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RECORDING OF WPI MUSICAL GROUPS IN ALDEN HALL

An Interactive Qualifying Project Report
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Degree of Bachelor of Science
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Abstract

The purpose of this Recording IQP was to record and archive performances of WPI music groups during the B'97, C'98 and D'98 terms, and produce a compilation recording. The task of recording facilitated an understanding and appreciation of Audio Engineering, which necessitated familiarity with and implementation of the appropriate selection of microphones, microphone techniques, and mixing for various recording environments and subjects.

1. Introduction

Recording is a highly skilled craft, combining art and science. It requires technical knowledge as well as musical understanding and critical listening ability. Using these skills, one can capture a musical performance and reproduce it with quality sound. The recording process is extremely complex, requiring consideration of many variables.

It is imperative to understand the process comprehensively before the task of recording is tackled. Recording is only optimized when acoustics and microphone techniques are fully appreciated, as are the limits of the available recording equipment. One may wonder what role acoustics plays in the recording experience. Acoustics is the study of how sound behaves in an environment. When referring to acoustics, we use the terms: reverberation, diffusion, resonance, and absorption. Reverberation is usually considered the most important measure of a hall's acoustics, and refers to the overall manner in which sound decays in a structure (Andrews, Michael and Michael V. Corbin, Andrew F. David, Kyle T. Warren, *Acoustical Analysis of Spaulding Recital Hall: IQP Interactive Qualifying Project*, May 1994).

Before a recording of any kind is attempted, the sound desired must be decided. The term "pleasant", when describing sound quality is extremely subjective. Objectives vary with the sound source and style of music being recorded. Classical recordings usually capture the ambience and complete sound of the subject, while the aim of most pop recordings is to closely mike and manipulate every instrument, molding the sound to satisfy the producers' tastes.

Once goals for the recording session have been set, choices of microphones and microphone technique, as well as recording media, must be made. Available for this project, were 2- AKG (cardioid), 2- (omni-directional), and 2- (hyper-cardioid) microphones. Microphone selection and microphone technique are definitely the most crucial variables of the audio engineering function. This recording IQP not only served to make high quality recordings, but also to document musical performances at WPI and specifically those in Alden Memorial Hall. Developing an archive system was one of the long-range goals of this IQP. Decisions have been made regarding which medium (i.e. compact disc, mini-disc, digital audio tape, cassette, and DVD) to use. Careful consideration of the cost-benefits of each available format was crucial, while research on possible cataloguing systems was needed, in order to exploit all possibilities.

This Recording IQP served as a medium through which the information obtained via research and the knowledge ascertained recording various ensembles and choirs were presented. In the future, this wealth of information on recording in general and the acoustics of Alden Memorial Hall will provide an invaluable reference to others who wish to capture musical performances in Alden Memorial Hall.

The IQP team did not attempt to reiterate what they encountered during their research but to present this information in a new light. The goal was to develop a system for documenting the musical performances of WPI, mastering and documenting recording techniques for quality recordings in worthy of archiving.

2. Literature Review

One of the first decisions the IQP group had to make regarded subjects of which to research. The available research resources were endless; the group found volumes of information on recording, acoustics, and recording mediums. The team assessed our directives, explicit goals set by the group and its advisors. The IQP group realized what issues were relevant to the project and focused on them. The group had not studied recording before this project; it was most feasible to steer away from extremely technical findings on acoustics and electronics. Emphasis was placed on those topics deemed necessary to entertain project directives: quality recordings, maximum utilization of available equipment, and developing archiving system. Every book on recording and audio engineering referenced, included in-depth studies on acoustics, microphone selections and technique, mixing, and post-production. Issues of audio storage and recording medium could not be ignored, and correlated with our primary goal of permanent archiving. The group decided to gain an understanding of the foundation of recording and its core principles.

2.1 Acoustics

"The acoustical performance of a sound-collecting or dispersing system in and enclosure is exceedingly complex because so many parameters are involved" (Olson, *Modern Sound Reproduction,* p. 249). The basic components of an acoustical system are a sound source, a space for the sound to travel through or reverberate within, and a receiver such as a human listener, or a microphone.

"The acoustic "life Cycle" of a sound can be divided into three components: direct waves, early reflections, and reverberation." (Alten, *Audio in Media,* p. 34) Direct waves are the sound waves that travel directly to the listener from the sound source. Early reflections are those sound waves that bounce off at least one surface before reaching the listener. Early reflections occur 10 to 30 milliseconds after direct waves. They occur so soon after the direct sound, that they are perceived as *part of* the direct sound. They are, however, important to the quality of the sound because they add fullness to the sound. Without early reflections, the sound is perceived as flat and dead. Reverb occurs when sound reflects from many surfaces before reaching the listener.

A quality closely related to reverb is decay. This is a measure of how fast a sound fades after its source stops producing sound, or how long the reverberation continues. A good recording studio is built specifically to reduce reverberation. It contains soft and sound-absorbing materials, and is designed in a shape that disperses sound waves and prevents standing waves. "The main objective in recording studios is to produce a diffuse sound field free of standing wave systems in the reverberant sound." (Olson, *Modern Sound Reproduction,* p. 274) This is achieved by covering the walls and ceiling with sound absorbing panels, or with cylindrical or serrated surfaces to dissipate, diffuse and disperse the reflected sound. "Curved surfaces are used in performance spaces for a variety of reasons. They may be designed to redirect energy around the space to provide sound to quiet audience areas, an example being reflectors placed over the stage. Alternatively, curved diffusers may be employed to cause scattering and diffusion and so prevent specular reflections, which can produce echoes from surfaces such as balcony fronts." (Audio Engineering Society, Vol. 44, May 1996, p. 354)

Another use of sound-reflecting materials is that of orchestral shells. "These shells can take various forms from little more than a reflecting wall at the proscenium, to almost complete enclosures around the orchestra. An orchestra shell is most necessary to provide acceptable conditions on-stage for the musicians. However, orchestra shells also modify the acoustical conditions experienced by the audience in the hall." (Acoustical Society of America, Vol. 100, Aug 1996, p. 889) Values such as Reverb and Decay are measured on a logarithmic volume scale called Decibels.

Sound is produced by vibrating objects. The numbers of molecules displaced determine the amplitude, or volume of a sound, measured in decibels. Decibel notation is always a comparison between two values, (Bernstein, *Audio Systems,* p. 23) measured on a logarithmic scale. The human range of hearing is very broad, ranging from 0 decibels (the threshold of hearing) to 120 decibels (the threshold of pain).
For more information on decibels, see also: Olson, *Book of Audio.*

Ambience is the way the particular acoustics of an environment interact with the direct sound source, including reverb, decay, and sound absorption. "Even with the many artificial reverberation devices available today, there is still no substitute for the sound of natural acoustics. Many producers try to add natural acoustics to overdubbed recordings by placing one or a few microphones several feet above and away from a sound source and taping just the ambience on a separate track or tracks. In the mix the desired amount of ambience can be blended into individual voicing or into the overall mix without affecting those tracks you wish to keep dry for other purposes." (Alten, *Audio in Media, p.* 427) Also included under the topic of Ambience is Noise.

"Noise – unwanted sound – is enemy number one in audio production." (Alten, *Audio in media,* p. 38) Ambient noise is the unwanted sound produced by outside sources such as vehicular traffic, jackhammers, sirens, thunder, wind, people shouting, or overhead aircraft. Noise also comes from inside sources as well, such as fans, the hum of fluorescent lights, ventilating systems, and appliances. Good studios are built to reduce the lever of ambient noise as well. This is done by building double walls, and massive floors that are resistant to transmitting vibrations from inside or outside of the studio. Sometimes the floor is made up of several sections; each isolated completely from the next.

