ACOUSTIC ENHANCEMENT AT THE HILBERT CIRCLE THEATRE

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1 INTRODUCTION

Over the past four decades, a considerable amount of literature has been written describing the use of electronic techniques to adapt or improve the acoustics of performance spaces. Less has been written about the relationship of such enhancement systems to the architectural acoustic environments in which they function and the process for adjusting and balancing such systems with respect to the physical environment. This paper describes experiences the authors have had while working with one system in a particular theatre and the changes made to that system after the authors had the opportunity to significantly alter the architectural acoustical environment of the subject space.

The space is the Hilbert Circle Theatre, the home of the Indianapolis Symphony Orchestra, and the system is a LARES installation completed in 1996.

2 HISTORY OF THE PROJECT

2.1 Early History

The Circle Theatre was originally built in 1916 as a vaudeville venue. The theatre served this use until the widespread popularity of motion pictures and the decline of vaudeville compelled its owner to convert it to a cinema. It served as a cinema until the decline of downtown Indianapolis forced the theatre to close in the 1970s.

2.2 1985 Renovation of the Theatre

In the early 1980s, the Indianapolis Symphony Orchestra (ISO) was looking for a new home and the City was looking for a major project to spur redevelopment of the city centre. After preliminary testing suggested that the theatre might become a suitable home for the orchestra, the ISO made arrangements to purchase the theatre and embarked on a five-year project to transform the decrepit space into a modern concert hall. The project was completed in the autumn of 1985.

2.2.1 Physical Elements of the 1985 Renovation Project

The renovation project included two major elements:

- Restoration of the historic architectural fabric of the original house
- Creation of a new permanent concert stage for the ISO

2.2.2 Electronic Aspects of the Renovation Project

Christopher Jaffe conceived an original electronic acoustic enhancement system as part of the 1985 renovation project. His recommendation to install such a system was based upon acoustical studies of the theatre that clearly demonstrated that the Circle Theatre would not have a satisfactory acoustic environment for orchestral music without extensive physical modifications or some form of electronic enhancement.

The detailed design of the original system, which was developed by the Jaffe office, has been described in various technical papers[1,2] and hence we will not describe the details here.

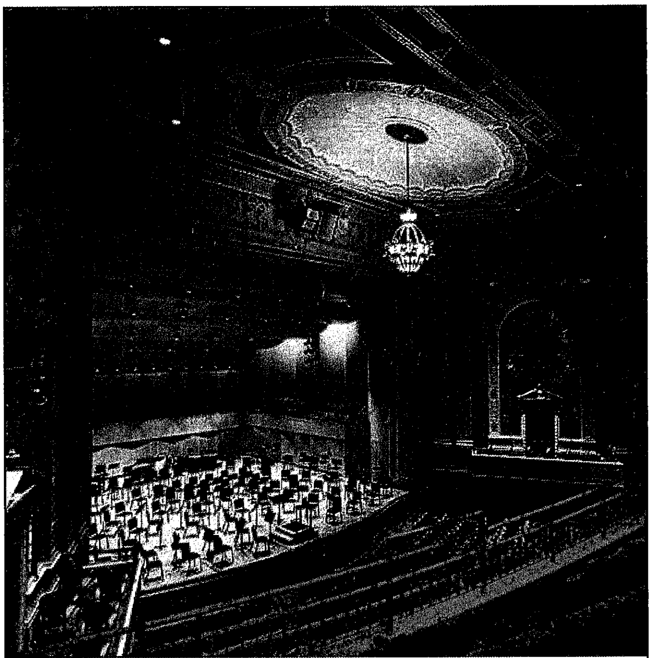

Figure 1: Interior view of the Hilbert Circle Theatre shortly after completion of the 1985 renovation project. The comparatively small volume of the house is apparent in this photograph. Note how far forward the balcony projects into the house. (Photo courtesy of the Indianapolis Symphony Orchestra)

2.3 1996 Replacement of the Original Enhancement System

By the mid-1990s, the original installation was showing its age and significant technological advances had been made over the intervening decade. The ISO were keen to upgrade the system and were able to secure the necessary financial support for such a programme from the Lilly Foundation in late 1995 and early 1996.

After considering the various commercial systems that were then available, LARES was selected as the basis for the new enhancement system.

