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Musical Theater History

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Sound Speaks Greater Than Words:

The Impact of the Sound Designer on the Modern Musical Theater Production

Theater is a malleable art form that borrows from and represents the world around which it was conceived in order to interact properly with the audience of its time. Theater is not a bubble that lives on its own; rather it borrows from the world around it and nothing is immune. The introduction of technology into the recorded and live performance has reshaped how the art form is performed and perceived by the audience. No technology as of late has reshaped musical theater more than amplification and recording technology implemented by the sound designer. I believe that the emergence of the sound designer and amplification in musical theater was a major vehicle in creating the "Broadway Sound" we know today and audiences have come to expect. This gradual change can be seen in the playwright's musical writing, instrumentation, and audience expectations of musical theater.

History of Amplification

Today, each actor is seemingly inches away from our ears as we can hear their every syllable, whisper, breath, and articulation choice with minimal deviation from their natural acoustical signature at close proximity. Their voice can even be modified to sound distinctly different from what they actually produce. While today many aspects of sound design are an art choice, the concept of amplification can almost be viewed as a hard science: enhancing a source through increased energy with as little modification to the tonal characteristics as possible. While this may sound easy to accomplish, it is one of the most difficult concepts that acoustics/ sound researches and developers have been trying to reproduce. Every microphone, preamp, speaker, and even cable has its unique characteristics that "shape" the sound, and not always for the better. Many of the tools system and sound designers use today simply attempt to counteract the *flaws* in the equipment or the placement of such devices. While technology is heavily relied on today to achieve amplification, the use of amplification in theater is not a recent concept. The use of acoustics was the first method in which sound was "amplified" through directivity and reverberant characteristics of a space.

Going back to the ancient Greeks, the masks of Greek Tragedy were designed to enhance the natural characteristics of the human voice. The masks acted as an acoustical resonator for the actor as it created a chamber for the sound to bounce around, increase in energy, and be focused towards a specific source. As Thanos Vovolis and Giorgos Zamboulakis from the Dramatic

Institute in Stockholm describe, “The mask becomes an instrument for the actor to control the volume of the voice, the direction, the rhythm, the articulation, and the tone. This helps to achieve maximum resonance for each vowel and clear definition of the consonants.” To the listener, “Speech becomes powerful, clear, and attractive” and gives the actor “an acoustical energy field, an acoustical aura that surrounds him or her” (Vovolis). The simple use of masks to naturally amplify the voice was the first attempt at amplification for large audiences. However, they had their limitations as they altered the vocal characteristics and formants of the voice, but only provided a minimal amount of perceived amplification. As theater was integrated into enclosed spaces, actors shed the masks and allowed the acoustical characteristics of the building to aid them in projection.

Some of the earliest examples of acoustics for a defined purpose in an enclosed space can be seen in the European churches of the Gothic Period. The long reverberation of the church allowed for a fuller, more “God-like” sound from the organ and choir. This reverberation helped carry the open vowel sounds but at the expense of consonants and intelligibility. The program and the voice of the church was adjusted to meet these unique characteristics: prayer was often performed in the style of a chant and choirs sang with long vowels and slow harmonic motion. Marshall Long explains that “Plain chant was something that angels did, a way of growing closer to God. It was part of the every day religious life, done for the participants rather than for an outside listener” (Long 11). The music of the day was also tailored to the acoustic characteristics of the church. Polyphony was first developed in the church with the *organum* of Leonon and later Perotin (Long 11-12). “The compositions were appropriate for the large reverberant cathedrals” (Long 12). As theater continued to develop with miracle plays “they were performed in rooms that would support the dialogue and make it understandable” (Long 14). Theater and music developed in a symbiotic relationship with architectural acoustic design that mutually influenced the character of the other.

At the height of acoustical design in the romantic era was Wagner’s opera house, the Festspielhaus built in 1876. The orchestra placement was also carefully chosen to suit the writing of his operas. Wagner is known for his love and use of the brass section and even invented several instruments for his sole use including the Wagner Tuba, contrabass trombone, and the heckelphone. Listening to his music, the full sound of the orchestra is instrumental to his writing, especially as seen in *Der Ring des Nibelungen* also known as *The Ring Cycle*. The piece premiered in 1876 and utilized his newly completed opera house (Bayreuth Festival). The orchestra was placed in a deepened pit “partially covered with a radiused shield that directed some of the orchestral sound back towards the actors” (Long 25). This not only is an early example of stage monitoring. but also muted the orchestra in the audience and helped the relative brass and string balance while allowing the orchestra to play at full volume (Long 25-26). This unique orchestral arrangement and the 1.55 second reverberation time made this space uniquely suited to his music. The use of natural acoustics was the only source of amplification until technology advancement allowed for the microphone.

The first examples of artificial amplification in theater utilized hard-wired microphones at the foot of the stage (hereby referred to as “floor mics”) and early loudspeakers. While it is difficult

to pinpoint the first production to utilize floor mics, Grant points out that the Broadway revue producer Earl Caroll was likely the first one to do so. An article on "Driving for Deco" titled *Vanished New York City Art Deco: The Second Earl Carroll Theatre* shows a picture of hidden area mics used in his productions. Ken Bloom also sites *Earl Caroll's Vanities* as "supposedly marking the introduction of microphones to the Broadway stage" (Bloom 475). Grant offers another claim by "[m]usical theater historians Lehman Engel, Miles Kreuger, and Gerald Bordman" who "all favor 1939-40 as the beginning. The vocals in the Cole Porter show *DuBary Was a Lady* (1939) […] secretly used amplification because of heavy brass orchestrations" (Grant). By the late 1950s and 1960s, many musicals used floor mics including *West Side Story* and *Pipe* Dream. It is interesting to note that many of the early implementations lacked a sound console located in the house that the operator could adjust. Eventually, elaborate staging and the desire for *cleaner* vocals created the need for a microphone that could follow the actor around the stage within close proximity; hence with the advancement of technology, radio frequency wireless microphones came into existence.