2.2 Microphones

Microphones are the most important equipment for recording (Sound Advice, p. 12). Much thought has to go into microphone selection before the actual recording. Be aware of the intended subject to be recorded. Assess what mikes are available, and make sure that there are more than enough of the right types and matched pairs of microphones to accommodate the most complex sessions in your project. Much information on microphone types and selection was found in Sound Advice: The Musicians Guide to Recording by Wayne Wadhams.

2.2.1 Microphone Selection

There are dozens of microphone types; each suited to a particular range of recording applications (*Sound Advice*, p. 12). In order to make the most of each recording opportunity, the group had to familiarize themselves with the major

characteristics of different types of microphones. Capacitor (condenser) microphones are mechanically, the simplest types used in recording; their only moving part is an extremely light diaphragm (*Handbook of Recording Engineering*, p. 47). The Handbook of Recording Engineering by John Eargle proved to be a great reference when we need to know exactly how microphones worked and differed. This IQP will not present the extremely technical facet of audio recording, but for more mechanical and mathematical-based research, Handbook of Recording Engineering is recommended. The references used discussed the mechanical specifications and offered very detailed information as to how microphones, including the condenser, ribbon, and dynamic microphones, convert sound [waves] to electrical signals. Once an appreciation for the different types of microphones available is developed, one can delve into microphone techniques.

2.2.2 Stereo Microphone Techniques

Many musical sources benefit from stereo microphone techniques. Stereo techniques capture the sound of a musical ensemble as a whole, using only two or three microphones, and are frequently used to record classical-music ensembles and soloists. For a detailed and comprehensive explanation of stereo microphone techniques, see: Bartlett, *Stereo Microphone* Techniques). Most of the paired stereo-recording solutions are grouped into two broad categories, coincident and non-coincident techniques. Coincident microphones are placed with their grills touching and their diaphragms placed one above the other. The two directional microphones are angled apart to aim approximately toward the left and right sides of the sound or ensemble. The greater the angle between microphones, the wider the stereo spread. Please find more detailed study

on coincident recording and localization in "Spaciousness and Localization in Listening Rooms and Their Effects on the Recording Technique" in the *Journal of the Audio Engineering Society*, Vol. 34, No. 4, April 1986, p. 255-268.

With the spaced-pair (non-coincident) technique, two identical microphones (usually omni-directional) are placed several feet apart, aiming straight ahead toward the musical ensemble (*Practical Recording Techniques*, p.144). During playback of this recording, a phantom image of the center instruments is heard midway between the stereo pair of loudspeakers.

Another less popular technique, referred to as the near coincidence pair, uses two directional microphones angled apart, with their grilles spaced a few inches apart horizontally.

The spacing increases the stereo spread and adds a sense of ambient warmth or "air" to the recording. Again, the greater the angle or spacing between microphones, the greater the stereo spread (*Practical Recording Techniques*, p. 146).

2.2.3 Other Microphone Concerns

There are a great many variables in the recording "function." Not only do microphone type and placement need to be considered, but the number of microphones also varies with the recording situation. This Recording IQP will allow us the opportunity to experience recording of many different subjects with various microphone setups, types, and quantities.

2.3 Live Audio Manipulation

The mixing console, or the "mixer," is important audio equipment and plays a staring role in this IQP. During all the live recordings performed in Alden Hall, the mixer will be used to "mix" the signals from microphones. "The mixer also allows you to control and combine or mix sounds from many different sources at once. Rather than simply choose between one sound or another, a mixer gives you the option to combine many sounds at the same time" (*Mackie. Compact Mixers*, p.3). There are two types of mixers, the digital and the analog. The IQP team will use both digital and analog mixers for live audio manipulation. For learning more about the different types of mixers and their capabilities, the book *Mackie. Compact Mixers* by Rudy Trubitt proved to be more than useful. Another recommended book is *Principles of Digital Audio*, by Ken C. Pohlmann. The left and right recording levels of the DAT (Digital Audio Tape) recorder could also be manipulated to "mix" the live signals coming from the microphones. Although this is a low-level type mixing, the recording sound levels could be altered so both left and right channels will be "balanced" in the DAT recording (Live Sound Recording, pg. 25).

2.4 Post-Production Audio Manipulation

The digital mixer could also be utilized to improve the quality of recorded music. It could either enhance or filter out frequencies. It could change the left and right channel levels, fade music and add 'special effects' such as the sound of people clapping. In

addition to the digital mixer, the computer will be used to edit the recordings. Software such as *GoldWave*, *SoundForge* and *CoolEdit* could be used to edit/alter the recorded music digitally. Noise reduction, fading, and frequency manipulation are just a few features of the audio software, *SoundForge*. Since all the recorded performances in this IQP will be recorded on DAT tapes, it would be very easy to transfer the recorded music to a computer hard drive. Once the music has been transferred to the computer, the 'audio-data' could be altered to whatever the IQP team wants it to sound like (Principles of Digital Audio). Other gadgets, like the reverberation machine will be used to enhance the sound quality. As Professor Bianchi stated, reverberation machines could improve the quality of "dry" music. "Dry" music is a product of undesirable acoustics, one that lacks ambiance. The amplifier is another audio equipment that could be used to enhance the quality of music (Modern Recording Techniques, pg. 198). It could amplify any frequency. In order to do these necessary enhancements, one should "monitor" the sound quality. The speakers and headphones are the perfect listening tools, or sound "monitors." Once the IQP team had adjusted the music to the desired quality, the recorded sound could then be digitally re-mastered onto digital media.

2.5 Digital Media

Rotary-head Digital Audio Tape (RDAT) was the first digital recorder for consumer use to incorporate a dedicated tape deck. The RDAT, more commonly known as DAT, originated from an experimental machine built by Sony. The quality of the

recorded audio on DAT tapes is superb, it surpasses the ordinary analog tape. Although DAT tapes are smaller than their analog counterparts, it is capable of storing up to two hours of audio data. DAT's are re-writeable, cheap, compact, and have excellent audio recording/playback capability. It makes it a popular medium for both amateur and professional recordings. In this IQP, the medium for the live recordings will be the DAT. A good source for more DAT information is *DAT: The Complete Guide to Digital Audio Tape* by Delton T. Horn.

Like the DAT, the Compact Disc (CD) is another digital recording medium. The CD is an accepted medium for pre-recorded music. CDs are reasonably priced and if proper care is taken, they could (theoretically) last forever. With the advent of CD-R and CD-R drives, the CD has become more popular, especially in the computer world. A CD-R is a blank CD and with the use of a CD-R drive and a computer, data could be written onto the blank CD. These writeable CDs are an inexpensive way to store data, audio or both (a blank CD only costs $2). A single CD could hold approximately 650megabytes of data, or 74minutes of audio. Although the CDs are cheap, they are not as widely used as the DAT. This is because CDs are not re-writeable, and it takes longer to record information on them. *The Compact Disk Book* by Bryan Brewer and Ed Key is a good source for CD information. Another source is *Demystifying Compact Discs: A Guide to Digital Audio* by Daniel Sweeney.

