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PROBLEMS AND PRIORITIES IN ORCHESTRA PIT DESIGN

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INTRODUCTION

In response to expressions of dissatisfaction with orchestra pit conditions from musicians, especially with regard to partially covered pits, this project was initiated to investigate their problems. Partially covered pits are becoming more and more common, and exhibit greater problems than open ones. The work has therefore been concentrated on covered pits. Questionnaire surveys of musicians and audiences were undertaken. Acoustic surveys of twelve theatres and opera houses were also carried out, concentrating on the pit acoustics. It was found that the orchestral players often play under severe difficulties. Experiments with isolated musicians in controlled acoustic environments underlined the difficulty presented by pit conditions. Reconcilation of the musicians' needs with those of the audience has been attempted, and priorities for design formulated. Some previously untried methods of solution have also been put forward. Figure 1 shows a typical example of the more heavily covered-in type of pit. Notice the considerable amount of unused space, the use of individual boxes to raise players, the cramping together of groups of instruments and the proximity of many to the walls.

SURVEYS

Audiences

The opinions of about 5000 opera-goers were canvassed by short questionnaires, distributed by blanket coverage (one per seat) at each of nine theatres.

Musicians

Detailed questionnaires were distributed to the members of seven professional orchestras playing for opera, and 139 replies were received after reminders. 25 questions dealt with a wide range of acoustic and other aspects of orchestra-pit playing, and were mostly to be answered in the context of the respondents' overall experience of partially covered and open pits. Copious comments were encouraged and received.

Acoustic Survey

As well as normal measurements of sound decay and steady state distribution throughout pits and auditoria, recordings of sound level were made in the covered and uncovered parts of six pits during performances.

SURVEY RESULTS

Audiences

The public were found to be unreliable in giving judgements on even moderately complex concepts, so only fairly simple points were covered. The principal relevant results were:

a) they are not very sensitive to acoustic subtlety (in the operatic situation) - as long as no strong echoes or other defects occur they are usually satisfied, except