2.4 Concerns with the Stage Acoustics

Almost from the reopening of the theatre in 1985 complaints were registered by the ISO musicians about the acoustical qualities of the stage. Among these concerns were:

- weakness of bass response
- poor communication between the various parts of the stage (both up and down stage, and cross stage
- overall loudness of the stage including a sense that the shell was trapping sound on stage instead of projecting it into the house
- harsh quality to the sound at forte levels
- overall size of the platform (too constricted)
- limited ability to tune the stage acoustics

Over the first six to eight seasons, various attempts to rectify the situation were implemented. These efforts included:

- suspending a large sound absorbing drapery above the acoustical canopy
- testing various arrangements of the overhead acoustical canopy panels
- testing various arrangements of stage risers
- adding absorptive material to the upstage face of the walls on either side of the proscenium

By the late-1990s there was general consensus that these modest changes had at best produced only minor improvements in the sound quality on stage. This had been confirmed through an exhaustive series of investigations involving both objective and subjective acoustic testing.[3]

Upon completion of the LARES installation in 1996, the musicians began to pressure the Symphony's management to address their concerns about the stage acoustics. In 2000, the ISO decided that support for such an effort could be marshaled and the Board of Directors authorised management to proceed.

2.5 Details of the Stage Renovation

2.5.1 Sources of the Concerns

The various studies of the stage acoustics revealed that musician concerns were largely related to the following physical attributes of the stage design:

- the acoustical canopy was too large, thereby directing too much early energy back down onto the musicians and compromising the coupling between the upper and lower portions of the stage house volume
- the acoustical canopy was set at too low an elevation over the stage, exacerbating the above problems
- the range of adjustment for the acoustical canopy was too limited as a consequence of code requirements for sprinklers in the canopy itself

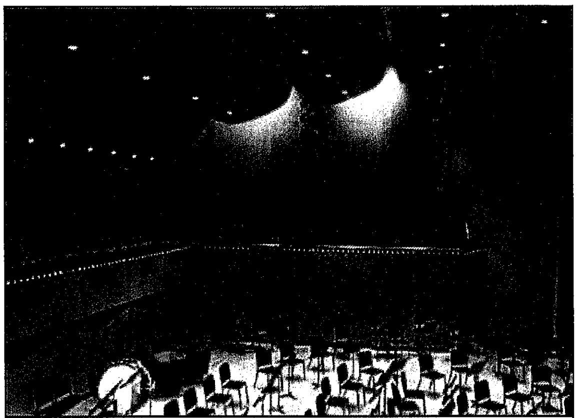

Figure 2: Close up view of the original 1985 Hilbert Circle Theatre stage. Note the planar nature of most wall surfaces (particularly the upstage wall at left and the fascias of the choral terrace), the density and low position of the acoustical canopy, and the cylindrical wall at the proscenium (right edge of this view). Also note how the downstage portion of the side choral terrace significantly cuts into the useable stage area. (Photograph courtesy of the Indianapolis Symphony Orchestra)

- the acoustical canopy lacked effective fine-scale diffusive treatments
- the acoustical canopy lacked any articulation in the cross stage dimension
- a lack of diffusive treatment on key wall surfaces, particularly the upstage wall behind the choral terrace and the fascia of the choral terrace
- large cylindrically shaped walls adjacent to either side of the proscenium arch trapped an excessive amount of energy on stage

2.5.2 Range of Renovation Ideas Studies

Over the years, numerous ideas had been generated to address these concerns. These ideas came from a wide variety of sources including acousticians, theatre planners, musicians, conductors, administrators and others. Because the stage acoustics had become a fairly charged political issue with the musicians, each of these 17 ideas was studied before a final renovation scheme was selected. The ideas and their disposition included:

1. Enlarging the proscenium arch: Some believed that enlarging the width of the proscenium opening would provide more space for large ensembles and improve projection of sound into the house. The proscenium arch had been enlarged to 14.6m as part of the 1985 renovation. Opening the arch further would have destroyed historically significant portions of the side walls of the auditorium and hence this idea was rejected.

2. Enlarging the stagehouse: Some suggested that this would provide more acoustical "breathing room" around the orchestra. Studies suggested that raising the volume of the stagehouse (then slightly less than 5,700 m^3 or approximately 200,000 cubic feet) would simply reduce the overall impact of the ensemble in the hall which contravened one of the other objectives of the project. This idea was therefore not implemented.