Digital Video Disc, other wise known as "Digital Versatile Disc" (DVD), is an optically read disc. It is identical in size and shape to the audio-only Compact Disc (CD) that has been around since 1983. The DVD is an extension of the CD. The DVD will offer the same digital-quality audio found on today's CDs, plus the digital picture quality

found on the new Digital Satellite System (DSS). The major advantage of this new format, compared to the current state-of-the-art formats (the CD and laser videodisc), is that it can store a great deal of audio and video information in an incredibly small space without sacrificing in quality. Manufacturers will produce special music discs in the new format. One major advantage of DVD technology is that it can store much more music; for example, the entire works of the Beatles fit on a single DVD. For a more in-depth look at DVD's, see also: "Stepping Up to DVD," pg. 183.

3. Methodology

The first area the team studied was Acoustics. This topic correlates with the other areas of our project, because the acoustics of any particular space influence how sounds in them are perceived. For example, try standing in the center of Alden Memorial Hall and whispering. Then stand in the front foyer and whisper at the same volume. One would notice that the whisper in the foyer sounds much louder because of the acoustics of that space. The walls, floor, and ceiling of the foyer are made of stone or other hard, sound-reflecting surfaces, which allows more reverberation. The acoustics of a space must be considered before any decisions about microphone placement or mixing are be made.

Microphones are the "heart" of this IQP, and this seemingly simple topic has many areas in which to delve. Microphone types is just one of these areas. The microphone types readily available for the project were the condenser (cardioid) microphones, and omni-directional microphones. Microphones vary in frequency response, sensitivity, and polar pattern (directional pattern), which describes how well they respond to sounds coming from different directions. The differences between microphone types were considered when the group decided which type of microphone to use. Use of the appropriate type microphone is imperative to ensure quality recordings. "Which microphone techniques should be implemented?" is just as important of a question as "Which type microphones should be used?" Microphone technique incorporates microphone selection and the placement of the microphones in relation to the subjects recorded. There are many different setups for microphone techniques, and the main categories include the coincidence pair (X-Y), non-coincidence pair (spaced-

pair), and near-coincidence pair. Each technique has its advantages and disadvantages, which were considered before each recording opportunity.

Once a particular setup was decided upon for a particular performance, the focus then shifted to mixing. Until the IQP team became more experienced, the group's mixing methods were less than sophisticated. Initially, the group expected to compare the mix with what was experienced first hand, making adjustments until there were no distinguishable differences between the two. This portion of the project required a musically trained ear; mixing is an art in itself as well as a science. Mixing does not just involve adjusting the dials until it sounds "right"; the mix is heavily influenced by the personal preference of the engineer. One person may like a prominent bass sound, while others might be partial to a stronger flute sound. There is no "right" or "wrong" mix for a recording, although there are definitely undesirables that may present themselves if gain levels, trims, and equalizers are not set appropriately, causing annoyances in the recording. If the treble was set too high, the recording was sometimes "*hissy,*" revealing a "*ssssssss*" sound. If the bass was overemphasized, then the recording sounded "*boomy,*" sounding as if it were played along with a continuous thundering sound. There were also certain mixer adjustments that made marked improvements in the sound of a recording. Sometimes, a slight increase of the midrange improved the intelligibility of speech in a recording, but too much made it sound harsh and annunciated.

The Recording IQP group expected that much learning would come through experimentation and following techniques and hints researched, but the IQP team formulated a set of guidelines for microphone selection and placement in Alden Hall, as well as initial settings for mixing. The settings needed to be altered slightly for different

ensembles, but this IQP allowed the team the opportunity to fully realize the acoustic properties of Alden Memorial Hall, how it influences sound. Discriminating mixer settings helped compensate for the inadequacies of Alden Hall.

The next major areas of focus were post editing and selection of a recording media. Post editing involved using the computers in the music lab to add effects such as artificial reverberation, fading into and out of tracks, splicing, filtering out "noise", enhancing desirable frequencies. One of the project's more ambitious goals was to develop a system for archiving these and future recordings, the team assessed the cost-benefit of various recording media before implementation of any system. Once, an archiving system was in place, tracks were then selected from the '97 – '98 archives for a "Best of WPI" recording.

3.1 Acoustics of Alden Memorial Hall

Through months of recording in Alden Hall, the IQP group deduced that Alden Hall is acoustically "dead." What this means is that sounds in Alden Hall do not reverberate considerably enough to consider it a "live" room. Technically, a dead room is one where the reverberations last for less than 3 seconds, and a live room reverberates for more than 3 seconds.

Sounds produced in Alden Hall are absorbed very quickly by the materials in the room. As stated earlier, soft, porous materials absorb sound readily, while solid, hard materials reflect sound rather than absorb it. In fact, all materials absorb sound somewhat, but harder materials tend to reflect more sound than they absorb. The

frequencies of the sounds being reverberated also have an effect on the amount of absorption. Higher frequencies are absorbed to a greater degree than low ones.

When the IQP group recorded in Alden Hall, lower frequencies were much stronger on the recordings than higher frequencies. This led the IQP team to the conclusion that the acoustics of Alden were such that the hall absorbed higher frequencies more so than lows.

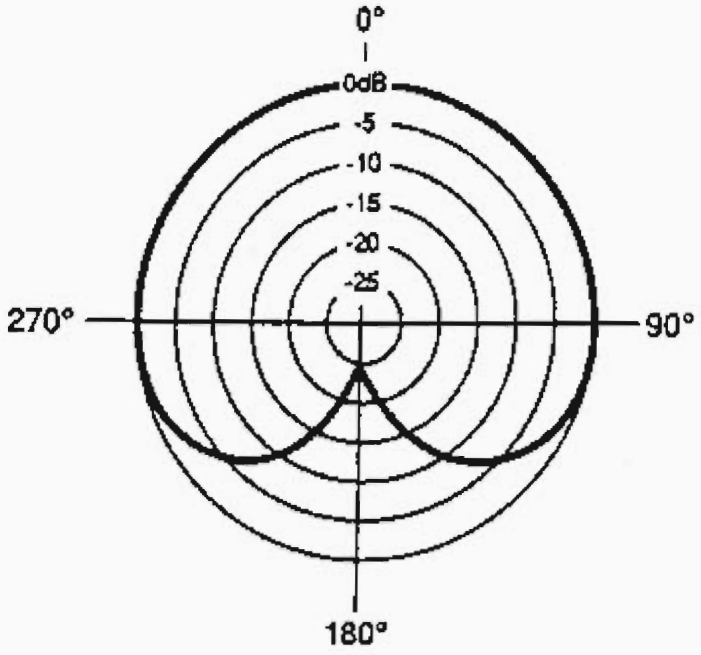
The causes of Alden's poor acoustics are due to the construction of the hall, and the materials of which it is constructed. The curtain at the front of the hall is a major factor in the sound-absorbing tendencies of the hall. The soft, velvet curtain has a very high sound absorption coefficient, hence its purpose of preventing backstage sounds to be audible from the audience. With the curtain closed during performances on the floor in front of the stage, it contributes a great deal to the deadness of the room. Possible remedies for this are to leave the curtain open, as visually unpleasant as it may be, or to install the band shell behind the performers. The shell is made of sound reflecting material, and its shape is such that it re-directs the sound back toward the audience. The large, open balcony with its plush seats also absorbs a great deal of sound for two reasons. First is its shape. The balcony opening spans the whole of the hall's width, and almost half its height. This allows for large quantities of sound to be trapped in the balcony, and never again reverberate towards the audience. Contributing to its ability to absorb sound are the plush seats, which, like the curtain, have high sound-absorption coefficients. Other sound absorbing materials are the porous ceiling, and during performances, the chairs and audience. There is an incredible difference in the acoustics of the hall with and without chairs and audience. People actually absorb quite a bit of

sound, and make large differences in the reverberation time. It is for this reason that major concert halls have plush seats, so that when performers are rehearsing, the seats simulate the way the room will sound once an audience is present.