Wireless microphones utilize the radio wave spectrum to transmit audio wirelessly much like a radio station does, only with a fraction of the power. Actors wore a small pack containing a frequency crystal, preamp, batteries, and a small radio transmitter that was picked up by a corresponding receiver at the sound console. The first wireless microphone was invented by Reg Moores and briefly made an appearance on *Aladdin on Ice* at Brighton in 1949. However, it was operated illegally and hence never patented (Moores). The first theater performance to likely use one was Carol Channing in Dolly in 1964 (Grant) and by 1981, Dreamgirls only used 5 wireless microphones. This was perhaps an artistic choice since wireless microphones were not yet embraced by the audience and critics as shown by various reviews. There was also a technical limitation as the interaction and intermodulation of radio frequencies was not yet well understood and required complex mathematics that is today handled by computers.

Eventually technology and a deeper understanding of the frequency spectrum allowed multiple microphones to be operated at a time. The first documented production to feature a wireless microphone on every actor was *Cats* in 1982 (Grant). Since then, the wireless microphone has become a staple in musical theater allowing actors to be heard over any orchestration or chorus anywhere on the stage and create the "Rock-n-Roll" sound found in musicals such as *Rent*. Today, nearly every musical has at least one wireless microphone on every actor, sometimes every foot, and even on props such as the gavel in *Phantom of the Opera*. The ability to place a mic nearly anywhere primarily picking up a single source gave way to a new possibility in theater of being able to control every aspect of the sound the audience hears. This gave way to the advent of the "Sound Designer" formerly called an engineer. This institutionally recognized the sound of a production as a design element that influences a show as much as the scenery, costumes, and lighting. The first person to be officially listed as the sound designer in a playbill was Jack Mann

for his work in *Show Girl* in 1961 (Pierce). As technology developed, this art form also continued to grow.

Originating in recording studios and later modeled in digital equipment was the ability to control and effect different aspects of the sound source. The EMI REDD 51 desk (shown to the right) was one of the first sound consoles to integrate audio level control, Parametric EQ -the ability to adjust the relative level on a frequency by frequency basis-, and compression- the ability to regulate the dynamic range of a sound source ("Behind Abbey Road […]"). Audio effects such as reverb, delay, modulation, and others were also created to further alter and shape the sound. These were first utilized in recording studios for producing albums such as the Beatles. The advent of digital audio and consoles allowed the programmability and more integrated use of such technology in theater. Today, audio consoles are computer driven with the ability to endlessly shape the sound by the designer and operator through the use of hundreds of parameters and automation.

Sound designers today are taking the ability to alter the sound to create new and enhanced experiences for audience members. Abe Jacobs remarks that "theater is an inherently amplified event: makeup amplifies the facial features, stage props are overly contrasted, and a single floor lamp in an apartment lights up the entire room evenly" (Abe Jacobs). Here we start to leave the idea of pure amplification. Instead, designers use the tools available to them to create art with the sound and add a new dimension to theater. Starting at a rather basic level, shows such as *Phantom of the Opera* utilize reverb and surround speakers to mimic the sound of an opera hall when dictated in the show aurally expending the space for the listener. This production also uses automation to move the Phantom's voice from one side of the theater to the other. Meyer Sound took this idea a step further and created the constellation system allowing the designer to change the perceived acoustics of the room in a very natural way ("Constellation"). This system utilizes strategically placed microphones and loudspeakers throughout the venue. Advanced processing of the incoming signal is used to virtually place the audience in any acoustic space imaginable. A brochure from Meyer explains how this system is utilized by theater artists:

> *"At Tokyo Disney Resort's 2,150-seat theater, Cirque du Soleil®'s ZED™ thrills audiences with a soaring, acrobatics filled musical fantasy about a mythological-comical character who reconciles earth and sky. Using Constellation, sound designers François Bergeron and Vikram Kirby have created a dynamic soundscape that entices the guests into a world of imagination, giving the show a heightened emotional texture. Working hand-in-glove with the primary and surround audio systems, Constellation allows the sound designers to transport the audience from one specific room to multiple environments and make them feel part of an emotional roller-coaster" (Meyer Sound).*

Systems such as this are so powerful in the way that they can impact the audience. At USITT, I recall a story where the designers of Disney's Aladdin encountered a problem: the space was so acoustically dead that the audience felt awkward while clapping. It turns out that when audience

members don't hear those around them clapping, they feel more self-conscious about doing so. Using a similar system, the designers changed the characteristics of the room to quite literally dictate when and how the audience clapped. Cirque de Soleil's *"O"* also uses this concept to coax the audience into clapping at appropriate moments.

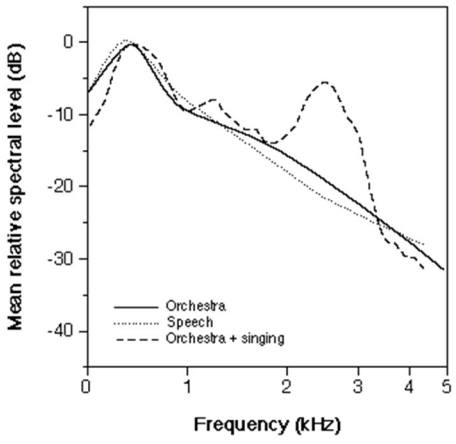
The newest addition to such capabilities is delay matrix based spatial processing pioneered by TiMax. This allows the most natural movement of a source around a space currently possible today. It's first Broadway use was in Disney's *Aladdin* allowing the sound to follow Jasmine and Aladdin as they soar above the audience on their magic carpet (Hardiman). Systems such as these has truly unleashed so many possibilities in sound amplification and design inside the theater environment and beyond.

Beyond special audio and artificial acoustic manipulation, digital processing of sound through "plug-ins" allows the designer to insert any number of effects onto a voice. These are often used with the intent of creating the most natural sound possible and correcting the *flaws* in amplification equipment. However, artists have always been finding ways to use the same effects and more esoteric ones to create unique sounds that evoke a certain emotion to the audience. Penn State's production of *Angels in America* does this very thing; many scenes utilize esoteric processing to create ghostly and possessed voices that separate those moments and characters from others within the show and create an unsettling and alien atmosphere. Such effects are also finding lives in new forms of theater used in a variety of ways such as the acapella musical *In Transit*.

