Resonance was to be used to raise the RT by up to 100% in the lower octaves (which are more important to the warmth of the music) and 50–60% at mid-frequencies.

Other acoustic targets for use of the auditorium for speech included emphasis of the early sound i.e. taken as the sound reaching the listener within 50 milliseconds of receipt of the direct sound, control on noise from mechanical services to a limit of PNC 20 + 2dB, adequate sound insulation from external noise and elimination of obvious acoustic faults. In the case of music, the low noise levels and elimination of faults remain important but a greater proportion of later sound (reaching the listener after 80 milliseconds) is preferred. The Assisted Resonance contributes to this requirement. Another important element of good acoustics for music is strong lateral reflection to the listener. Within the many constraints of the design this was to be encouraged. Some provision was needed to throw reflections back to performers. In the case of an orchestra, an element of enclosure was needed to help players hear each other and to contain the sound sufficiently to avoid undue disturbance by the large volume of the fly tower.

Form of the auditorium

Acoustic requirements played their part in influencing the geometry. In particular, the concept of a moving ceiling presented questions about its shape and its role, if any, in distribution of sound from the stage.

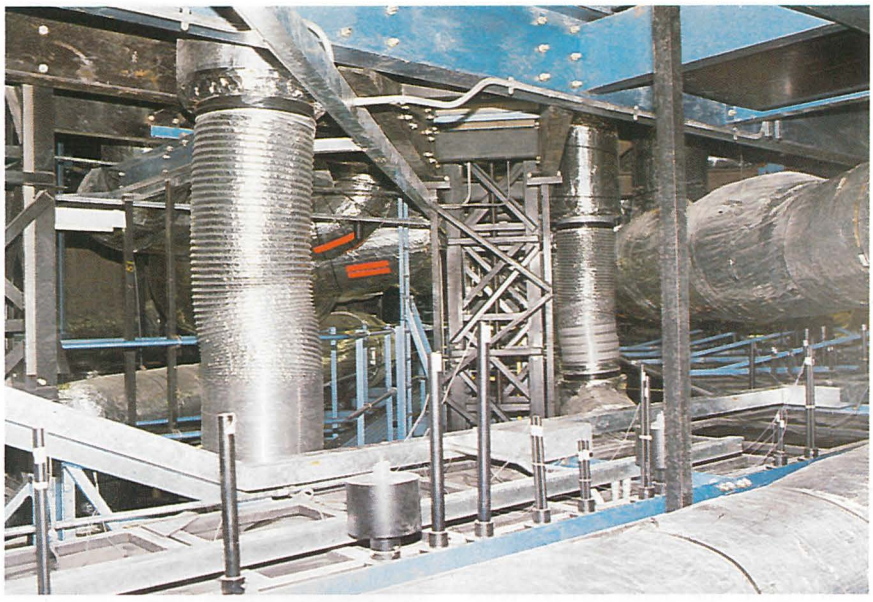
One of the features of thrust stages in large auditoria tends to be the absence of extensive side wall surfaces sufficiently close to the performer to reinforce the sound to the listener without such a long delay as to cause 'fogging' of the sound. Where performers come forward on stage, and can then face away from part of the audience, there is also a tendency to lose the speech clarity. With careful design, a ceiling can provide useful reflections to all seats to overcome these limitations.

However, a moving ceiling makes this provision more complicated. The geometry needs to ensure that with both upper and lower positions, reflections (from a wide variety of positions on the stage) are distributed without focussing or without 'dead' spots.

Calculations were carried out to find appropriate geometry for reflecting ceiling panels. The recurring conflict between sound reflection and location of lighting bridges was complicated by the movement of the ceiling. However, with careful adjustments to the geometry of the ceiling planes it was possible to suggest a means of satisfying both.

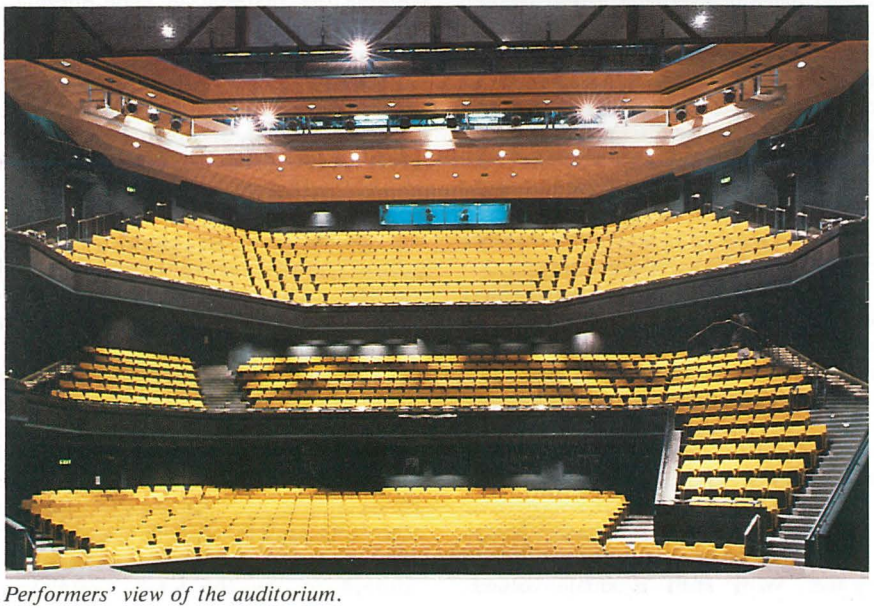
An acoustic model

Because of the importance of sound reflection from the ceiling, concern about the effects of deep balconies and interest in the proportion of 'early' to 'late' sound reaching the listener, an acoustic model was proposed. The author was aware of some experimental work being carried out on techniques for modelling acoustics in the Department of Architecture at the Univer-



Flexible duct terminations above the moving ceiling. Some of the Assisted Resonance elements can be seen in the foreground.

The tall lightweight screens behind and around the orchestra provide diffuse mid/high-frequency reflection.



Performers' view of the auditorium.