Proceedings of The Institute of Acoustics

ACOUSTICS OF THE ROYAL EXCHANGE THEATRE

D. K. JONES

UNIVERSITY OF NOTTINGHAM

Introduction

This theatre is built on the exchange floor of the Royal Exchange Building. The theatre company required a building, for performances of theatre "in the round", to seat an audience of more than seven hundred. Since the theatre was to be built inside an existing building the fire authorities required the audience to be able to see, during performances, if the surrounding exchange building caught fire. The walls of the theatre were therefore to be glazed. The acoustic problem was quite simply to provide adequate speech intelligibility for "in the round" performances in a glass walled theatre with the seating capacity of a West End theatre.

The theatre company had successfully used an experimental theatre on the exchange floor and wished to replace it with a permanent building. The walls of the experimental theatre were of thick wooden planks with gaps between them and a double layer canvas for the roof. The surrounding building had a reverberation time excessing five seconds. Sound from the theatre escaped through the gaps, excited the large volume of surrounding air and then fed back the slowly decaying sound into the theatre. The decay curves in the theatre therefore had double slopes. Intelligibility was not affected by this effect. The clients considered it to be beneficial to chamber music and desired its retention with, if possible, some measure of control.

Design Principles

The main acoustic problem in designing this type of theatre is that the actor speaking has half his audience behind him! Speech conveys information. It tells us WHO is speaking and WHAT is being said. We are all well aware that the telecommunications authorities have never found it necessary to transmit the whole of the speech bandwidth. Their prime duty is to maintain intelligibility - they are more concerned with WHAT rather than with WHO. As an acoustician perhaps one should simply state that the S.I.L. covers the three octaves from 600 Hz to 4800 Hz. Identification of the speaker requires a wider bandwidth. In noisy conditions speech becomes unintelligible because the energy in the S.I.L. band is masked and in large reverberant spaces the speakers own vowels can provide the masking. Loss of intelligibility may be due to a surfeit and not a shortage of vocal output!

ACOUSTICS OF THE ROYAL EXCHANGE THEATRE

Sound sources are usually directional. If the source is large compared to the emitted wavelength then the propagated sound tends towards a plane wave and if the sound source is small compared to the wavelength thence spherical wave is transmitted. The rates of the longest to shortest wavelengths produced by the voice is about 500:1 - considerably more than the range of the sizes of human heads. The standard literature shows that the polar diagram for vowels is almost spherical whilst consonants are preferentially propagated to the front.

Design of the Royal Exchange Theatre

Since vowels can mask consonents, particularly behind the speaker, it was essential that the reverberation times be kept short. Good sight lines were essential to obtain maximum direct sound. The audience should be placed as close to the stage as possible and none is more than thirteen metres from the edge of the acting area.

The sound insulation between the auditorium and the surrounding Royal Exchange Building had to be adequate. It was not possible to construct a structure sufficiently massive to eliminate feed back from the surrounding area nor did the clients desire this. In any case most of the cladding was glass for reasons mentioned above. The separation achieved is about 32 dB. In order to exploit this effect for special effects the top two metres of the walls consist of large pivoted panels. When these are open the fed back level is about twelve dB below the level in the theatre. For music the louvres are partly opened.

In order to reduce colourations instead of the more usual hexagonal or octagonal buildings which have pairs of parallel sides a seven sided building was chosen and the plan was rotated at each gallery level. This produced irregular wall surfaces.

To provide adequate sight lines the seats are steeply raked. From the acting area one sees a wall of people, the glass walls are largely obscurred and echoes from the glass panels are thereby eliminated.

A shorter than usual reverberation time was selected. The theatre is somewhat larger than is usual for "in the round" performances and it was thought that intelligibility could only be maintained if the reverberation times were short and that they were not allowed to rise significantly at low frequencies. Absorption is provided entirely by the audience and the shell. Low frequencies are absorbed by the large areas of glazing and by the steel decking of the roof structure.