In any large-scale modern musical, the audience may not be directly aware of all the technology behind what they are hearing. Many musicals today often tour with semis full of amplification equipment costing in the millions and have become an integral part in the artistic integrity and representation of the work. The advent and integration of this technology changed the face of theater forever especially in how musicals are written, scored, and perceived by the audience.

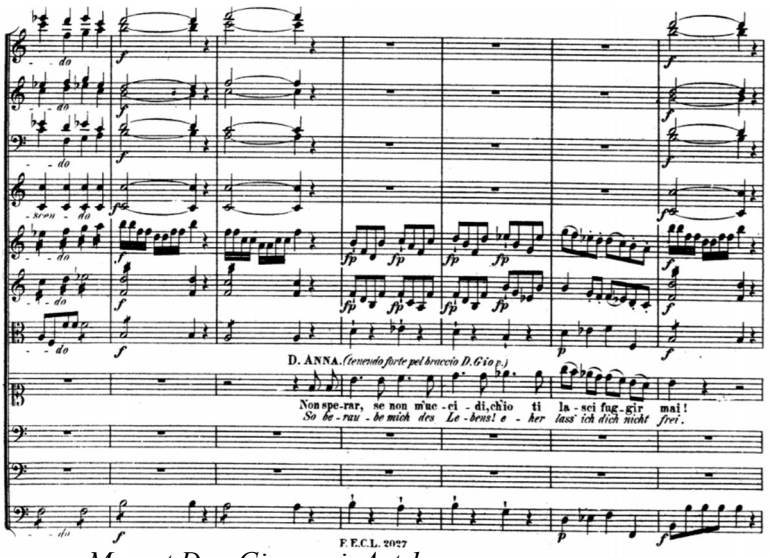
Scoring and Voice for Amplification

In the early years of Opera, composers were keen on proper orchestration for the voice. The great composers, in addition to being great melodic writers, knew how to combine different instruments to create unique sounds and how to orchestrate to allow a solo line on the oboe to pierce through a full string section. The same goes for the voice. Operatic singers used unique formants of their voice to pierce through an orchestra in a frequency spectrum where the orchestra was weak in comparison. On the right is a graph displaying the frequency spectrum of famous tenor Jussi Bjoerling in the 1970s compared to the average spectrum of human speech and an orchestra. Normal speech would be unsuitable to overcome an orchestra as it occupies nearly the same frequency spectrum. However, the operatic voice accentuates the 2-3kHz range which allows



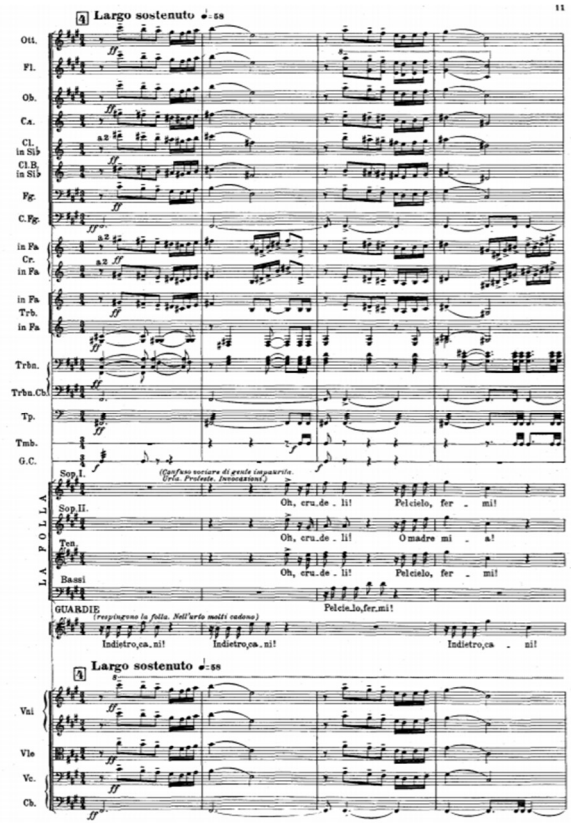
the singer to be heard over the string and woodwind section of an orchestra. (“Vocal Ring, or The Singer's Formant.”).

In addition to the tonal modifications to the voice, the early composers were careful to thin orchestration while a solo voice was singing and thicken the writing only in ensemble sections or while vocals were not present. Mozart was a tremendous orchestrator, and examples of this can be found throughout his Operas as he carefully chose what instruments to put over various voice types. To the right is an excerpt from Act 1 of Mozart’s Don Giovanni opera. It’s a great example of how the orchestration is greatly altered in voicing, breadth, style, and dynamics to allow the lone soprano voice to be heard. Mozart is more judicial with the projection and tonal characteristics of the male voice as it can more easily overcome certain sections of the orchestra. This technique worked great for a number of years, but eventually composers felt limited by how small they had to make the orchestration during vocal passages.



Mozart Don Giovanni, Act 1

As acoustical design came into play, especially in regards to Wagner and Puccini, brass often came to the forefront of the ensemble. The singers would be easily over powered if it wasn’t for the smart acoustical design of the space. To the right is an example from the first act of Puccini’s Turandot. Here, singers are expected to be heard over fortissimo strings, woodwinds, and brass- essentially a full orchestra. Without smart acoustical design, this most likely would not be possible especially with the singers behind the orchestra. This is unlike the symphonies of Mahler and similar composers that used the voice over the full breadth of an orchestra where the vocalist was placed upfront. This reaction to available technology in regards to orchestration can be extrapolated similarly in future decades as different amplification technologies are introduced.



Puccini Turandot, Act 1

For the following few decades, a blend of Mozart's and Puccini's techniques in regards to tonal balance became the norm through the creation of the "American Musical." Orchestration changed greatly with the addition of the march-like American sound and later the addition of piano- a key component of the ragtime scene- followed by the "big band" sound. Even though instrumentation and style changed greatly, the teachings of Mozart can still be seen; when an actor is singing, the orchestration is reduced and broadens greatly when the vocals end. For the most part, this rule remained unbroken until the original production of *Hair* broke every rule in the book.

