Proceedings of The Institute of Acoustics

AN ELECTROACOUSTIC REFLECTOR (E.A.R.)

D.J. YOUSIF and P.H. PARKIN

I.S.V.R., SOUTHAMPTON UNIVERSITY

1. Introduction and Basic Design Concepts

The work reported in this paper is concerned with the design and performance testing of an active reflector device for use in auditoria to strengthen reflections. Conventional reflectors are not always easy to arrange, especially in modern thrust stage theatres [1], but they can be used in auditoria to increase the intelligibility of sound in both the audience and stage areas. However, conventional reflectors have many disadvantages and limitations: the plane size and/or thickness, and hence the weight, often need to be large to ensure proper functioning at low frequencies. An active electroacoustic reflector (E.A.R.), a combination of microphone and loudspeaker arrays, could be both more compact than a conventional reflector, and also could provide stronger and adjustable reinforcement.

The performance of such an active reflector has been investigated in different environments. The advantages of this active reflector are that it can usually re-radiate more (or at least as much) energy than falls on it, it is lightweight, the energy re-radiated can be controlled in both amplitude and direction, its position can be changed, it can be insensitive to audience conditions, and it can cover all the audible frequency range.

The basic design concept was to bring the microphone close to the loudspeaker, to make the reflector compact, and then to avoid electroacoustic feedback by using unidirectional microphones, connected in anti-phase [2], and oriented symmetrically in a region of weak loudspeaker sound field. Minimization of gain can then occur due to feedback along two paths: (i) that of the direct sound from the loudspeaker to the microphones, and (ii) that of the sound via room reflections.

Path (i) reduction is accomplished first, by using two cardioid microphones placed back to back in a region of weak loudspeaker sound field and symmetrically with respect to the loudspeaker axis, thus receiving the same S.P.L. from the loudspeaker. Secondly, by using a specially designed electronic unit consisting of two anti-phase preamplifiers and a mixer, the two equal signals received from the microphones are balanced out. The possibility of such signal treatment is conditional on the microphones' arrangement with respect to the loudspeaker.

Path (ii) can only be minimized by the directionality of the loudspeaker and its placing and orientation in the room.

2. Operation and Results

Tests with pure tone, white noise, pink noise, speech and music were carried out in anechoic conditions. It was found that the problems of path (i) were satisfactorily solved, the achievable gain of the E.A.R. under anechoic conditions being about 13 dB on average over the audible frequency range. With various source positions, an omnidirectional microphone in selected positions was used to record the levels with and without the E.A.R. in operation, the difference between them being called the improvement. Fig. 1 shows the improvement versus frequency in 1/3 octave bands when the receiver was 5.20 m from the reflector, at an angle of 10° to the right of the normal to the E.A.R. centre, the source being in the plane of the reflector to the left of the normal, a white noise source being used. The figure shows good improvements in the range 200 Hz to 10 kHz.

The E.A.R. was also tested in a quite reverberant lecture room of volume 330.75 m^3 and in the Turner Sims Concert Hall at Southampton University, of volume 2335.5 m^3. White noise, pink noise, speech and music were used as sound sources. Several positions of the E.A.R., the receiving microphone and the sound source were used and the results were recorded. Fig. 2 shows the improvements obtained in the lecture room with recorded speech, there being a maximum value of 12 dB at 2 kHz. The figure shows good improvements over the range 250 Hz to 3500 Hz, and poor results for the higher frequency range, ascribable to the lack of such high frequency energy in speech.

Fig. 3 is a three-dimensional histogram showing some Turner Sims Concert Hall results. The y-axis represents the improvements in dB. The x-axis represents seven distances from the E.A.R. with various positions of the receiving microphone. The z-axis represents 21 third octave band centre frequencies starting from the frequency of operation of the E.A.R. (a white noise source was used). A maximum improvement of 8 dB was obtained at a frequency of 800 Hz and at a distance of 7 metres. In general, the improvements indicated in the figure are significant for the first six positions, but those at a distance of 10 metres are poor.

3. Conclusions

Comparison of the results in the anechoic chamber with those in the two reverberant rooms shows that provided the E.A.R. microphones are adjusted for minimization of the direct path (i), then the limitation on the maximum E.A.R. gain obtainable is set by the reverberant path (ii). The gain obtained under anechoic conditions is about 8 dB higher than under the "best" reverberant conditions. In the two reverberant rooms the maximum gain before feedback is about 3 dB higher in the larger room (the Turner Sims Concert Hall). This is believed to be largely due to the comparative positioning of the room surfaces in the smaller room, resulting in relatively stronger path (ii) signals.

References

1. P.H. PARKIN, H.R. HUMPHREYS and J.R. COWELL 1978 "Acoustics, Noise and Buildings". Faber & Faber Ltd., London.

2. V.S. MANKOVSKY 1971 "Acoustics of Studios and Auditoria". Focal Press, London.

AN ELECTROACOUSTIC REFLECTOR (E.A.R.)