b)/

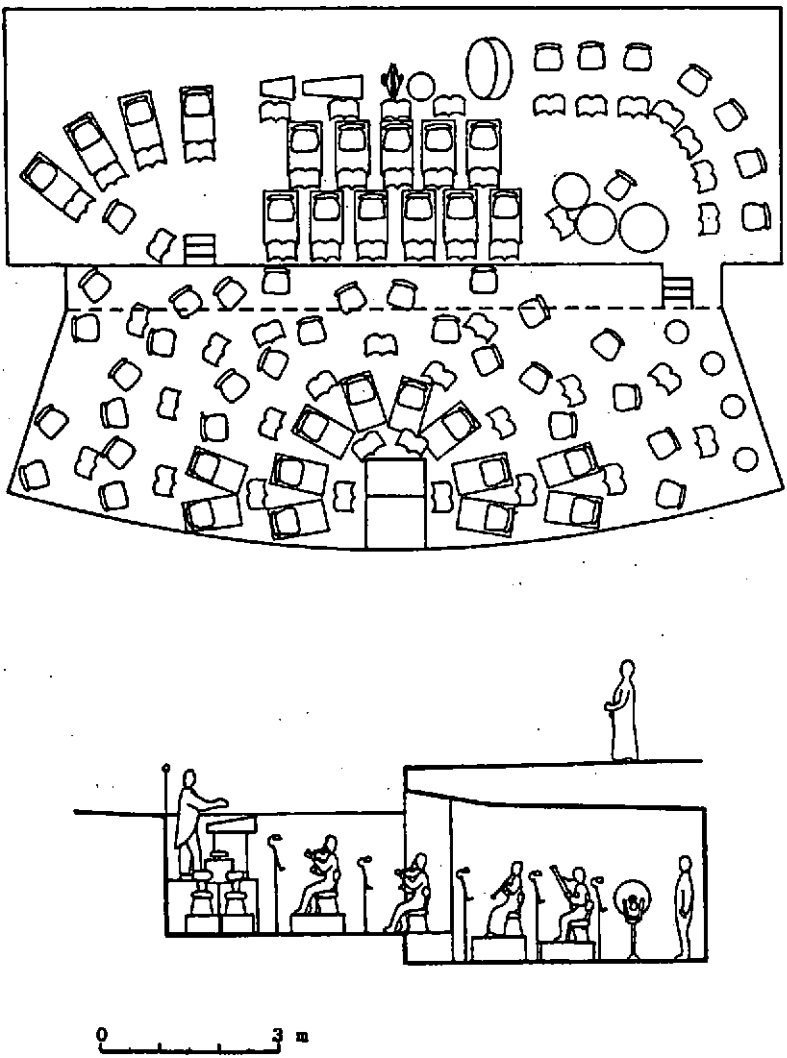

Fig. 1. Plan and section of a typical heavily covered orchestra pit.

b) almost invariably the orchestra is too loud for the audience to hear the singers properly (even with covered pits)
c) the majority like to see the orchestra (one argument for covered pits is to put the players out of sight).

Musicians

Non-Acoustic Factors

Solutions have to be sought to the problems of pit design as a whole, not merely its acoustical aspects. The exploitation of a musician's skills cannot properly proceed unless all the non-acoustical factors are such as to allow him to concentrate fully on his musical performance.

Psychological factors are those which do not physically affect a player's ability to perform when in place, but which can affect his frame of mind and his approach to an activity which is critically dependent on a positive mental attitude. Thus apparently minor annoyances can become quite important. The principal culprit is the difficulty of access to the pit and of moving about within it. People and instruments are injured unacceptably often. Loose cables for music-stand lights are a constant source of annoyance and danger. The level of facilities and cleanliness below-stage is often lower than would be acceptable in most white-collar workplaces. Large low ceilings can have a slightly claustrophobic effect, particularly with the decor and low light levels usually found in pits.

Ergonomic factors directly affect the musician's ability to do his job. The principal problem (and one which is at least as important as most of the acoustic ones) is simply lack of space and inability to provide comfortable efficient seating arrangements. 80% felt that space is generally lacking, and for string players, who have to move to play, the situation is even worse. Precarious seat positions, difficult vision and danger of collision give rise to physical tension, inhibiting good playing. Changes of floor level, walls, and raised boxes for individual players all lead to the usable area being considerably less than the plan area. Rather than the 1.0 to 1.25 m^2/player usually allowed in design, 1.5 m^2 would seem more appropriate. Pits raked down towards the back are the opposite of the arrangement used on concert platforms, and provide poor sightlines amongst the players and to the conductor.

A good acoustic environment is only part of the recipe for obtaining the best possible performance from an orchestra, and not necessarily the most important part.

Acoustic Factors

Sound levels

The principal acoustic problem is simply that players experience excessively high sound levels, especially those seated beneath the stage. 75% said that in covered pits they suffer excessive levels "always", "often" or "quite commonly", the main sources being brass and percussion. Sound levels were measured in six widely differing pits during performances. In the woodwind section, the Leq for complete acts ranged from 86 to 92 dB(A), with peaks from 105 to 110 dB(A). Exposed to such levels, pit musicians are surely at risk for occupational hearing loss.

Almost all aspects of a player's performance can be adversely affected by high sound levels. At the best, timing, balance and rhythmic accuracy suffer, and at

the worst complete mental confusion and inability to play can occur. (26% said this sometimes happens to them).

Lack of contact with the stage

It is desirable for all those taking part in making music to be able to hear each other, even more so when visual contact is lacking. Only 17% of the musicians (almost all string players seated at the front) felt that in covered pits they can generally hear the singers well enough, and 45% said they never can. In serious cases, the level of singers' sound reaching a player at the back of the pit can be as much as 25 to 30 dB below the level he receives from his own instrument. Experiments with isolated musicians under controlled conditions were carried out to investigate how ease of ensemble varies with the received level of a unison accompaniment. The results indicate that reasonable ensemble is virtually impossible in such circumstances of masking by self-produced sound.

Ensemble within the orchestra

Partially covered pits provide very strong early reflections back into the orchestra. Although it is known that early reflections back into a body of players help them to hear each other, desirable intensities and delays are not yet firmly established. 58% preferred open pits for ensemble, and 29% thought both types to be about equally good. During the controlled experiments mentioned above, the variation of the player's output with the received level of (a) accompanist and (b) pink noise was also measured. The results suggest that during tuttis, the total level of nearby players' sound may be too high in the covered part of a pit, masking one's own sound and forcing one to play louder. Meanwhile, players some distance away are not heard sufficiently well unless they are particularly loud.