3. Eliminating some or all of the choral terrace: The then Music Director of the ISO, Raymond Leppard, believed that this would solve the space constraints and address musician complaints about overall levels of loudness onstage. Total elimination of the choral would have also eliminated essential backstage circulation space and was therefore not feasible. After investigation, it was concluded that some reduction of the choral terrace could be achieved by making the supporting walls thinner and relocating the stage return air transfer ducts. This latter concept was implemented.

4. Creating coupling passages between the stage and organ chambers: The original theatre had organ chambers on either side of the house and portions of these chambers were adjacent to the proscenium wall. The concept was to connect the chambers to the stagehouse volume to facilitate the transfer of energy from the upper volume of the stage to the house. Unfortunately the portions of the wall to which they were adjacent contained the major structural columns supporting the proscenium arch and openings of the required size could not be accommodated in this zone. This idea was rejected.

5 Creating a coupling passage above the proscenium arch: A similar concept was suggested for the area above the proscenium arch. This would have required the relocation of large amounts of ductwork and the replacement of large areas of the historic auditorium ceiling with sound transparent material. The combination of these requirements made this concept inordinately expensive and hence financially impractical.

6. Replacing the acoustical canopy: This concept involved demolition of the existing canopy and development of a new canopy with appropriate acoustical features and new rigging. This approach offered the possibility of substantial acoustical benefits, modest cost and significant additional rigging flexibility for the stage. This idea was implemented.

7. Adding diffusing treatments to the stage walls and balcony fascias: Once a decision had been reached to reconfigure the choral terrace, it was a foregone conclusion that the new balcony fascias would be designed from the outset with appropriate diffusing characteristics. This change also allowed for a reinterpretation of the architectural design of the stage, one that also facilitated adding diffusive treatments to other walls surfaces throughout the stage area. This concept was therefore included in the programme.

8. Installing additional fixed absorption on the stage: Over the years a significant amount of fixed absorption had been added to the stage with mixed reactions from the musicians. Some felt the absorption helped reduce the loudness on stage, some felt it made no

difference while still others believed it fostered an undesirable change in the timbre of the sound on stage. For the musicians, this concept was also intuitively antithetical to the objective of increasing sound projection to the audience. It was therefore decided to minimise the use of absorption in the final design scheme.

9. Providing shields between musicians or sections: Shields were viewed negatively by many musicians, particularly those who had to sit upstage of them. The hope was that we could minimise the need for shields as much as possible.

10. Reshaping the side walls: This was related to the idea of reconfiguring or eliminating the choral terrace. This was implemented.

11. Adding orchestra risers: Although the orchestra's experience with risers was mixed, it was agreed that a properly designed riser system would promote the best possible hearing conditions on stage and would enhance views of the orchestra from the stalls. This was incorporated into the programme on a provisional basis. Risers were designed but were not built due to budget constraints.

12. Replacing fixed walls with movable walls: A small minority suggested scrapping the concept of a permanent orchestral stage in favour of the demountable system of shell towers found in many multi-purpose halls. We believed that such a solution was not in keeping with the goal of providing a first rate symphonic acoustic and therefore rejected the idea.

13. Changing stage materials (both wall and floor materials): Musicians questioned whether the construction of the original stage was acoustically appropriate. Our studies suggested that the materials and their assembly were not at fault per se, but rather that the articulation of the elements was not sufficient. The new designs used many of the same materials (wood and gypsum board), added some new ones (glass-fibre reinforced composites) and reshaped many surfaces to promote additional diffusion.

14. Changing house materials (carpet, railings, upholstery): Some questioned whether the theatre chairs, carpeting and some upholstered railings in the house could be replaced to increase the natural reverberance of the space and reduce the reliance on the electronic systems. Our analysis revealed that such changes would produce only a minimal increase in reverberance. We recommended against this change.

15. Adding a stage extension or changing the stage elevation: Some musicians suggested extending the stage further into the house to provide more room on stage. Sightline studies revealed that this would compromise the ability of people in the balcony to see the front of the stage. We also investigated simultaneously raising the elevation of the stage. This was infeasible given ceiling heights under the choral terrace and other spaces adjacent to the stage. Both of these ideas were rejected.