3.2 Appropriate Microphone Techniques

Once an appreciation for the acoustics of Alden Hall was realized, we began considering microphone techniques. We knew what instruments would "carry their own," and what instruments needed to be close-miked. As mentioned previously, we realized that Alden Hall did not allow much reverberation of the higher frequencies. To compensate for this property, strings, flutes, piccolos, and other high frequency instruments were close-miked.

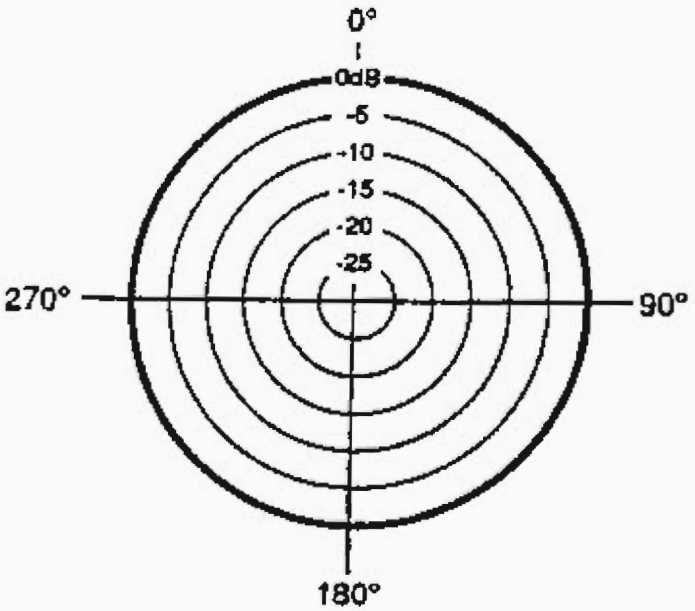
"Which microphones do we use?" was a very popular question among the group. There are many types of microphones on the market, but the team had access to a very limited selection. Omni-directional microphones are suitable for recording in environments where there is adequate reverberation and a balance between the frequency ranges. Employment of the cardioid microphones was decided upon on almost all occasions. Cardioid microphones are directional and very sensitive; they pick up sound from only certain directions. See Figure 1.1. Because Alden allows rapid decay of sound waves, the direct wave must be recorded before it has a chance to reverberate and decay.



CARDIOID

Figure 1.1

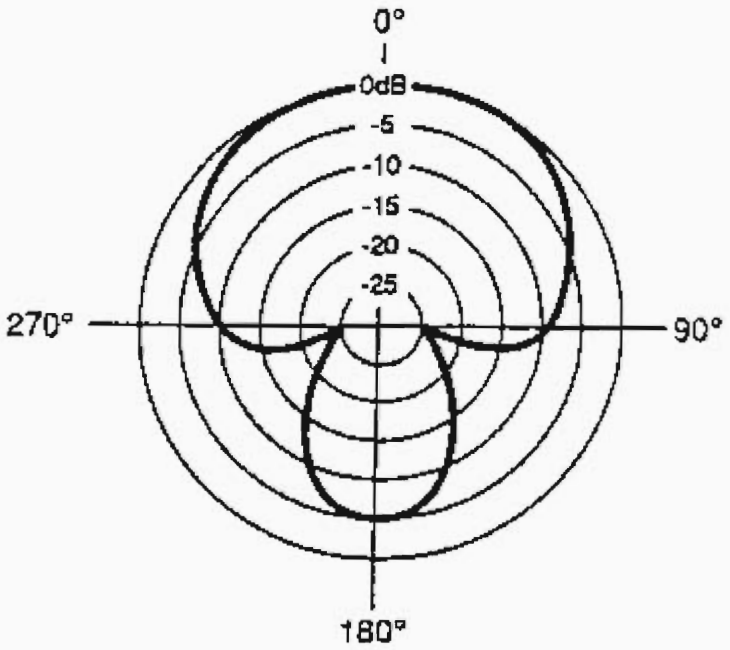
Omni-directional microphones have a much wider range, recording from all directions. See Figure 1.2.



OMNI-DIRECTIONAL

Figure 1.2

The wide pattern allows unwanted sounds in the recording. Audience noise was very noticeable in the test recording [with omni-directional microphones] the IQP performed early in the project. Even audience whispers and hustling were picked up by the microphones, while the music, which should have been the focus, seemed to be in the background or very distant. Omni-directional microphones are ideal for recording in large reverberant (7+ second reverberation) churches, where sound wave decay is delayed and absorption is at a minimum. Hyper-cardioid microphones offered more direction than the omni-directional microphones, but not quite enough. See Figure 1.3.

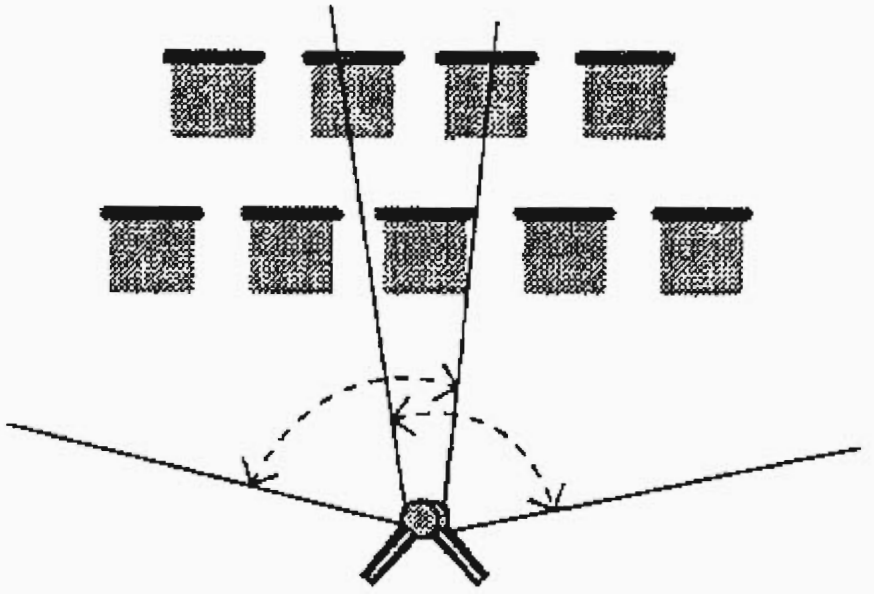


HYPER-CARDIOID

Figure 1.3

Once appropriate microphone types were selected, decisions pertaining to number of microphones and actual microphone setup (technique) have to be made. Microphone

technique varies with the environment and the subject. The team most often used the XY coincidence pair technique. See Figure 1.4.



XY (coincident) configuration. Two cardioid mics, one aimed to the left, the other to the right of the center of the sound source.

Figure 1.4

The XY configuration is only one of the possible stereo microphone techniques. This technique was popular with the group, because the aim of most of the recording sessions was to capture the musical ensembles as whole units. Again, the coincidence microphones are placed so that their grills touch and with their diaphragms placed one above the other. One microphone is aimed to the left, while the other to the right. The angle between the pair should not exceed 110°. This set up offers a realistic stereo spread, but phasing and frequency canceling problems may occur if the spread is too wide. Not employed regularly, are the near-coincidence pair and the spaced pair. These

techniques offer a very "loose" recording; some instruments are lost and the piece may sound "muddy."