Lack of feedback from the auditorium

In a normal concert hall the orchestra is to a large extent immersed in the reverberant field it produces, and 'response' from the hall helps the players in various ways. Most theatres are rather lacking in reverberance, but for musicians in the back of a partially covered pit these aids to performance are further removed because they receive very little energy back from the auditorium. 50% of non-string players felt their own perception of the sound they made in the auditorium to be at odds with that of the conductor, and 60% overall felt rapport with the audience is usually lacking. 71% of those who play beneath the overhang in covered pits considered that open pits are better for producing a satisfactory tone quality. For the string players seated at the front of the pit, there is little difference between open and closed pits for tone quality.

Results from the acoustic survey corroborate the above findings. The front part of a partially covered pit exhibits reverberation characteristics like those of the auditorium it is in, but in the covered part the acoustics are more complex. The local RT there is very short, typically 0.4 to 0.7 seconds (unoccupied); too short to support good tone quality. The acoustic field cannot really be described as reverberant, but the confined space means that the steady state level is nevertheless very high. Figure 2 shows a typical decay curve recorded in the covered part of a pit. Poor coupling to the auditorium renders the level of reverberant auditorium sound very low (-10 dB in Fig. 2). This is probably low enough not to be audible most of the time, at least to the player creating the sound (for whom the reverberant level will be even less). With the auditorium decay slope commencing so far down the decay, T_{15} is often unaffected by the auditorium reverberation.

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DESIGN PRIORITIES AND SOME REMEDIAL MEASURES

Attempting to formulate design strategies to meet the various identified needs, it became clear that, opera consisting as it does of a combination of largely irreconcilable elements, resolution of all the difficulties cannot be achieved merely by good design, though this can help greatly. All the problems, acoustical and otherwise, are interrelated, and alleviating one may well aggravate another. We consider the most important points to be tackled in the design of partially covered pits to be in this order:

a) lack of space and poor ergonomic design
b) excessively high sound levels
c) insufficient auditory contact with the singers
d) insufficient auditory contact with the rest of the orchestra
e) insufficient auditory feedback from the auditorium.

Space, Cover and Floor Levels

The amount of space per player needs to be increased above that used for concert platforms. We cannot at present place limits on the amount of cover acceptable to musicians. They generally prefer as little as possible. A well-designed pit with a lot of cover may be preferred to a poorly-designed one with little cover. A single floor level is to be preferred, but inevitably this aggravates sightline and/or headroom problems. Ideally plenty of flexibility should be designed into the flooring system in such a way that orchestras can experiment to achieve an optimum arrangement without having to sacrifice security or space by using many small boxes or similar impedimenta. Preferably the complete floor should be on a number of lifts, but failing this expensive facility, well-fitting large-area rostra should be provided.

Sound Levels

Any measures to increase the transmission from the pit to the auditorium will tend to decrease sound levels in the pit, for example, an acoustically transparent pit rail, perforated stage apron or by flaring the pit surfaces towards the auditorium. Since there is little of a reverberant field in the pit, absorbents should be carefully placed to allow for the effects of instrument directivity, and the need for diffusion of sound throughout the pit [1]. More space per player would also help to reduce sound levels.

Contact with Singers, Ensemble within the Orchestra and Feedback from the Auditorium

The pit rail can be designed to reflect sound from the stage to the back of the pit, but unless the pit is a long way below stage level, this is not likely to be very effective.

Any measures to reduce the early energy level within the pit will tend to make the auditorium sound more audible in the pit, and might improve the inter-communication between sections of the orchestra.

An electroacoustic system is proposed which aims to alleviate all the problems quoted in the section heading. Microphones pick up reverberant sound in the auditorium, and vocal sound on the stage, and the signals are sent via delays to a grid of loudspeakers on the pit ceiling. This would allow the rear players some of the advantages of an open pit (the ceiling would preferably be absorptive) while giving the audience the improved balance of a covered one. Field trials with a crude prototype have demonstrated the potential of the system.