16. Extending the stage walls to meet the floor: The original stage walls were used as transfer chases to return air from the stage to the backstage area where it was then collected and returned to the air handling unit. The walls on the stage side were undercut to provide an opening into these transfer chases. Some musicians felt that these undercuts acted to absorb sound. The designs for the new stage relocated the return air transfer chases and allowed us to avoid this detail.

17. Adding diffusive treatments to the upper stagehouse walls: There were questions about the need to provide diffusive treatments above the choral terrace. Our studies concluded that this was necessary and this concept was incorporated into the programme.

Based upon the above a preliminary renovation concept was established by the design team, approved by management and the acoustical committee of the orchestra and authorised by the ISO Board of Directors.

3 IMPLEMENTATION OF THE STAGE RENOVATION

3.1 Changes at the ISO

By the time the stage renovation project had been authorised, the Music Director of the ISO, Raymond Leppard had retired (he now holds the title Music Director Emeritus) and the orchestra was engaged in the process of selecting his replacement. Most American orchestras would hesitate to proceed with substantive changes to their concert venue in the absence of a fully staffed artistic leadership. In Indianapolis, the lengthy study process (the first acoustical studies of the stage had occurred at least ten years earlier) and the broad consensus around the need to renovate the stage made it possible to proceed in the absence of a music director.

3.2 Final Design of the Stage Renovation Project

The stage renovation project included several major elements:

- An acoustical canopy, comprising four separately adjustable elements. Each row of elements consists of three molded glass-fiber reinforced polymer panels separated by acoustically transparent bands. The designs for the molds were inspired by architectural details in the ceiling of the auditorium and detailed to promote diffusion in both directions (upstage/downstage as well as cross stage). Each row of panels is suspended by two line-shaft winches that allow independent adjustment of the height and angle of each row. For non-symphonic events, the panels can be detached from one winch and flown out.

- New box seating areas at each side of the stage. Above each set of box seats is a technical gallery faced with decorative grillework. Behind the grillework is a series of doors that can be used in conjunction with the acoustical canopy to adjust the acoustical coupling between the upper and lower volumes of the stage.

- A new choral terrace at the rear of the stage. This terrace is narrower in depth than the original allowing more useful area on stage for the orchestra.

- A new surface treatment on the upstage wall behind the choral terrace. This design of this treatment employs curving wood forms and pilasters.

- A new stage floor comprising hardwood flooring on a resilient mounting system.

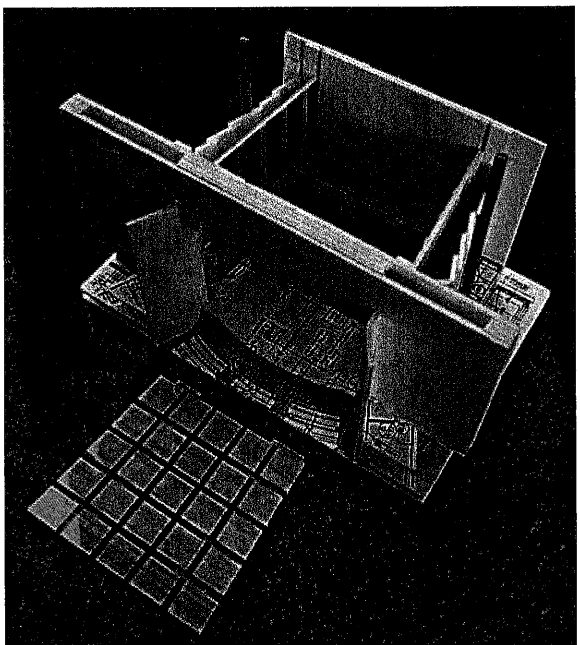

Figure 3: Acoustical concept model used to communicate design concepts to the architects at the very outset of the design process.

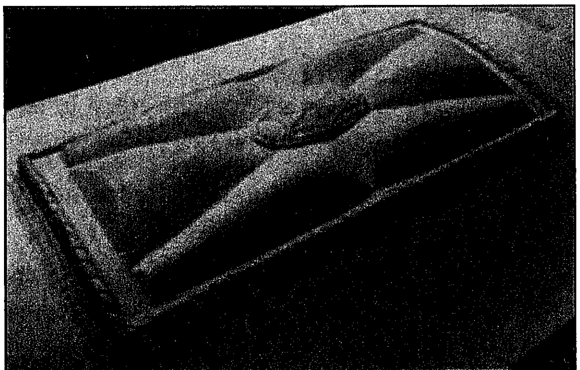

Figure 4: Clay study model showing the complex compound curvature of the acoustical canopy panels.