The group used, on many occasions, other microphones in addition to the XY cardioid pair. While the XY technique provided for a nice comprehensive recording, some instruments were lost or overpowered by other instruments; close miking helped remedy this problem. Close miking involves placing a directional microphone near the sound source, and then carefully adding or mixing it to the overall or master mix. This technique was used extensively. The group almost always put directional microphones on the string and woodwind sections. We experienced a similar situation when recording performances of vocalists with band or orchestra accompaniments; again, we close-miked the vocalists, usually choirs, and mixed the tracks. It worked very well. The group did not have the opportunity to close-mike individual instruments. Pop recordings usually employ close miking of all instruments, and mix the tracks together in postproduction. What can result from this practice, if the engineer is not careful, is a very dead and sterile sound. How is the room and reverberation captured when *all* of the microphones are directed at individual instruments? Well, it is not, and that does provide for a pleasant recording. Through each session, the group kept in mind the importance of ambience and reverberation; without either of these elements, a recording not worthy of archiving is produced. Mixing was previously mentioned several times, but mixing is quite complex. When the acoustics do not provide for an excellent recording, mixing is often used.

3.3 Live Audio Manipulation

The mixer was instrumental in making acceptable recordings: exaggeration of mid and high-range frequencies, through manipulations of the mixer equalizer, compensated for the lack-luster representation of higher frequencies in Alden Hall. There is not a formula or simple technique for using a mixer. Mixer settings will vary at least somewhat for every session, even those is the same facility. The volume or decibel level of the subject as well as the acoustics of the environment are factored into the mixer settings. The Mackie 12-track mixer the group used had many useful features. See Figure 5.

Sometimes the sessions were too dynamic or volatile to incorporate live mixing, or "undesirables" were picked up despite the team's efforts. Instances like these, were perfect opportunities to maximize available postproduction methods. Just as sound can be molded before it is recorded, it can be changed afterwards. Available to the IQP team, were computer software, a digital mixer console, and post-production techniques using the analog Mackie 12-track mixer.

3.4 Post Production and Computer Manipulation

Provided the acoustics are nice or mixing techniques are exploited, very little post-production may be needed. This was sometimes the case, but there were many recorded selections that could be improved upon. Some performance selections needed artificial reverberation added, while others needed additional mid and high frequency boosting, cutting and pasting, fading out, and other editing. If post production is needed, the music that needs editing is transferred digitally onto a computer.

Mixing boards are also be used for post editing, but since computers are more powerful, a music engineer will be able to make exact and precise editing on the selections. The IQP team used a Digital Roland mixing board to edit several recorded selections that did not need pin point accuracy. Designed to meet the needs of project and home recording studios, the VS-880 is packed with an array of features, including eight tracks, 64 virtual tracks, onboard EQ, a 14-chanel mixer with automation, a removable storage medium, and optional internal effects. The Roland mixing board can provide adequate editing tools if a computer is not available. The VS-880 was primarily used in this IQP to cut and paste music selections so that the recordings will flow more smoothly.

After the music has been arranged with the VS-880, the selections that needed more precise editing were transferred onto the computer. The IQP team had access to several PowerPC Macintoshes in the WPI Music studios and labs. Most of the Macintosh machines have installed music authoring and editing software like the Digital Performer2.1, Mark of the Unicorn, more commonly known as "MOTU", Band in a Box, Max, Masterlist CD and many others. The IQP team mainly used the Digital Performer for the Macintosh. This is a powerful software that could aid a music engineer tremendously. One can virtually change a form of music signal into another with this software.

After the music has been transferred onto the computer, additional cutting and pasting of music could be done with the Digital Performer. The results are usually more precise because the computer uses exact values for editing. The IQP team fully utilized the many amazing features of the Digital Performer. The Performer was like the Roland mixing board, but with more features and capabilities. With Performer, plus the plug in

MOTU effects, the IQP team improved several recorded selections. A sneeze was erased, dry music was improved by adding reverb, very loud claps were softened with the volume controls, and the music balance was equalized with the panning tool and so on. Music that had too much bass was rectified by decreasing the low frequencies and increasing the mid and high frequencies. The Digital Performer can find peak values in a recording, so that these "peaks" could be lowered to prevent the music from clipping. Noise reduction is also one of the many features of Performer.

After all the necessary improvements, the selected recorded music were "bounced" onto a new files. Digital Performer is said to be a 'constructive' software. It does not alter original music files, instead, it saves a new file with all the new settings and retains the original file in its 'original state.' The changes made are not saved onto the original file. Software is deemed 'destructive' if it overwrites or tries to edit the primary music file.

4. Conclusions and Recommendations

After three terms of recording performances performed at Alden Hall, the IQP team came to the conclusion that Alden Hall does not have the acoustical properties of a "fine" music hall. Alden Hall was not designed to have the same properties as Carnegie Hall or other great musical halls, but as a multi-purpose building where college social events and productions could be held.

The materials that make up Alden Hall's interior are not conducive to good acoustical properties. The seemingly porous material that makes up the ceiling does not reflect the sound waves coming from the main stage properly. They absorb many of the sound waves. The balcony, with its large opening and plush seats also absorb much of the sound in the room. Due to the different amounts of absorption of different frequencies, the low frequencies are more pronounced than the high frequencies; these acoustic properties are obvious when one listens to musical performances at Alden Hall. High and midrange frequencies, which are absorbed more easily, do not reverberate appreciably due to the hall's design. Low frequencies dominate all unmixed recordings done in Alden Hall. In all of the recording sessions in Alden Hall, it was necessary to adjust the equalizer settings to compensate for the lost high frequencies. The inevitable prominence of high frequencies encourages live mixing. This was done after listening to the first few recordings from the hall and recognizing the pattern of lost upper frequencies.

If this project is continued in the future, the IQP team recommends the testing of Alden Hall with a white noise generator to determine which ranges of frequencies are

most absorbed by the room, and to make recommendations of how Alden's acoustical properties may be improved.

If a recording of an Alden performance is needed, the IQP team recommends an X-Y Cardioid Coincidence pair technique, at least 8 feet away from the podium and at the maximum, 20 feet away. With this setup, the high frequencies that are usually drowned out by the low frequencies are still audible. If the high frequency instruments are outnumbered by the low frequency ones, the IQP team suggests a "close" miking with hyper-cardioids microphones. The compact, close range small focus of the hyper-cardioids make it an ideal mic to record specific frequency instruments. See appendix A for different mic setups that the IQP team used to try improve the 'acoustic' properties of Alden Hall.

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Appendix A

The floor plans in the follow pages follow the same legend:

Figure 2.1

Date: November 8, 1997

Subjects: WPI Concert and Stage Bands

Location: Alden Hall

Equipment: DAT recorder

MACKIE Mixer

2 Cardioid Microphones

2 Microphone Stands

Setup: The band was situated on the floor of the hall in front of the stage. The strings were in the front most section of the band, and right after them were the wood winds, then the brass. To the left of the Brass and Strings was a piano, and to the right was the percussion section.