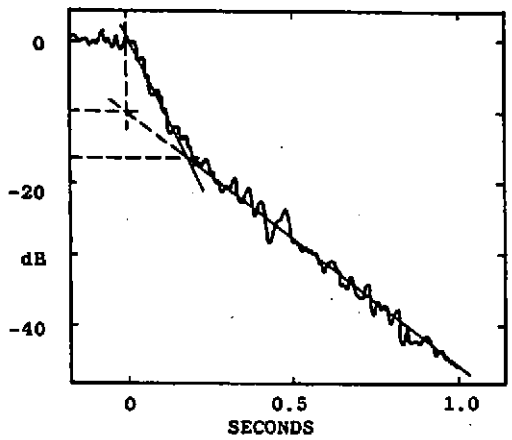

Fig. 2 Interrupted noise decay (1KHz octave band), measured in a partially covered pit. Source and receiver both in covered part.

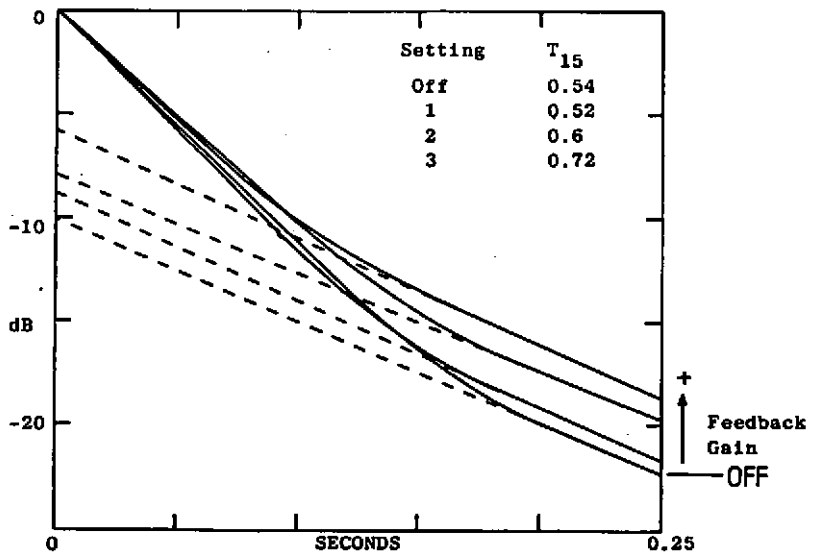

Fig. 3 Pink noise decays recorded in the covered part of a pit with auditorium feedback. Each curve is an idealisation of the average of two recorded results.

Audibility of the singers and T_{15} both increased in the pit, and the ratio of early/reverberant sound was reduced (see Fig. 3). As with all such installations, a permanent unattended system suitable for all productions would not be easy to design. Some compression would certainly be necessary at least in the voice channel, so that solo passages would be adequately amplified without the full chorus adding significantly to the high sound levels.

CONCLUSIONS

Audiences at opera performances seem not to be particularly concerned with good acoustics as long as no major defects occur. A very common complaint, however, is that the orchestra is heard much too loudly relative to the singers.

It has been confirmed that musicians playing in partially covered orchestra pits experience an acoustic environment quite different from that generally found on concert hall platforms. Problems both acoustical and non-acoustical seem to be more severe, and account for the high level of dissatisfaction felt amongst musicians towards orchestra pits. The physical factors affecting the various problems are seen to be highly interdependent, and this makes them more difficult to reconcile in the already highly constrained situation of a theatre building. Many of the methods used in the treatment of concert halls are not available in the case of opera houses and theatres.

Priorities for design goals have been suggested, and some new ways to improve the situation of the orchestra have been put forward. In order to be successful, however, all the different factors must be taken into account. Whilst some improvements are undoubtedly possible in most pits, in a situation of such compromise as an opera house it is most unlikely that all the participants will ever be satisfied.

REFERENCE

[1] E.L. Harkness, 'Performer Tuning of Stage Acoustics'. Applied Acoustics, Vol. 17, pp 85-97 (1984).

ACKNOWLEDGEMENTS

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