3.3 Initial Tuning Process

The stage renovation project was planned over a 15 month period commencing in the Spring of 2001 and the construction occurred over the Summer of 2002. The new stage was inaugurated at the ISO's annual Opening Gala on 8 September 2002. Adjustment of the LARES installation and the new architectural acoustic elements occurred during the week prior to the gala. The process included a mixture of objective measurement processes and subjective listening.

The first step involved developing a provisional setting for the new acoustical canopy. This setting would be used for the first rehearsal by the orchestra and be adjusted in response to subjective listening in the house and on stage as well as discussions with the musicians and conductor.

The second step covered the retuning of the LARES installation. As a first step, we verified equalisation and level balance of the various loudspeaker groups throughout the house. We then reviewed and adjusted the transfer function equalisation (coupling of system output back through to the microphones). As expected, this had changed given the significant changes to the stage acoustics.

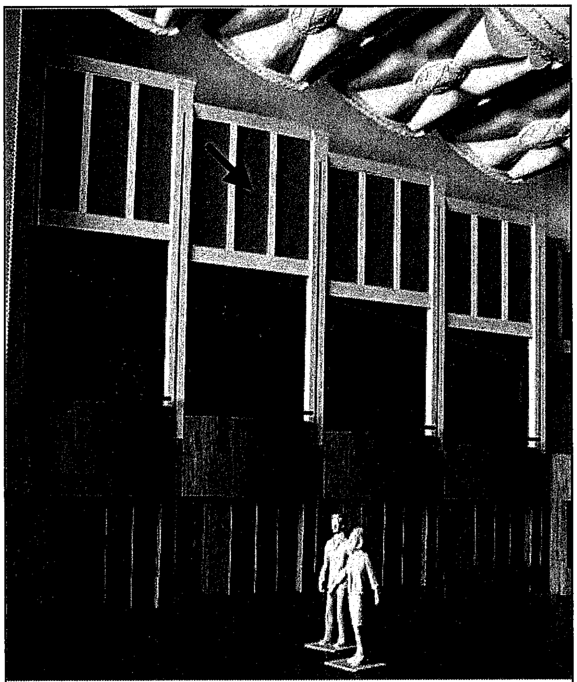

Figure 5: Final architectural model showing the profile of the new side boxes and the technical gallery above. The dark beige insets in the face of the technical gallery (see arrow) are the wood grillework with hidden doors for adjusting the coupling between the upper and lower portions of the stage volume. Also visible at the top of the photograph are the acoustical canopy panels.

The final steps involved working with the orchestra and conductor during the rehearsals leading up to the gala concert. During this process, we experimented with different settings on the doors in the technical galleries as well as adjustments to the heights and attitudes of the acoustical canopy panels. These settings were recorded and stored digitally in the computer system that directs the canopy winch system. Adjustments to the LARES system were similarly recorded and stored.

3.4 Subjective Impression of the Results

There was general agreement that the new stage had produced a substantive improvement in the acoustical quality for the audience, and more specifically in the following:

- The sound of the orchestra had greater impact
- The orchestra was better balanced with the low strings being significantly stronger
- The tendency of the brass to dominate was reduced somewhat
- There was improved integration between the natural sound and the enhanced sound

There was also broad agreement that the acoustic environment of the stage had been significantly improved for the musicians. Self-hearing was reported to be much improved as was communication between players. Bass response was reported and observed to be stronger. The only area where there was disagreement was regarding the degree to which there had been a reduction in sound levels on stage. Some musicians felt this had improved, others felt no improvement had been achieved and only one or two felt the stage had gotten louder.