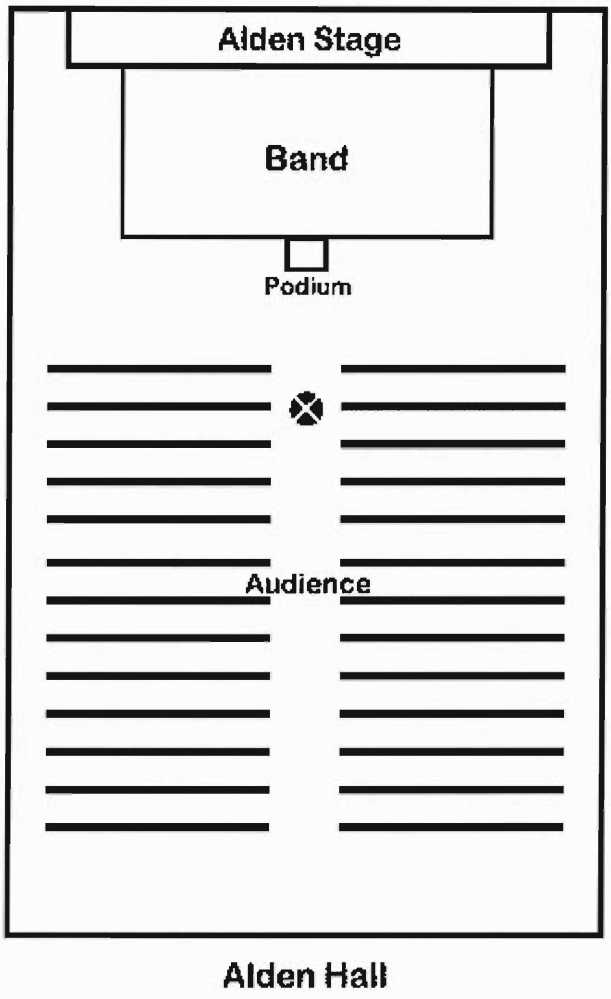


Figure 2.2

Mixer Settings:

Since this was the first recording done by the IQP team, the mixer's equalizer settings and trims were all at unity. Channel 1 was panned to the left while channel 2 was panned to the right to maintain a 'stereo' effect.

Date: December 3, 1997

Subjects: Alden Voices Women's Choir, WPI Strings and WPI Brass Ensemble

Location: Alden Hall

Equipment: DAT recorder

MACKIE Mixer

2 Cardioid Microphones

2 Omni Directional Microphones

4 Microphone Stands

Setup: The band shell was in place on the floor of the hall in front of the stage. Inside the shell, there were risers in place, with Alden Voices standing in parts on the risers. The Altos were on the left, and sopranos on the right. On the floor in front of the risers, the Brass was set up in a semi-circle, and in front of the Brass was the String Ensemble, also in a semi-circle. To the left of the Brass and Strings was a piano, and to the right was the percussion section.

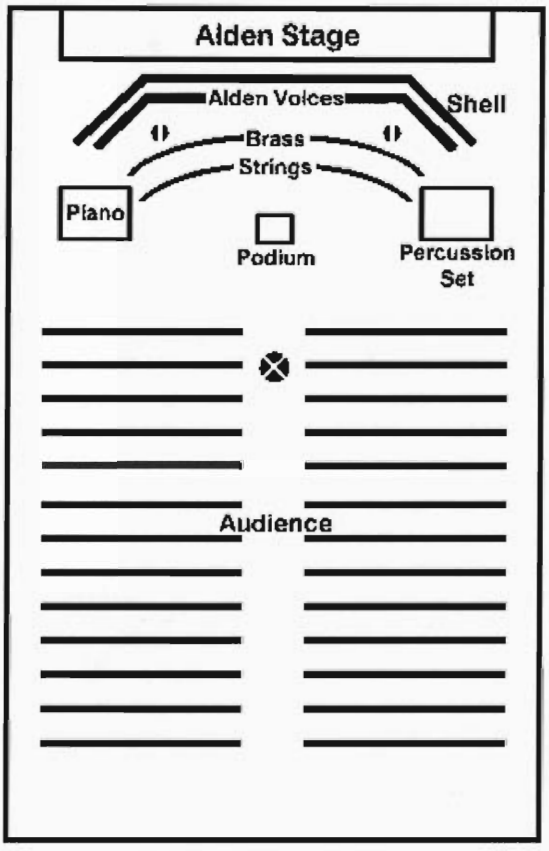


Figure 2.3

Two AKG cardioid mics in a coincidence pair at ten ft. from the conductor's podium and two cardioid mics for separate miking of the Altos and sopranos of Alden Voices. These mics for Alden Voices were placed behind the Brass, and in front of Alden Voices. Each was placed 7 feet high and 3 feet away from the section to be recorded, and trained at the center of the section being recorded.

During different sections of the performance, only certain groups performed for certain pieces, and for some, they all performed together. When Alden voices was not performing, their mics were muted.

Mixer settings:

Low and midrange equalizers were set at their unity value, and the high was set at +9. This is because Alden Hall absorbs high frequencies very easily, and without boosting the high range, the mix lost its clarity and sparkle. These qualities returned when the high range was boosted. Channel 1 was panned to the left, and channel 2 to the right for a stereo effect, and their gains were both set at 12:30

Date: December 3, 1997

Subjects: Alden Voices, WPI Strings, WPI Brass, WPI Woodwinds

Location: Alden Hall

Equipment: DAT recorder

MACKIE Mixer

6 Cardioid Microphones

6 Microphone Stands

Setup: The band shell was in place on the floor of the hall in front of the stage. Inside the shell, there were risers in place, with Alden Voices standing in parts on the risers. The Altos were on the left, and sopranos on the right. On the floor in front of the risers, the Brass was set up in a semi-circle, and in front of the Brass was the String Ensemble, also in a semi-circle. To the left of the Brass and Strings was a piano, and to the right was the percussion section.

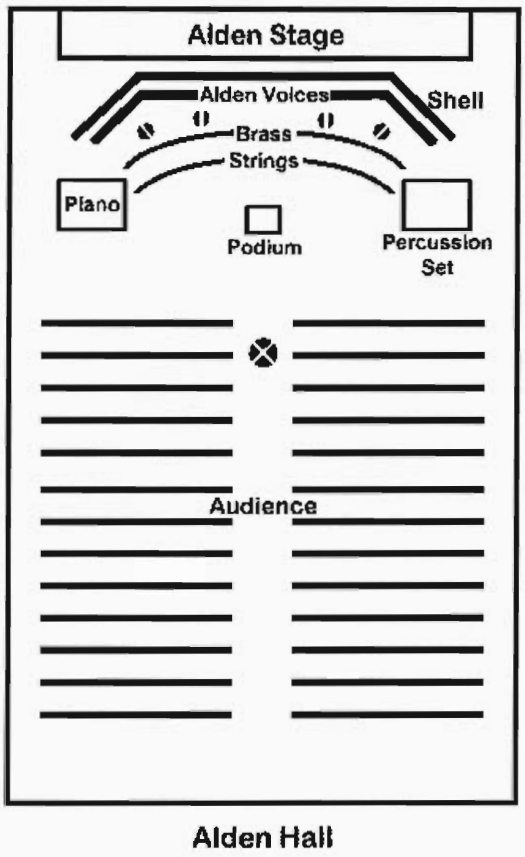


Figure 2.4

Two AKG cardioid mics in a coincidence pair at ten ft. from the conductor's podium and four cardioid mics for separate miking of the Altos and sopranos of Alden Voices. WPI's Lens and Lights provided the mics for Alden Voices, for amplification of during the show. Lens and Lights fed these mics into their mixer, and the IQP team tapped off of their source into the team's mixer. The mics were 2 to a channel: the two left mics on channel 3 and the two right mics on channel 4. These mics were placed behind the Brass, and in front of Alden Voices. Each was at 7 feet

high, and 3 feet away from the section to be recorded, and were trained at the center of the section being recorded.

During different sections of the performance, only certain groups performed for certain pieces, and for some, they all performed together. When Alden voices was not performing, their mics were muted.

