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"ASPECTS OF ELECTRO-ACOUSTICS IN RECENT AUDITORIA"

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This paper describes strategy for the main electro-acoustic provisions in two auditoria recently opened - the Harrogate Conference Centre and the Theatre Royal Plymouth (main auditorium)* - with reference to their interaction with the room acoustics.

HARROGATE CONFERENCE AUDITORIUM

As the prime function of this 2,000 ft. auditorium is to cater for conferences, a high quality speech system was needed. Separate facilities were arranged in the form of a stage mounted or flown cabaret system which can offer good quality and substantial power for performers not wishing to bring their own equipment. The speech reinforcement system was to provide for speech and 'piped' music only. The other systems are not described in this paper.

The form of the auditorium was originally close to circular. The result of changes to geometry and use of absorption to cope with concave curvature left the natural room response tending towards the 'dead' end of the acceptable range. These conditions suit the need for clear intelligible speech. A clear speaker can be heard in all 2,000 seats without undue effort, and without reinforcement! Whereas this tends to compromise the use of the hall for music, some warmth can be introduced by means of a 90-channel Assisted Resonance system. Table 1. shows the change in RT available in this way.

TABLE 1.

	OCTAVE BAND CENTRE FREQUENCY Hz.							
	63	125	250	500	1K	2K	4K	
Octave Band RT Natural	(1.3)	1.2	1.1	1.0	1.0	0.95	0.85	Seconds
+ Assisted Resonance	2.6	2.4	2.0	1.3	1.5	0.95	0.85	Seconds

A major concern in developing the speech reinforcement system was to organize well defined coverage with minimum overlap and minimum projection of sound energy to surfaces outside the listening zone. The Architects were concerned to avoid surface mounting of loudspeakers, preferring recessed positions behind acoustically transparent visual screening. The main system was located to minimise the angle of separation from the stage. The use of positions at the side of the stage was considered, but this offered less potential for a simple form of even coverage and balance, in view of the auditorium geometry. It was decided to complement the main system with a system of coverage from overhead, designed with some flexibility including

* Acoustic consultancy for these projects was carried out by the author at SRL and later in association with SRL.

delay and zonal switching, to extend the scope for natural sound for a variety of layouts.

Controls were arranged to allow considerable flexibility. By use of a simple relay switch, two feeds to the systems were available and were designated 'MUSIC and 'CALLS' for general building P/A background music and calls. For conferences the 'MUSIC' feed is taken over, leaving the 'CALLS' feed available for over-ride calls in the case of emergency. This over-ride is also available to the Chairman. This arrangement provides a useful control on signals fed to the auditorium. A range of microphones can feed up to 12 platform mikes, 6 each side or 12 floor mike sockets to a Midas mixer (2 x 12 into 8 into 2) tied into a patch panel taking Formula Sound S19G graphics in ⅓ octaves and Klark Teknik delay (up to 150 milliseconds). Loudspeakers are fed via 100 volt line. Platform speech is routed to the forward system (9 Philips LBC 3053 units over the stage) and to Tannoy dual concentric units under the rear overhang. Speech from the floor is fed to 17 LBC 3055 units (short columns). There is also some flexibility in this routing to allow the separate components of the system to be combined.

Forward System

The system located over the stage (the forward system) involves conventional speech columns carefully arranged to allow even coverage with minimum overspill into the reverberant sound field. On plan and in section, the coverage is dealt with in three zones - see Figs. 1 and 2. It was decided to deal with fold-back for conferences separately if and when required. The six loud-speakers nearest the stage were mounted on a conventional lighting bar offering flexibility for adjustment. A substantial area of acoustically transparent facing material > 70% open mesh was introduced into the ceiling. The second row of forward loudspeakers can be adjusted within reasonable limits. For the overhead system, the broad spread to low/mid frequency sound from conventional cones was inappropriate.

Previous tests on use of column loudspeakers laid horizontal above an audience for a small reinforcement system elsewhere had proved encouraging. Although, ideally, a tighter beam in both directions is helpful, the column tightens up only one way. The use of crossed columns or larger units was considered, but it was felt that sufficient control could be achieved by tightening down in one direction. Loudspeakers can be rotated about their long centre-line. This arrangement could not cover the seating below the overhang at the rear of the auditorium. Here, the ceiling height was sufficiently low to allow the use of dual concentric cones.

The proper use of delay units and equalisation on both the main overhead columns and the under-balcony systems encourages natural sound when used with the forward system or other sources on stage. This overhead system was found to produce evenness in the listening area of $\pm$ 2 dBA when fed pink noise. In view of very good intelligibility and natural quality, the more critical impulse level tests have not been carried out so far.

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PLYMOUTH THEATRE ROYAL

In this case, the natural room acoustics favour speech - this time as a result of restriction on the built volume. An auditorium volume of just over $3m^3$ per seat for a 1,200 capacity resulted in deep balcony overhangs. Some parasitic reverberation is avilable from an empty fly tower. However, with a sensible quantity of material in the tower, the reverberation times shown in Table 2. apply.

TABLE 2.