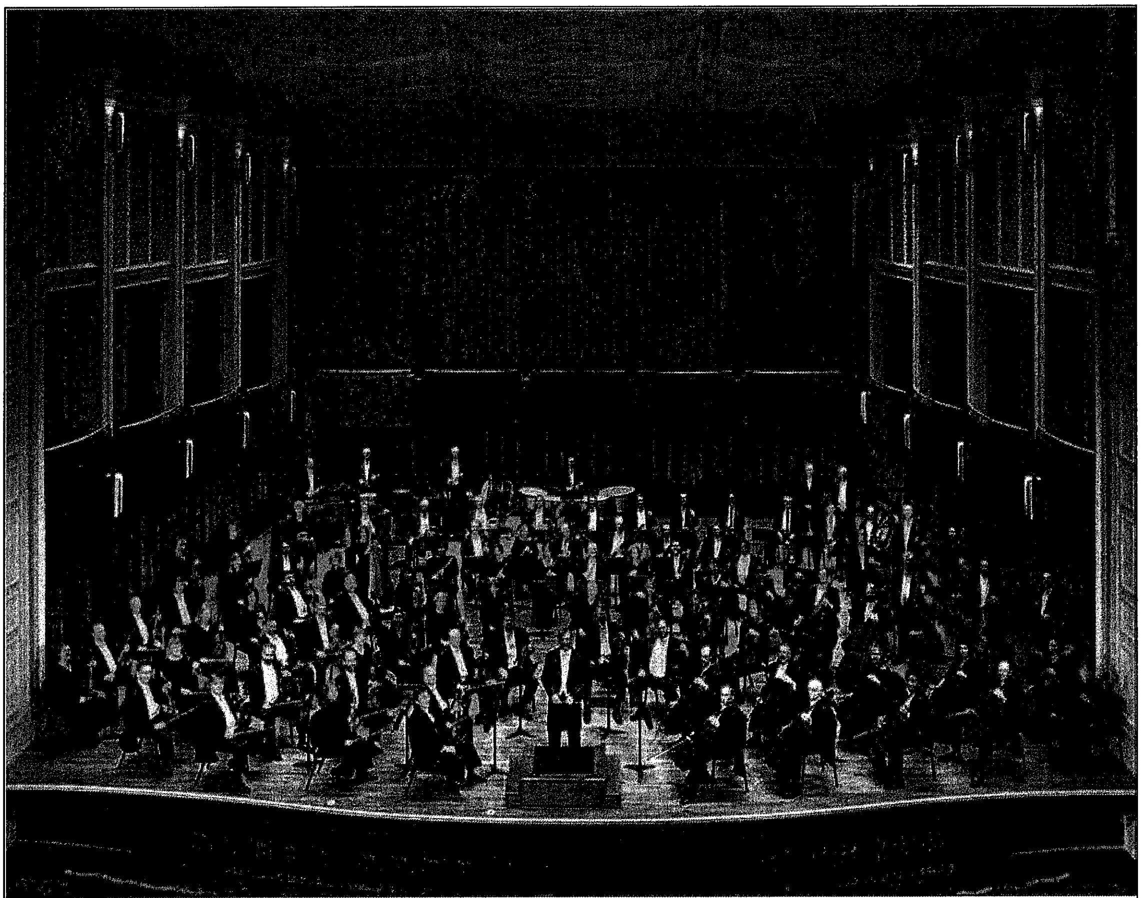

Figure 6: Maestro Mario Venzago and the Indianapolis Symphony Orchestra on the new stage at the Hilbert Circle Theatre. Visible in this photograph are all of the major elements of the renovation including the canopy, technical galleries, side boxes, narrow rear choral terrace and diffusive wall treatments. (Photograph courtesy of the Indianapolis Symphony Orchestra)

4 FINAL TUNING

4.1 The New Music Director Arrives

While there was universal agreement that the inauguration of the new concert enclosure and electronic enhancement system tuning sessions of 2002 resulted in a remarkably improved acoustic environment for both performer and audience, this work was done without the participation of the Orchestra's new Music Director, Mario Venzago, whose concerts were scheduled later in the season. In the late spring of 2003, we received word that the Maestro had expressed some concerns about the hall's acoustic response when he listened in the audience during other conductors' concerts, citing an overly loud and heavy response. We were also informed that these concerns were usually expressed in the first week after the Maestro's return from European engagements and that he was more satisfied in subsequent weeks of listening and performing.

In response to these concerns, we suggested an acoustic rehearsal with Venzago during the first week of the 2003-04 season. The primary goal of this rehearsal would be to investigate alternate settings for the electronic enhancement system (changing energy levels and timings) to develop a response more pleasing to the Maestro.