In many ways, *Hair* changed the game in musical theater. It was the first production in which Rock-n-Roll was brought to the stage in all its glory. Rock-n-Roll natively relies heavily on amplification for its production; an electric guitar- vital to the Rock-n-Roll sound- would be nothing without its amplifier. The classic Rock-n-Roll ensemble relied almost exclusively on electrified instruments with the exception of the drum kit (a descendant from the early snares used to communicate across vast battlefields) such as the electric guitar, electric bass, and synthesizer. Hair for the first time brought all of these instruments, almost exclusively, onto the Broadway Stage. The instrumentation consisted of three trumpets, trombone, percussion, drum kit, electric bass, two electric guitars, electric piano, and baritone saxophone ("Hair"). This unique pairing of instruments was never before seen in the theater and was a mix between a big band and classic rock ensemble reminiscent of "Earth, Wind, and Fire" that started performing a few years after *Hair* opened on Broadway.

In the same light of breaking every standard in musical theater, *Hair's* orchestration as it pertains to the band and vocal interplay broke every rule set forth by the early composers such as Mozart that has mostly been adhered to since. Instead of relaxing the band with the addition of vocals, the band actually grows stronger to match the intensity of the voices. It's as if the orchestration gives no regard to balancing the band to the natural capabilities of the human voice. As Abe Jacob explains, "in the earlier days, the orchestrator knew that when the vocal was in, the orchestra was quiet; it was not a full orchestration." The departure from this standard can be seen in the very first song in the show: Aquarius. Listening to the original Broadway Cast Album and more so in the 1976 movie soundtrack, the band only grows stronger when vocals are introduced, a stark contrast to the methods of past composers. This would not be possible without either extremely hindering the volume and "excitement" of the band or the adoption of vocal amplification. Now orchestrators must "look to the sound designer to overcome these obstacles" (Abe Jacob).

Abe Jacob was brought in as the "sound consultant" to help fix the poor sound of the show. He added more loudspeakers to increase the volume and bring the "Rock-n-Roll" feel into the theater. He also deployed wired microphones in fixed positions around the stage, adjusted staging, and adopted a very early wireless microphone for Claud. As the production's lighting designer Jules Fisher noted, "the improvement to the sound quality was immediately apparent" (Thomas). With the success of *Hair* it became apparent that the Rock-n-Roll sound was here to stay in the theater and the sound designer became as integral to production as any other artist. Orchestrators continued to exploit this new found technology and addition to the theatrical world pushing the boundaries of amplification.

Eventually sound become part of the theater experience and this is true for no other production more than *Rent*. *Rent* utilizes a very heavy and unforgiving rock sound that the actors have to be projected over. Often in theater, the sound designer, director, and design team alike want to hide the actor's microphone (or element) as much as possible. However, in *Rent* the exact opposite is often true. Every notable production I could locate utilized head-worn boom or gooseneck microphones (also referred to as "Britney" mics) that are easily visible by the audience. A small detail such as this plays a massive part in the technical and artistic nature of the show. First, this type of microphone is often extremely visible to the audience and announces to the world that the actor is wearing a microphone. In a show such as *Rent*, part of the experience is perhaps knowing that the actors are wearing a microphone just like any other pop star would do. It also allows for the sound designer to be more judicious in their use of amplification so the visual-auditory image is more aligned. On the technical aspect, a microphone such as this creates a more intimate, fuller, deeper sound that many associate with rock-n-roll and is just a step away from giving the actor a handheld microphone often associated with the rock-n-roll sound. Obviously for practicality reasons, productions of *Rent* refrain from actors using handheld microphones as their primary source of amplification. Additionally, the gain before feedback ratio (how much amplification one can get with a certain system before the amplified source itself is louder than the original source at the microphone) is greater since the microphone is moved closer to the performer's mouth where the sound originates. For these reasons, a seemingly small choice like the type of microphone can play a huge role in how the show is perceived by the audience and treated by the sound designer.

Before delving back into orchestration, it is interesting to see that the microphone choice, even with today's technology, is still widely influenced by the style of music and instrumentation. In *Hamilton* all three "theatrical" microphone techniques are used: forehead placed lavaliers (reminiscent of classical musicals), boom microphones (such as those used on *Rent*), and handheld microphones (reminiscent of rap music). Watching the show, it is interesting to see how these microphone types are carefully chosen for the unique role each character conveys and the style of the particular song.

As the role of the sound designer increased and technology caught up with the needs of the industry, orchestrators began relying more and more on amplification to make their work possible. Back in the days of Beethoven, if he wanted to hear a violin solo over an entire brass section playing at fortissimo, it simply wouldn't be possible. Instead he would either have to change the dynamics of the brass, change the orchestration completely, or have the entire violin section play the part. Today orchestrators are doing this very thing on Broadway Musicals and leaving it up to the sound designer to balance weak instruments among much stronger ones. Many modern orchestrations include those similar to *Rent* and *Hair*: kit, percussion, electric guitar, electric bass, synthesizer, brass, and saxophones. However, these newer musicals also want to have a wide array of colors available so orchestrators have also included more delicate instruments such as acoustic guitar, violin, acoustic bass, flute, and clarinet among others. Without the advent of amplification, it is very unlikely these orchestrations would be possible. A great of example of this is the orchestration for *Legally Blonde*. In the "Legally Blonde Remix" a solo violin is often stacked up against the entirety of the instrumental ensemble. In classical orchestration this would be a very

poor choice; however, with the technology available, such unique instrumentations and colors are possible and changed the sound of the orchestra to encompass a much vaster array of colors.

The introduction of computer-generated samples in the orchestra has also widened the pallet of composers and orchestrators in recent years. A popular fully programable and automated sampler called mainstage can now be seen on nearly every large-scale and small-scale musical being produced today. Using a singular keyboard, a single player can play hundreds of "instruments" over the course of a song. To understand the scale that electronics and amplification have embedded themselves into modern-day musical orchestration, one has to see the inside of the pit for themselves. I would recommend watching this video featuring the music director of Hamilton: Alex Lacamoire (https://www.youtube.com/watch?v=jHs0NVvTxHY).

Among other challenges for today's orchestra is the absence on the reliance of natural acoustics. Today's theater environment has accomplished so much in reducing the natural instrumental sound that amplification of the orchestra is often a necessity. Today, "scene designers want to extend the set over what was an orchestra pit; so, therefore the orchestra is placed underneath the overhang or in another room so they obviously need to reinforced by remote broadcast to the theater" (Abe Jacob).