	OCTAVE BAND CENTRE FREQUENCY Hz.						
	125	250	500	1K	2K	4K	
Octave Band RT Natural	1.3	1.2	1.0	0.9	0.85	0.65	Seconds

Again, a 90-channel Assisted Resonance System was used which, at the time of writing, has produced a useful increase in RT and is currently being brought up to full performance with the first musical events in the building.

There are two other specific aspects of the electro-acoustic design of particular interest for the design process - the use of show relay as an under-balcony boost and the approach to provisions for speech reinforcement and show sound.

Under-Balcony System

In positions where the balcony overhang is deep, a row of dual concentric cones was arranged within the hard plaster balcony soffit. Every other unit was an all-channel Assisted Resonance feed. The show relay feeds the loudspeakers between, via a Knowles delay unit (normally set at 25 ms and 48 ms). A compressor limiter will protect the system from overload. Although the loudspeakers are very close to the listeners (just over a metre away) the output is very low, and the delayed signal does not alter the direction of the source significantly, particularly with visual queueing. Apart from providing a useful boost to speech under the balconies, this arrangement appears to 'fill out' music for listeners in these positions.

Sound Reinforcement and Show Sound

Experience of previous projects suggested that no matter what provision is made in a new building, it is likely that the taste of the incoming sound engineer will differ from that of the theatre/acoustic consultants. The strategy at Plymouth was, therefore, to provide only a very basic general-purpose system with sufficient wiring and mixing facilities to allow the facilities to be 'grown'.

A range of microphones was provided to feed up to 27 tie lines from the stage to a portable Electrosonics PEP mixer (16 into 8 into 2). "House" p.a. is via 4 Electrovoice Eliminators, two each side of the stage. A range of loudspeakers is available for a wide variety of sound from the stage, foldback and effects. Again, a patch panel is provided for introduction of e.g. EQ and delay.

The Eliminators are not highly directional. Each unit is directed towards the upper or lower part of the auditorium seating area on the side at which they are located. Since the room acoustics are again relatively 'dead' and distances to the room boundaries are short, sound energy thrown away from the listener tends to be re-directed into the listener relatively quickly, making directional characteristics less critical than usual. Whereas this allows a basic general purpose provision, there is no doubt that there is substantial scope for building on this.

Implications

The real test of these systems is going on now as the auditoria find their feet. Two particular points have come to the attention of the author. First, the relatively 'dry' room response of both auditoria, as might be expected, allows a great deal of freedom of means for controlling the sound fed into the space. At Harrogate Conference Auditorium the longer lateral dimensions mean that directional control is critical in relation to any remote reflective surfaces. At the Theatre Royal Plymouth the lower volume and relatively short RT render directional requirements less critical.

The second point concerns loudspeaker directivity. Whereas some loudspeaker suppliers present polar diagrams describing directivity, the influence of the mounting position, e.g. close to a wall or in a recessed slot and the relationship to nearby loudspeakers can, of course, alter the polar diagram substantially. Whereas estimates of the likely polar response of complex mounting geometry can be made, there appears to be substantial scope for research work in this area to be converted to working guidelines for practical system design.

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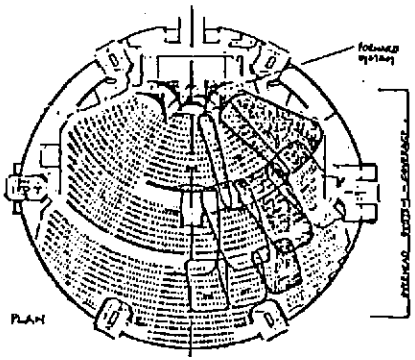

FIG. 1 HARROGATE CONFERENCE CENTRE
Plan

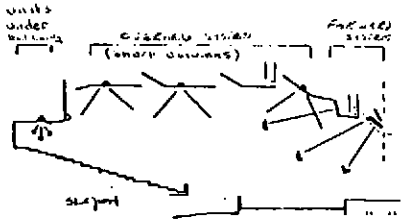

FIG. 2 HARROGATE CONFERENCE CENTRE
Section

Architect : MORGAN BENTLY FERGUSON & CALE
Theatre Consultants : CARR & ANGIER

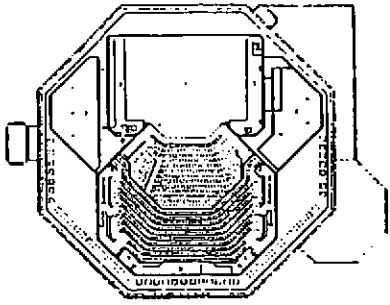

FIG. 3 PLYMOUTH THEATRE ROYAL
Plan

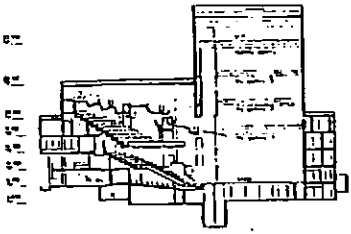

FIG. 4 PLYMOUTH THEATRE ROYAL
Section

Architect : PETER MORO PARTNERSHIP
Theatre Consultants : CARR & ANGIER