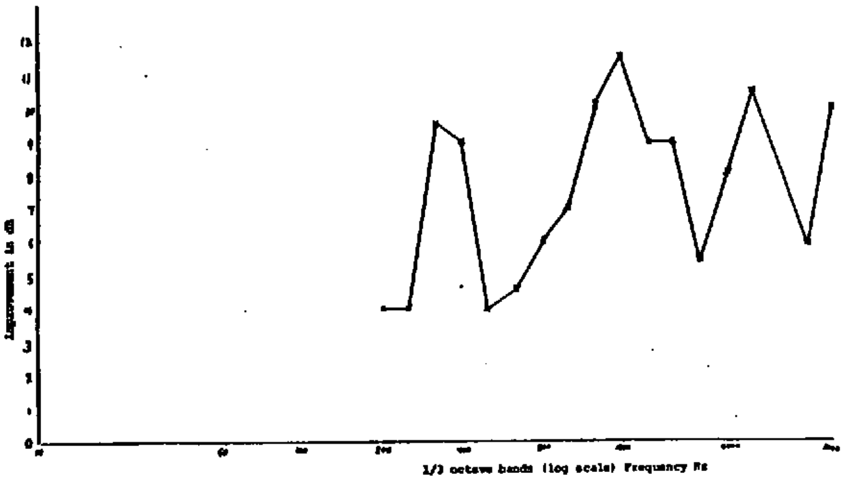

FIGURE 1

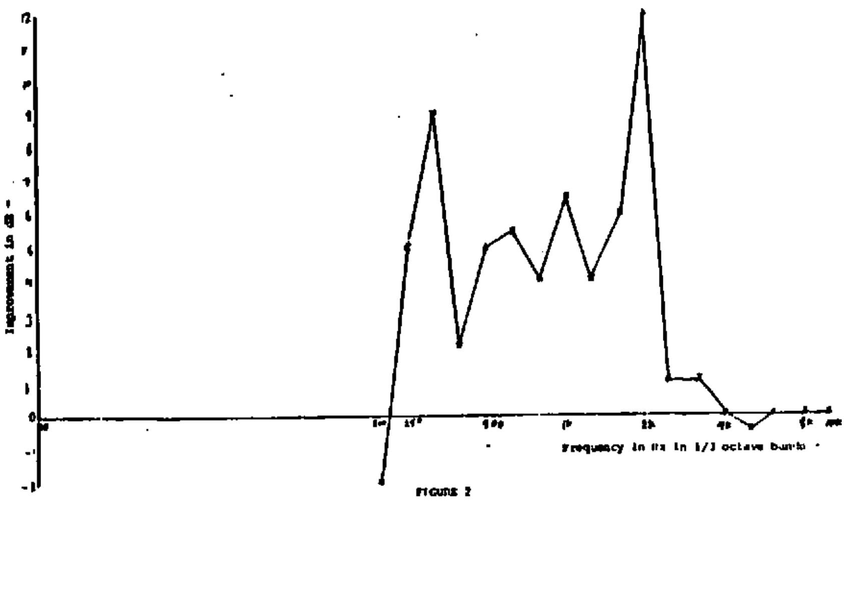

FIGURE 2

AN ELECTROACOUSTIC REFLECTOR (E.A.R.)

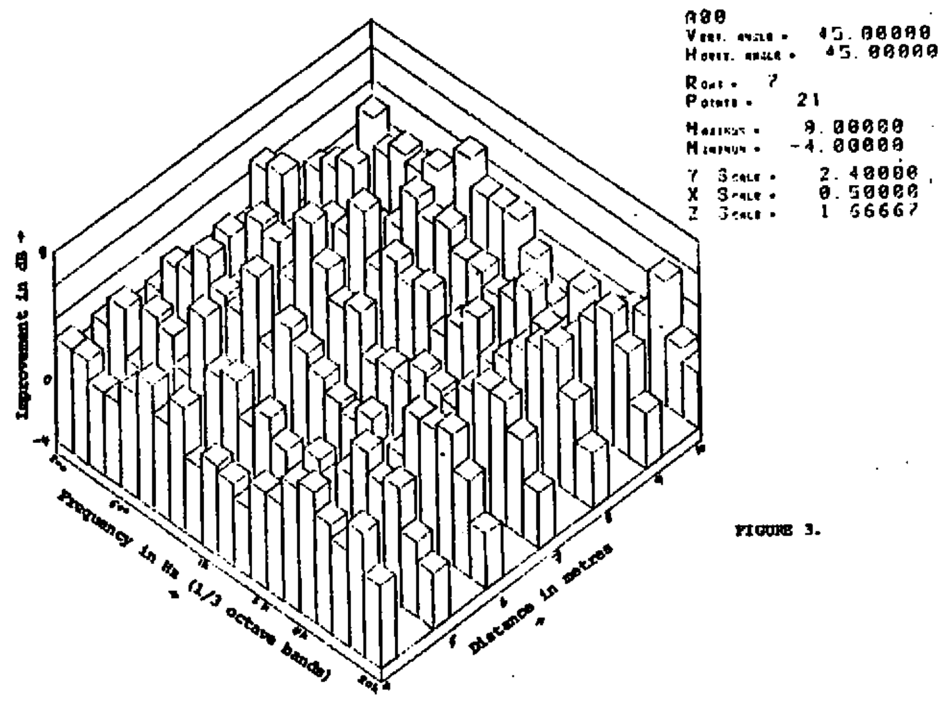

FIGURE 3.