With the great expansion of the variety of the orchestra and reliance on amplification, it becomes the role of the sound designer to balance the orchestra and re-create the composer's vision in a studio-like setting. Abe explains that he finds it very helpful "to have the orchestrator sitting at the sound console during rehearsals and techs to tell the operator and designer what his intentions were in this part of the chart" just like a producer and artist might do in a recording studio setting.

The inclusion of amplification has also re-shaped the sound of the vocalist. In most modern musicals, gone is the nasally sound of the opera singer caused by the artificial 2-3kHz frequency bump that helps elevate them over an orchestra. Instead, a much more intimate, balanced, and perhaps sweeter sound is desired for certain musicals. Others demand the most brass and crass sound from the vocalist. Either way, amplification has allowed the vocalist to leave the classical operatic voice that once was necessary to be heard over an orchestra for a much larger variety of options.

To the dismay of Broadway "purists," amplification has also changed the skill set directors look for in talent. In the past, the ability to sing to every row in the house was a necessity. Ethel Merman was a musical-theater phenomenon of her time. "She was Cole Porter's favorite singer because he could hear every lyric he wrote in any song she sang. But even lesser mortals had to be able to project their voices into the farthest corners of a theater" (O'Toole). Ever since amplification was introduced, this was no longer a necessity. Sound designer Otts Munderloh claims that "Actors were better trained in the past. […] Nowadays, an actor isn't expected to reach the last row. Miking enables people to get away with giving less than their all" (O'Toole). Furthermore, even Opera has been impacted by amplification:

> *According to Franco Bertacci, a New York vocal coach who specializes in opera students, "Even in opera, young singers are not learning to project. The record companies now run the opera houses, and those kinds of old, big voices are difficult to record. Small voices*

> *are easy to record. They are perfect for opera videos or, in the case of Broadway, cast recordings. Amplification and recordings are merely an impression, or print, of the real voice." (O'Toole).*

The focus on the musical theater voice now- as viewed by many sound designers and vocal coaches- is on quality of tone rather than projection. In Abe Jacob's words, "There are still some very good performers on stage and sound systems have gotten so much better and everybody is so accepting of them that it doesn't make a lot of different what the quality of or the projection power of an individual is. It all works out together in the sound systems."

After some discussion with Abe, we came to the conclusion that this major change started "when television and movie star personalities were brought on to do live theater." These celebrities were great at attracting crowds to the theater but "they were trained to project a few feet away to a microphone. And so now, many of the celebrities working need the help and air of a microphone and a great sound system" to make them sound natural in every seat of the house (Abe Jacob).

The inclusion of the sound designer has undoubtably allowed more freedom and expression in both the orchestra and the cast and changed the sound of the Broadway show. Interestingly, similar changes can be seen in popular music since after all, both forms are connected and don't live in isolation. The popular culture world outside of theater has embraced the use of audio technology as much and perhaps more than the theater world. This has helped shape audience expectations for the theater, and for the most part, they are given what they are asking for.

Recording Technology and its Impact on Music

It wasn't too long ago when the only option to listen to music was to travel to a live performance or play it yourself. Prior to 1877 with the advent of the phonograph, recorded performances simply didn't exist (Thompson). Consequently, every performance of a song was entirely unique. As predicted by Thomas Edison, his invention, the phonograph, was "liberally devoted to music" (Thompson). At first, entrepreneurs began putting phonograph recordings into coin operated machines on city streets "where [a] passersby could listen to several minutes of audio: jokes, monologues, songs […] They were an instant hit" (Thompson). It wasn't long before the phonograph made it into people's living rooms.

The availability of recordings changed the music industry forever. Producers realized that if people were going to purchase music, they would want some predictability in their choices, so genres were created to separate music into similar forms. In 1920, the first hit emerged in the blues category. "Crazy Blues" by Mamie Smith sold one million copies in six months and paved the way for popular music. Soon the jazz category followed among others, including "hillbilly" music (Thompson). Surprisingly, the popularity of opera also surged when a recording of tenor Enrico Caruso was released. This allowed the average person to access more high-brow associated art forms: a trend that would continue with theater and classical music.

The limitations of wax cylinders also altered how composers wrote their music. According to Mark Katz, a professor of music at the University of North Carolina at Chapel Hill, "Performers and composers ruthlessly edited their work down to size. When Stravinsky wrote his Serenade in A in 1925, he created each movement to fit a three-minute side of a disc; two discs, four movements. The works of violinist Fritz Kreisler were 'put together with a watch in the hand,' as his friend Carl Flesch joked. Blues and country songs chopped their tunes to perhaps one verse and two choruses." Furthermore "The three-minute pop song is basically an invention of the phonograph" (Thompson and Katz).

The recording technology of the time also changed how talent performed. Phonographs were very poor at producing high or low frequencies as shown by the frequency plot to the right (Moyer). This made certain instruments nearly unusable with the recoding equipment of the time. Among these black-listed instruments were violins and high female voices (Thompson). Recording artists changed their orchestrations and techniques to create the best recordings possible:

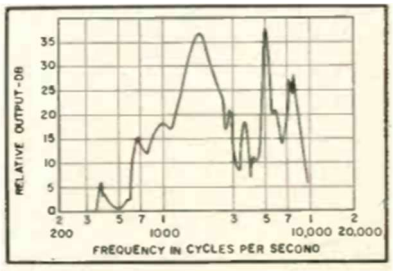


Fig. 2. Relative frequency response of an early Victor acoustic phonograph based on an ideal frequency record with 500 cps crossover.

> *"Jazz bands replaced their drums with cowbells and woodblocks, and the double bass with a tuba. Klezmer bands completely dropped the tsimbl, a dulcimer-like instrument whose gentle tones couldn't move the needle. […] To capture quiet passages, singers or instrumentalists would often have to stick their face right into the recording horn. But when a loud or high passage came along, "a singer would have to jump back when hitting a high C, because it's too powerful, and the needle would jump out of the groove," says Susan Schmidt Horning, author of Chasing Sound and a professor of history at St. John's University. (Louis Armstrong was famously placed 20 feet away for his solos.) "I got plenty of exercise," joked the opera singer Rosa Ponselle. If a song had many instruments, musicians often had to cluster together in front of the cone, so tightly packed that they could accidentally smack an instrument into someone else's face." (Thompson).*

Perhaps the largest change to a live performance is that absolute perfection is expected. As the hit singer Ada Jones explains "On the vaudeville stage a false note or a slight slip in your pronunciation makes no difference. […] on the phonograph stage the slightest error is not admissible." Because a single performance of a piece lived on forever, a new focus was placed on an artist who could do a "clean take." Unlike a live performance, the mistake is on record forever.


