.J.,Stothers, I.M., and Nelson, P.A.,"A Multiple-Error LMS Algorithm and its Application to Active Control of Sound and Vibration," *IEEE Transactions on Acoustics, Speech and Signal Processing*, Vol.ASSP35, No.10, 1423-1434, October 1987.

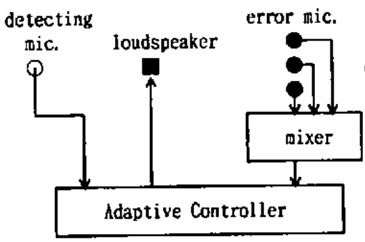

Fig. 1 Diagram of the fundamental ANC unit

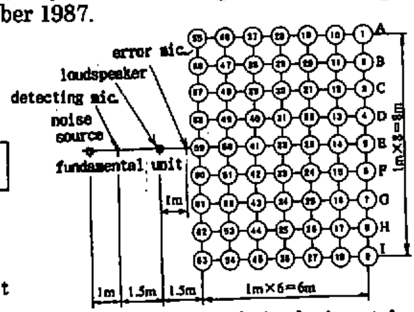

Fig. 2 Arrangement of the fundamental ANC unit

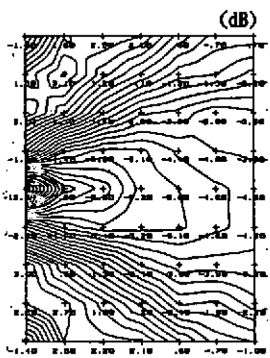

Fig. 3 Sound attenuation contours of 250Hz (1 error mic.)

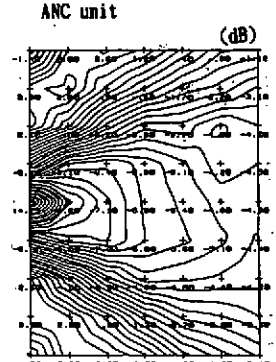

Fig. 4 Sound attenuation contours of 250Hz (3 error mic.)

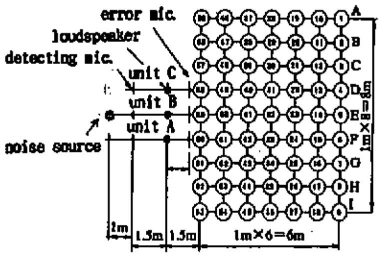

Fig. 5 Arrangement of the LSC-ANC system

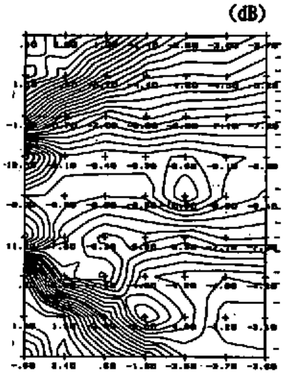

Fig. 6 Sound attenuation contours of the LSC-ANC system(250Hz)

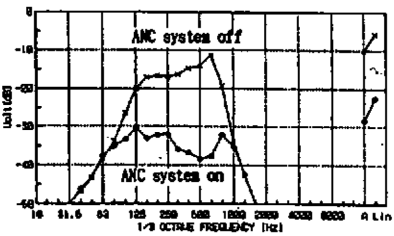

Fig. 7 Sound attenuation at the error mic.

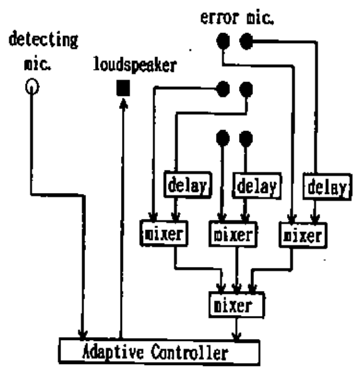

Fig. 9 Diagram of the fundamental ANC unit with the supplementary microphones

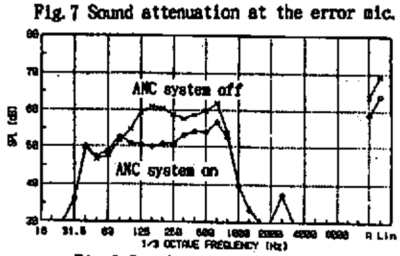

Fig. 8 Sound attenuation at the measuring point No. 23

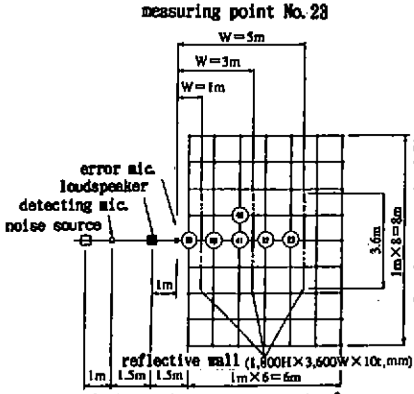

Fig. 10 Measuring arrangement of the effect of reflected sound

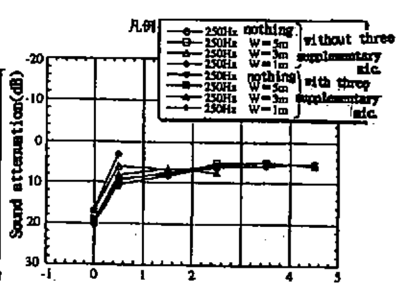

Fig. 11 Effect of the reflected sound and the supplementary microphones