Mixer settings:

Low and midrange equalizers were set at their unity value, and the high was set at +9. This is because Alden Hall absorbs high frequencies very easily, and without boosting the high range, the mix lost its clarity and sparkle. These qualities returned when the high range was boosted. Channels 1 and 3 were panned to the left, and channels 2 and 4 to the right for a stereo effect. The stereo mic gains were both set at 12:30, and the cardioids for Alden Voices were set at 9:00.

Date: December 4, 1997

Subjects: Alden Voices, Wells College Choir, WPI Men's Glee Club, WPI Brass, Simple Harmonic Motion, Interstate 8

Location: Alden Hall

Equipment: DAT recorder

MACKIE Mixer

6 Cardioid Microphones

6 Microphone Stands

Setup: The Band shell was in place on the floor in front of the stage. On risers inside the shell were (left to right): Alden Voices, the Wells College Choir, the WPI Men's Glee Club, all four rows deep. In front of the singers was the WPI Brass, and to the right of the brass was the piano.

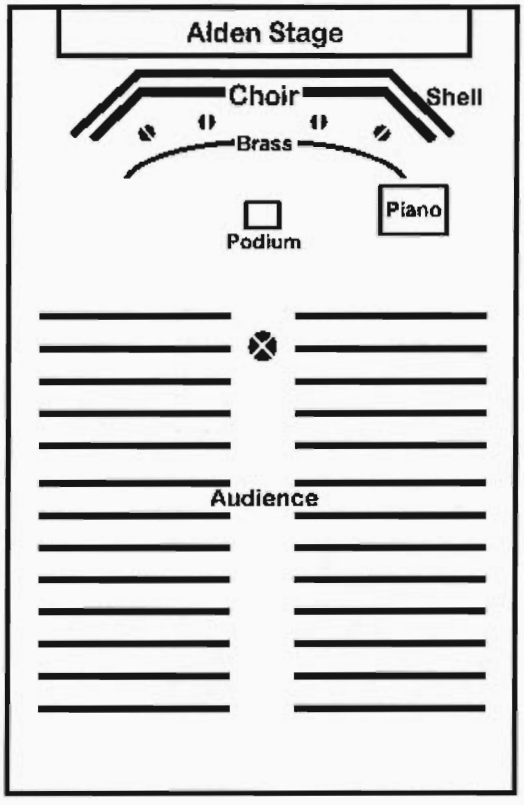


Figure 2.5

The microphones used were 2 AKG cardioid mics, and 4 SHURE 57's . The 4 SHURE 57 mics were evenly spaced in front of the choirs at a distance of 3 feet and at a height of 7 feet. They were aimed at the center rows of singers. The 2 AKG microphones were in a coincidence pair setup and were about 15 feet from the podium.

Date: February 15, 1998

Subjects: WPI Brass and WPI Strings

Location: St. Paul's Cathedral, Worcester

Equipment: DAT recorder

MACKIE Mixer

2 Cardioid Microphones

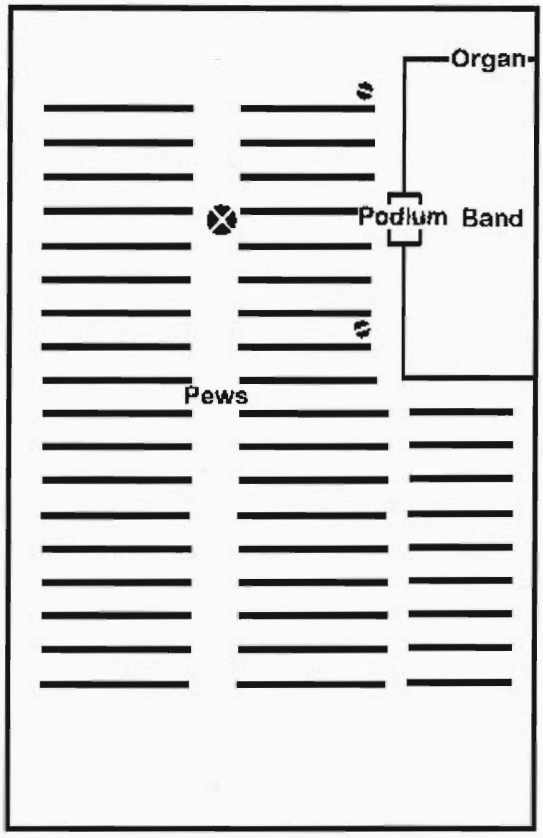
2 Hyper-Cardioid Microphones

Roland VS-880

External SCSI 4-Gigabyte Hardrive

4 Microphone Stands

Setup: The church was divided into 3 sections of pews, one central, and one on either side. The two columns of pews on either side did not extend as far forward as the center column, leaving some floor space in either front corner of the church. The instrumentalists were set up in the right-hand corner. The Brass was against the front right wall of the church, facing the front center, and the Strings were in front of them.



St. Paul's

Figure 2.6

The 2 hyper-cardioid mics were placed 3 feet away from the band. These mics were 15 feet from each other, and both mics are aimed towards the center of the band. The 2 x-y pair cardioid mics were placed 15 or at least greater than 15 feet from the podium.

Mixer Settings:

The low, midrange, and high equalizers were set at +1. Channel 1 was panned to the left, and channel 2 to the right for a stereo effect, and their gains were both set at unity. The trims for channels 1 and 2 were set at unity level. Channels 1 and 2 were from the x-y coincident mic setup.

Channels 3 and 4 are from the spaced-pair mics. Channel 3 was panned to the left, and channel 4 to the right for a stereo effect, and their gains were both at unity. The trims of channels 3 and 4 were both at 12:00. The trims are higher for the spaced-pair mics because the hyper cardiods do not pick up signals as strongly as the cardioid mics.

Date: February 20, 1998

Subjects: WPI Concert Band and Soccomm

Location: Alden Hall

Equipment: DAT Recorder

MACKIE Mixer

2 Cardioid Microphones

2 Hyper Cardiod Microphones

4 Microphone Stands

Setup: The band shell is on the floor right in front of the Alden Stage. The brass and percussion are located near the back of the shell while woodwinds are located at the front, near the podium. There are two additional shells that are being used as projector screens. One on the left, and one on the right.

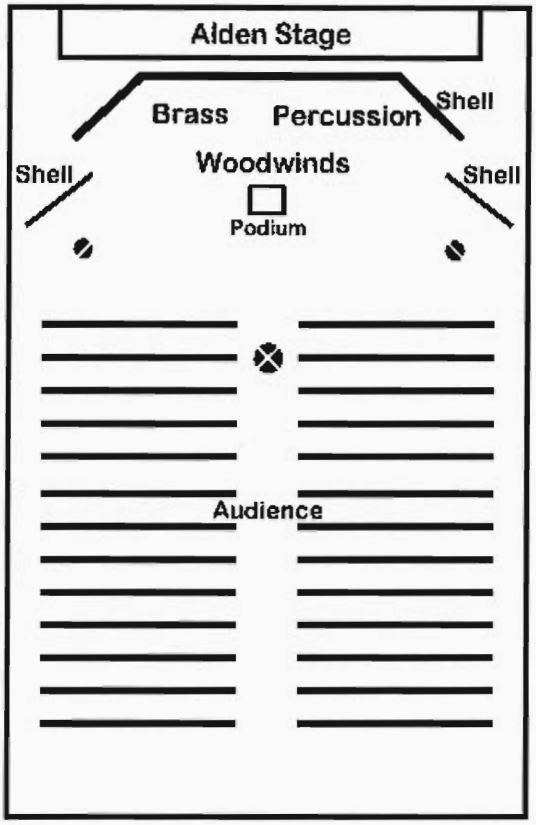


Figure 2.7

The two x-y pair cardioid mics were placed 10 feet away from the podium while the other two hyper-cardioid microphones were placed near the shell/projector screens. The hyper-cardioid mics were 6 feet away from the shell/projector screen. The IQP team decided to put the hyper cardioid mics near the shells so that the mics will pick up the ambience of the room, since the theme of this particular recording is Space.