WHAT you want is your kind of music. It may be classical or it may be "rag-time." It may be the "hit" of the latest musical comedy or it may be a selection from "Faust." With the

Edison Improved Phonograph

you can have your kind of music and your friends can have their kind. This wonderful music-maker has no single specialty. It is a versatile entertainer. It produces, with fidelity, the songs of all singers; the music of the masters; the old tunes as well as the popular airs of the day.

"The American Nights Entertainment," a booklet which will suggest many ways of making home more desirable than the club, which will help entertain friends, which will give ideas for money-making programs, sent free on request.

National Phonograph Co.
18 Lakeside Ave., Orange, N. J.

New York London Paris Berlin Brussels Sydney Mexico City

[Full page advertisement in September Magazines.]

More importantly, recordings changed people's relationship with music. Before recordings, one might only hear their favorite song performed once a year when the Louis Armstrong band came to town. Now, "on demand" listening is a reality. As one phonograph ad boasted "the music you want, whenever you want it" (Thompson). The ability to hear the same

song and even the same performance of the song over and over again changed people's relationship with the music. "Previously, you might become very familiar with a song- with its tune, its structure. But you could never before become intimate with a particular performance" (Thompson). Now people could listen to a song and become familiar with every nuance of the recording- a particular jazz solo, a subtle inflection the singer adds, or a certain reverb tail.

As recording technology and media quickly improved through the record, tape, CD, and eventually the internet, the availability and quality of recordings exponentially increased. In popular music, the published recorded performance is often no longer feasible live without the use of pre-recorded tracks. Listeners also expect the live performance to sound as similar as possible to the album they have been listening to ad nauseum. Arguably with the exception of classical music, there is a single version/performance of a song that is viewed as the "gold standard." This same expectation enforced upon pop music has also made its way into the theatrical environment.

Impact of Recordings and Amplification Technology in Theater

Take the hit show Hamilton for instance. In its early years of performances (and arguably still through today), access to this musical was reserved to the privileged few through extremely high ticket prices. During the holiday season in 2017, tickets to the Broadway performance of Hamilton sold for $1,150 (Cox). The popular music present in the show was incredibly popular among the younger audience members who often could not afford to see the show. Their only glimpse into the production was the cast album. I distinctly remember young theater fans having the ability to seamlessly sing along with every word of the soundtrack without ever seeing the actual production. The amount one would have to listen to the recording over and over again to memorize every word and inflection in every song is mind-boggling. It is a certainty that this has created a set expectation of exactly what the show should sound like when they finally see the production live. I believe the design team was highly aware of this reality and made the production sound consistently as close to the soundtrack as possible.

In my interview with Abe Jacobs, we talked a lot about what the introduction of the cast album did to theatrical sound:

> *"In the late 1940s people were able to buy an LP of a Broadway musical that they had seen in the theater, Brought that recording home and listened to it on their record player. And sitting in their favorite chairs, the theater goer and his family would listen to that recording and recreate the magic that they found in the theater experienced a few evenings or weeks before. Today, you can download songs from a yet unproduced musical, listen to it on high quality earphones or home music system and at some future date go to the theater and have us- the sound designer- and the actors recreate the magic you experienced in your head. That I think makes a big difference in what theater going is these days" (Abe Jacob).*

He believes that the narrowing of the gap between imagination and reality is responsible for theater goers expecting to hear exactly what they heard in the cast recording. In Abe's words:

> *"The basic change in the audiences are because of the fact that what audiences retain as a reference is no longer imagination, but whatever they had heard sampled and stored and then reproduced by artificial means […] when you go to the theater, cinema, or opera house, what audiences expect is a sound that they have heard previously by mechanical reproduction rather than sound they heard previously live."*

Abe also brings up a very interesting point in our discussion: "that perception of what something sounds like is no longer your own experience, but somebody else's." As mentioned earlier, when one went to the theater- or any live event for that matter- what they walked away with was the sound that their imagination held on to; and as we know, imaginations are faulty. One would eventually culminate their memories into a hazy portrait of the event that is focused more on the general feeling they had about the performance rather than the details of the audio. This led to one's yearning to experience that feeling again: not necessarily hearing an exact reproduction. The introduction of the cast recording now creates a concrete version of what the listener attaches to and expects. Even with today's sound systems, "it's certainly different to reproduce sound on a pair of headphones or in a home living room than it is in a 1,000 seat theater" (Abe Jacob).

This expectation is in part responsible for bringing the pop music and studio sound into the theater. As composer John Kander explained in a 1995 New York Times article, "Amplification of voices on Broadway has become heavier to compete with pop music. […] Then the orchestra started getting amplified to compete with studio sound and no one could sing over it. The constant increase in sound levels has completely depersonalized musical theater" (O'Toole).

Even today this battle plays out between artistic bodies in a production. After the sound designer spends time with the orchestrator and composer getting the sound of the orchestra just right, the lyricist comes in and says '"I can't hear my words.' So, then we back it off and start all over again. The director comes in and says 'it needs to be louder to be exciting'" (Abe Jacob). This discussion can be seen at all levels of theater and I have experienced it many times at Penn State. In Penn State's production of *Hands on a Hardbody* that I served as the sound designer on, there was a great evolution of the sound as different entities wanted their respective ideas materialized. Similarly, to the discussion that Abe described, after getting the relative sound of the vocals together the music director and I spent a lot of time perfecting the sound of the band. Eventually we found a mix that we really liked and we moved into the first full run with the band and cast. Unsurprisingly, to cleanly hear the vocals without raising the overall amplification levels, I had to back off the level of the band. During the intermission that night, the director approached me and said "It's not exciting enough, everything has to be louder." So, I gave the direction to the mixer to bump everything up. At rock concert levels, suddenly the ears start to behave differently as they grow fatigued to the frequencies needed to understand the human voice. So once again to help the audience in hearing the lyrics, the balance was altered starting the discussion all over again.

