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ACTIVE CONTROL OF NOISE IN INTERIOR SPACES

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INTRODUCTION. This paper presents technical information on experiments in the application of active methods for reducing noise in closed interior spaces. In this context, active noise reduction means the reduction of airborne noise by a secondary airborne cancellation source. That is, superposition of a 180° out-of-phase acoustic signal with an unwanted noise. The cancellation signal, which may be introduced into the system by loudspeakers, is derived from the unwanted noise by electronic control means [2][3][4].

ACTIVE REDUCTION OF NOISE IN THREE DIMENSIONS. Reduction of noise in an anechoic environment at 500 Hz is shown in Fig.1. In this figure the original acoustic signal is introduced by a waveguide labeled, "Source 2." The cancelling signal is also introduced by a waveguide immediately adjacent to the original source. The cancellation waveguide is labeled, "Source 1." The figure shows an acoustic field map for an area 25 cm x 76 cm in front of the waveguides. The contour lines represent lines of equal attenuation. To obtain the data shown, the absolute field strength was mapped with only the original source turned on. Then the cancellation source was turned on, and its magnitude and phase were adjusted to produce the maximum attenuation possible. The maximum attenuation was measured at a point 51 cm away from the source on the center line of the original source. The contour lines shown in Fig. 1 represent the difference between level measured when the noise source was on alone and when both sources were on and the cancellation source was adjusted for best attenuation. The location of greatest attenuation corresponds to the reference microphone location. However, great attenuation is achieved over the entire area. Manual sine wave adjustments were used for clarity and ease of measurement. However, it will be shown that the results also apply to more complicated noise.

Fig. 2 shows the attenuation of a broad band noise. The measurements were made in a 400 cubic meter reverberation room. This is a much more difficult environment, since the reverberant field within the room acts as a "background noise" which limits the performance. The data was taken under automatic control using two large "sub-woofer" loudspeakers. The attenuation extends from 12 Hz to about 400 Hz and could be measured and heard everywhere in the reverberation room.

Fig. 3 shows the reduction of harmonic noise in an outdoor environment. The first three peaks of the noise are well attenuated.

NOISE ATTENUATION IN A MODEL FUSELAGE AND A MODEL ROOM. Measurements were made in a fuselage model 178 cm long and 36 cm in diameter. The ends of the model were terminated by 2.5 cm thick wood. The body of the model was 0.8 mm thick aluminum. Tests were performed within the model by injecting a noise and then superimposing a cancellation signal adjusted for the proper magnitude and phase. [1]

Fig. 4 shows a 400 Hz, sine wave noise within the fuselage model. The superposition of the cancellation signal with the original signal results in a 20 dB to 35 dB reduction everywhere within the model.

Fig. 5 shows the same basic configuration where the sine wave excitation is 190 Hz. The attenuation is of the same magnitude as before and occurs everywhere within the model.

Fig. 6 shows the attenuation of noise in a simulated room which models a real condition where there is a beating, low frequency noise. The figure shows that more than 20 dB of attenuation can be obtained even in the presence of beats. The data was obtained with the system under fully automatic adaptive control.

SUMMARY. This brief paper has summarized a number of ways in which active noise control may be applied to achieve considerable attenuation in closed interior spaces. Moreover, there are several approaches that may be taken, and this provides flexibility in engineering design and latitude in the methods of application.

References

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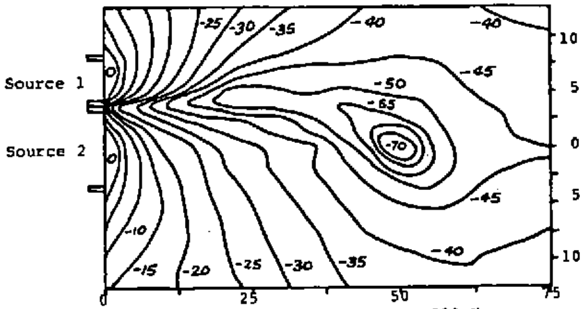

Fig. 1 Contours of Equal Attenuation at 500 Hz. Sound is Radiated from Two Tubes. Dimensions are in cm.

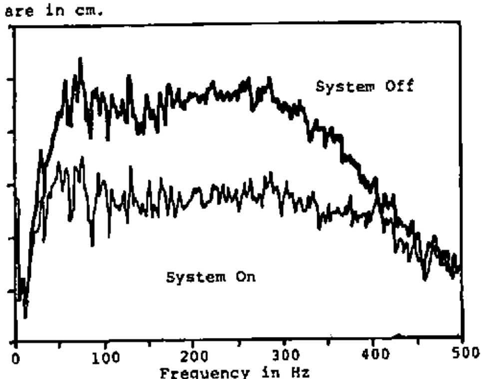

Fig. 2 Automatic Adaptive Noise Cancellation of a Broadband Noise in a Reverberation Room. Vertical Scale is 10 dB per Division.

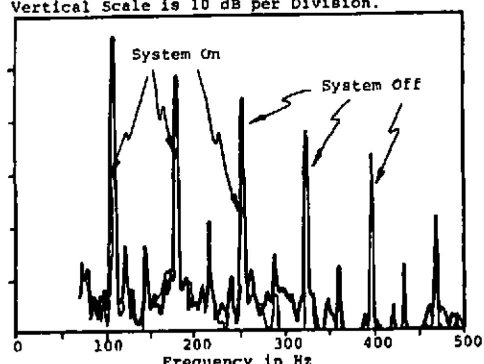

Fig. 3 Automatic Adaptive Cancellation of Harmonic Noise Outdoors. Vertical Sacle in 10 dB per Division.

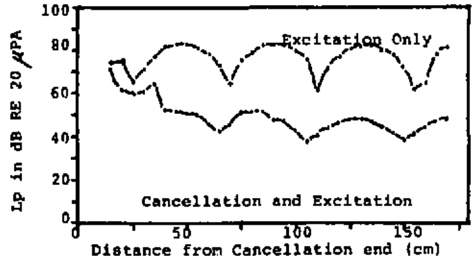

Fig. 4 Cancellation of Noise Inside Fuselage Model. 400 Hz Pure Tone. Noise Source Inside Model, 10 cm from Left End.

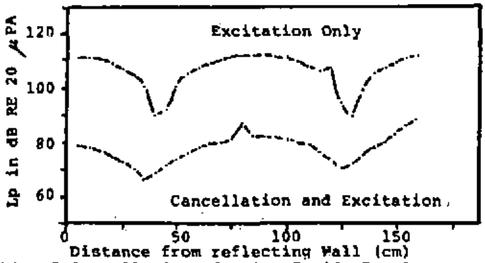

Fig. 5 Cancellation of Noise Inside Fuselage Model. 190 Hz Pure Tone. Noise Source Outside Model.

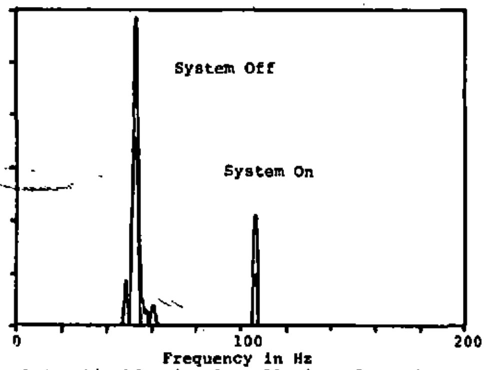

Fig. 6 Automatic Adaptive Cancellation of Beating Noise in Model Room. Vertical Scale is 10 dB per Division.