Mixer Settings:

The low, midrange, and high equalizers were set at +1. Channel 1 was panned to the left, and channel 2 to the right for a stereo effect, and their

gains were both set at unity. The trims for channels 1 and 2 were set at unity level. Channels 1 and 2 were from the x-y coincident mic setup. Channels 3 and 4 are from the spaced-pair mics. Channel 3 was panned to the left, and channel 4 to the right for a stereo effect, and their gains were both at unity. The trims of channels 3 and 4 were both at 11:00. The trims are higher for the spaced-pair mics because the hyper cardiods do not pick up signals as strongly as the cardioid mics.

Date: April 4, 1998

Subjects: Interstate 8, MIT Chorallaries, Mount Holyoke V8's, RPI Rusty Pipes, Wellesley Widows, Simple Harmonic Motion. (Acappella groups)

Location: Riley Commons

Equipment: DAT Recorder

MACKIE Mixer

2 Cardioid Microphones

2 Microphone Stands

Setup: The cardioid mics were spaced 5 feet apart, directly in front of the stage, and at a height of 4 feet above the stage floor. The reason for this was that the planned setup of a coincidence pair and a spaced pair proved impossible due to either faulty mics or cables. The faulty spaced pair was removed, and a single coincidence pair was attempted, but the soloists, who stood between the mics and their backup groups drowned out the backup. To remedy this, the stereo pair was separated and placed to either

side of where the soloists stood. This setup provided us with the best sounding mix of soloists and backup.

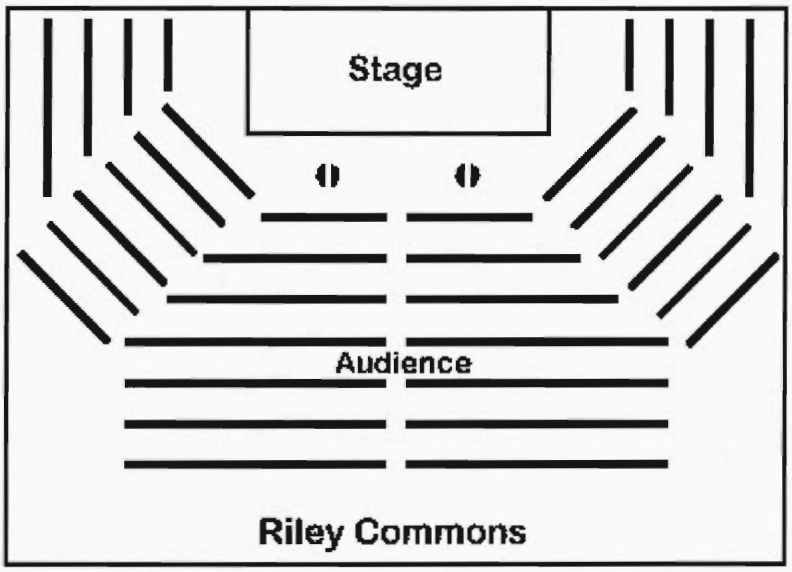


Figure 2.8

Mixer settings:

Both mic gains were set at 11:00. The high equalizer was set at unity, the midrange was boosted to +2, and the bass was boosted to +2. This was because of the close miking used. At a short distance, there is not much between the source and the mic to absorb the sound of high frequencies, so they need not be boosted. The mid and bass were boosted to add more fullness to the sound and take away the tinny, flat sound that was observed with unity equalizer settings. The channels were panned 1 to the left and 2 to the right for a stereo effect.

Date: March 5, 1998

Subjects: WPI Chamber Orchestra, Los Pleneros del Coco, and WPI Stage Band

Location: Alden Hall

Equipment: DAT Recorder

Mackie Mixer

2 Cardioid Microphones

2 Hyper Cardioid Microphones

4 Microphone Stands

Setup: The Plena were situated on the stage of Alden Hall, while the WPI bands were located right in front of The Plena. The shell was placed on the stage, right behind the Plena. The WPI bands were on a raised platform, a foot lower than the main stage. The percussion was on the right side of the WPI bands and was at floor level. The grand piano was also at floor level, but at the left side of the band.

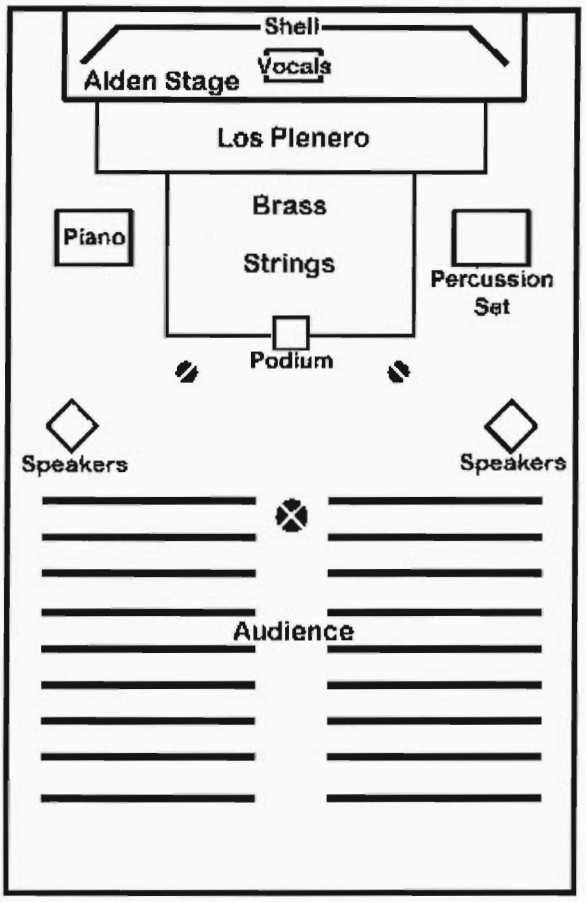


Figure 2.9

All the instruments and singers were miked and amplified. This presented a variable that the IQP team has no control over. The sound was amplified through two speakers, placed 20 feet from the main Alden Stage. The speakers were 35 feet from each other.

The high frequencies produced by the strings are usually drowned out by the lower frequencies produced by the brass. After taking this to consideration, two hyper cardioid microphones were placed 2 feet away

from the platform where the strings are located. The mics were 15 feet from each other. This mic setup is generally known as the spaced-pair technique. With this setup, the other instruments did not overpower the strings.

The IQP team placed the other 2 cardiod mics 35feet away from the front most platform (the 'strings platform'). The mics were in a 'X-Y' coincident setup.

Mixer Settings:

The low, midrange, and high equalizers were set at +2. Channel 1 was panned to the left, and channel 2 to the right for a stereo effect, and their gains were both set at unity. The trims for channels 1 and 2 were set at unity level. Channels 1 and 2 were from the x-y coincident mic setup. Channels 3 and 4 are from the spaced-pair mics. Channel 3 was panned to the left, and channel 4 to the right for a stereo effect, and their gains were both at unity. The trims of channels 3 and 4 were both at 12:00. The trims are higher for the spaced-pair mics because the hyper cardiods do not pick up signals as strongly as the cardioid mics.