As referenced in the "scoring for amplification" chapter, the microphone has greatly changed the quality of the voice found in musical theater today. Since the beginning of recording technology, artists have been finding ways to exploit the sound of the microphone. Frank Sinatra is perhaps the pinnacle example of a symbiotic relationship between his voice and the microphone.

In Glenn Berger's "My 30 Minutes with Sinatra: The Saddest Thing of All", he explains how Frank Sinatra changed the expectations of the voice:

> *"That kind of singing [Opera] seems so false to us today, but at the time it was what was necessary to reach the back row of the great concert halls so everyone could hear the words over the clangorous orchestra.*
>
> *Remnants of that style can be discerned even in early recording stars, like belter Al Jolson, or crooner Rudy Vallee, who preceded Sinatra. You can hear the style changing and becoming more real with a guy like Bing Crosby. Recording made it possible for people to sing in a more natural style because they didn't have to project in the same way. The vocal was amplified electronically on stage, and, at home, we listened with our ears by the speakers and turned up the music as loud as we wanted.*
>
> *Sinatra perfected this possibility. By using impeccable mic technique, and taking full advantage of the recording medium, Sinatra created an intimate effect where it sounded like he was singing only to you, whispering directly into your ear. It is incredibly sexy. In this sense, Sinatra was the ultimate modern vocalist. He changed our sensibility of what vocals were meant to sound like" (Glenn Berger 154-155).*

This change in the voice can also be seen in theater where now the quality of the voice is focused on more than one's ability to project. As sound designer Tony Meola explains "Broadway singers do not get hired for their projection anymore. […] We're producing a generation of non-projectors. My job is to make the non-projector sound like those who do project" (O'Toole). Sound designer Abe Jacobs has a slightly different view. During a seminar with Abe, he explained that actors are responsible for projecting to the first ten rows. Beyond that, he can provide some assistance.

Even with this change, it is important to note that projection is still important even with the inclusion of amplification. Microphones are not magic: they can only amplify a sound so much before running into the laws of physics- gain before feedback and electronic noise. It is often a pet-peeve of sound designers when an actor does not project. During my 2019 summer work at Goodspeed Musicals, a few actors used their vocal amplitude to express an intimate scene. At one point during tech, an actor claims that he can't hear his partner in the scene four feet away. The designer explained how they must still project and there's only so much amplification can do. Although this is an extreme example, the expectations of actors have greatly changed with the advent of amplification.

The advent of amplification and recording technologies have had a tremendous impact on every aspect of theatrical sound from the talent, audience expectations, and technology available. It is the job of the sound designer to embrace these changes and satisfy the needs of all parties involved.

Role of the Sound Designer

The sound designer for any production is responsible for overseeing and shaping everything the audience hears. Similar to the evolution of theater and technology, the role of the sound designer has changed in response to numerous factors and every sound designer views their

roles slightly differently. To understand how the role and abilities of the sound designer have changed, one must look at a brief history of the theatrical sound designer.

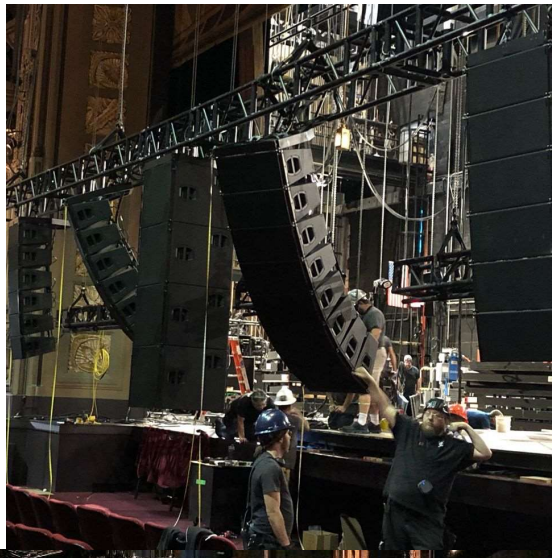
According to Abe Jacob, the sound designer's job was originally parted out to various entities. The stage manager would put together any sound effects needed for the play, the conductor would run through sound checks with the actors (if using area mics), and if a wireless mic was present for the lead actor, the assistant electrician would manage the rudimental sound system for the show. As larger bands and amplified instruments were introduced into the theater, a so-called "sound consultant" was necessary to manage the sound of the band and actors. According to Grant, Saki Oura was "the first person to receive Playbill credit for 'consulting sound engineer' for 1945's *One Touch of Venus*" (Grant). Abe Jacob began his career in concert audio before being brought onto *Hair* as the "sound consultant." After that, people began to realize the impact carefully formed audio can have on a production. According to Abe, "there were a few instances of a sound designer working, but that was again limited until […] I sort of got the first Broadway credit in 1972 with *Jesus Christ Superstar*." From there, the sound designer became a necessity in nearly every modern play or musical.

Sound design is a unique field that requires a vast amount of knowledge in various topics. Just as those in acting talk about the "triple-threat," sound designers must span to some degree the dichotomy of sound design. Sound designers often view their abilities on a spectrum between the artistic and technical. Neither end of this spectrum can act alone: one cannot achieve an artistic masterpiece without some knowledge of the technical elements necessary to achieve the design just as the technical knowledge is rather useless without the ability to use it purposefully to support the show. However, with the sheer size and technical demands of modern Broadway shows, design teams have been created that encompass a range of abilities that work together to achieve the final product. On a standard Broadway production, the sound team will consist of the sound designer, his associate, assistant(s), perhaps an intern, production audio, A1, and A2. Speaking in great generalities, this list spans the artistic-technical spectrum from the sound designer and associate being the most artistically focused to the production audio and A2 who are almost purely technically focused. While the role of the sound designer is split between these different bodies, with the exception of the A1 discussed later, I will group each of their contributions to the show under the generalized guise of the sound designer. For details on these different roles, I would recommend reading chapter three in Shannon Slaton's book "Mixing a Musical."