4.2 Tuning Process

The acoustic rehearsal was scheduled to coincide with Assistant Conductor auditions utilizing the same repertoire: Beethoven's *Symphony No.5*, Richard Strauss' *Don Juan*, Stravinsky's *Firebird Suite*, selections from Williams' *E.T.*, and other works. The experimental approach was to have co-author Scarbrough to listen in the balcony with Maestro Venzago and manipulate the electronic enhancement settings while co-author Blair conducted the orchestra in excerpts.

The first excerpt chosen was the *Firebird Suite's Infernal Dance*. The short impulsive chords opening the work, spanning an extreme frequency range, were repeated for A-B comparisons of various response settings. The options for appropriate settings were quickly narrowed to two, and we explored the remainder of the piece, sometimes asking the orchestra for different styles of attack and articulation. In the process, two important points were determined:

1. the optimal setting for the enhancement system chosen during this rehearsal was unchanged from our 2002 concert setting, except for a 0.5 dB reduction in level, and

2. much larger perceived improvements to the orchestral sound could be developed by asking the orchestra to change aspects of its playing.

At this point, we collectively shifted our attention from attempting to change the room response to changing the orchestra.

For example, in the second movement of the Beethoven Symphony (starting at rehearsal letter D), we asked the brass and strings for shorter articulations and a more sustained sound from the woodwinds. The result was maintaining energy of the attack without overloading the room with acoustic energy. Repeated queries from Venzago from the balcony to the players ("Trumpets, do you feel like you are playing *forte* here, or do you feel you are holding back?") reinforced the orchestra's collective response to a new way of playing.

This approach of focusing attention on repeated excerpts, breaking the orchestra into its component parts to adjust balance and articulation, and the Maestro calling down to the players to verbally confirm, from their perspective, how they fit into the whole was continued in the other repertoire. In the course of about an hour and a half the sound of the orchestra was transformed, in effect "tuning the orchestra to the room."

5 CONCLUSIONS

Our work with the Indianapolis Symphony Orchestra at the Hilbert Circle Theatre reinforced our perception that the quality of an electronic enhancement system is shaped in important ways by the architectural acoustic environment of the stage area. It confirmed our expectation that a well-designed stage area will foster improved integration between the natural and enhanced sound in a space yielding a more natural sounding result. The other major conclusion reached in this work is the importance of being able to work with the orchestra and conductor to shape the orchestra's sound in response to the physical and electronic changes made in a space. In a time span of less than two hours, we were able to make improvements in timbre and orchestral balance that would likely have been impossible to achieve in other ways.

The tuning process demonstrated again the value of working closely with musicians and conductors to refine the tuning of electronic enhancement systems. These systems offer a tremendous range of flexibility but as is often the case in such situations, this range provides a daunting range of options. Our experience suggests that the subjective impressions of experienced symphonic listeners, especially musicians, conductors and artistic administrators can provide invaluable assistance in identifying where and how to adjust these systems to achieve the best possible effect.

6 POSTSCRIPT

The authors had the opportunity to spend two days in Indianapolis prior to this year's Opening Gala. Maestro Venzago continues to work to shape the orchestra's sound, the benefits of which are clearly audible. Musicians generally continue to report good satisfaction with the acoustics of the stage and are enthusiastic about the difference this has made for sound quality in the auditorium.

During our visit, we had the opportunity to address one specific concern that had been registered by Music Director Venzago and the ISO's Director of Artistic Planning, Toby Tolokan. Specifically, they expressed concern that attacks in the bass register were indistinct and that the bass range lacked the kind of crisp articulation that characterised the balance of the frequency spectrum. After some listening of our own we concurred and made some minor adjustments in LARES settings. The adjustments included increasing the time it takes for the LARES processors to produce peak output at low frequencies (below 250 Hz.) before commencing the specified exponential decay, and slightly decreasing the level of the low frequency reverberation. The first adjustment had the effect of separating the peak of the low frequency reverberant energy from the peak of mid-frequency reverberant energy thus making the low frequency peak more easily discernable. The latter adjustment was needed to bring the overall perception of balance between mid-frequency and low-frequency reverberation back into line.

7 REFERENCES

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