While each sound designer has a slightly different artistic image, they are responsible for such a vast array of elements. Sound designer Richard Brooker during a seminar sponsored by the Association of Sound Designers described the sound designer as the ultimate communicator. The sound team has to not only coordinate among themselves but with nearly every element of the production including the musical director, musicians, director, actors, stage management, lighting, scenic, and costumes/wardrobe. Not only does the sound designer have to create the sound for the audience, they must do the same for every actor onstage, every musician in the orchestra, and numerous other monitoring systems. The sound designer is also responsible for the communication systems the stage manager uses to communicate with the crew and the video systems that allow

the cast to see the conductor and the stage manager to see the stage. The sound designer has to balance the needs of these various bodies with that of their design.

While not every party involved can always be pleased, it is up to the sound designer to find a solution or diffuse the situation. For instance, every sound designer or A1 has stories about actors demanding to hear themselves onstage like they were singing in a rock concert. For various technical reasons, sending vocals onstage is usually frowned upon by sound designers. This is often hard to explain to the actor whom may have been accustomed to hearing themselves onstage. On the opposite side of the spectrum, there is the actor that demands rock-concert monitor levels onstage. While this can ruin the image for the audience and muddy the sound, it can also be dangerous. In a video conference with Shannon Slaton, he recalls a "star actor" that demanded outrageous monitor levels onstage. Even in a large theater, when the band was removed from the main system, the overall level was still too loud from the stage monitor system alone. During a tap number, he claims that the onstage level reached 110dB. At these levels, it is actually hazardous to one's hearing and the local IATSE union required hearing protection for their backstage crew. Eventually after careful reasoning with the actor, the levels were slowly reduced to an acceptable level.



A large-scale musical will have thousands of devices and miles upon miles of cable that must be specified and managed by the sound team. On a basic level, the sound system is comprised of transducers- devices that turn acoustic energy into electrical energy-, processors that modify the sound, and speakers that turn the sound back into acoustic energy. While most devices fall into these three categories, the complexity involved in each one is truly mind blowing. To the right are a few pictures of the sound system currently deployed on Hamilton in California courtesy of Mike Rukstad. Large scale productions such as Hamilton often have hundreds of speakers, 40+ wireless microphones, hundreds of network devices, numerous computers, and consoles/processors that help manage the audio flow between hundreds of inputs and outputs. It is no wonder sound design teams have expanded greatly in recent years.

However, even with all this technology, the goal of the sound designer remains the same: to bridge the gap between the actor and audience. In response to my assertion that the sound designer's primary goal is to bridge the gap between the actor and the audience in the most natural way possible, Abe Jacob agreed: "it certainly is- to reproduce sound

with the same quality and level as it is at the source whether it be the actor, the musician, or whatever. If you can do that correct, you are correct as far as what sound reinforcement, sound design is. Anything else is a special effect" (Abe Jacob). He later goes on to say "A quite duet onstage needs to be just that; and if you have a sound system that can produce that effect in the last row of the theater, then you've done your job. As I've stated before, the sound design is basically to reproduce in every seat in the venue what it sounds like at the source." While this may sound easy, achieving a natural sound in every seat of the audience is one of the hardest things to accomplish.

Designers today use the many tools available to them to not only make the most natural and transparent sound possible, but to also shape the sound to enhance the show. The current hit show *Hadestown* designed by Jessica Paz does just that. Jessica Paz received a Tony award for her inventive and impactful sound choices. During an online presentation she explained some of the techniques she used in the more unusual aspects of the show. During the earlier West End production of *Hadestown*, she found the natural sound of the automation rather interesting as the stage shifted between scenes. In an effort to make her design as organic as possible, she attached contact microphones to the stage, sent them through a subharmonic synth and other filters to create an earthquake like experience when the stage shifted between scenes. When the show moved to Broadway, she found the American automation equipment to be nearly silent, so she opted to use pre-recorded sounds to create a similar effect. Additionally, she uses many different elements on vocals to make some interesting textures. Using a program called Mainstage, she was able to put any number of effects onto any voice. This ability is most profoundly used whenever a character speaks into the prop microphone onstage. Instantly their lavalier microphone is processed through a slap-back delay, reverb, EQ, and in the case of "Why We Build the Wall," a subharmonic enhancer. Utilizing the technology available today, Jessica Paz and other designers have a vast pallet they can use to shape the sound of the show compared to the limited technology Abe Jacob had in his early career.

As technology only improves, designers will have more "colors" to work with in creating an immersive experience for the audience that not only amplifies the show, but in many cases enhances the story-telling elements. Modern musicals such as *Hadestown, Hamilton,* and *Beetlejuice* use advanced technology and techniques to create a truly unique experience for the audience that could never be replicated outside of the theater environment. In this way, the modern sound designer plays a large role in telling the story and helping the audience connect with the actors and vice versa. Just as the director relies on the actors to execute their vision from night to night, the sound design team designs the elements and system for the show, but it is up to the A1 or mixer to carry out this design every night.

Bringing the Show to Life: The Theatrical A1

The A1 (Audio 1) also known as the head audio, audio engineer, or mixer is responsible for carrying out the designer's vision from night to night. Unlike many of the other technical elements during a show, sound is very unique in that nothing is the same from night to night. While the light board op presses go to bring up a predetermined look, the A1 must create this "look" for every performance. To the A1, no one performance is ever the same. Each night every actor is going to

sing differently, each musician is going to play with a slightly different set of dynamics and tone, and these two groups are often played by different people each night by understudies, swings, or substitutes. Additionally, emotionally and physically the audience can change the energy and literally sound of the show. On a technical side, even the temperature and humidity can have a major influence on the sound depending on the size of the venue not to mention the exact placement of one-hundred plus microphones. While it is up to the A1 each night to balance all these elements, their main goal is to get as close to the original design as possible and to create an enhanced experience for the audience. There is a selection of Shannon Slaton's book "Mixing a Musical" that explains what goes through a mixer's head fabulously well:

> *"The song starts off as a whisper. The orchestration is thin, no more than two violins and a cello. Then it starts to grow. More instruments are added. She stands up. She hits a big note as the orchestra swells and then it all immediately shrinks back down to a couple of strings. Then it starts to build again, but this time there are more instruments, and now she is walking downstage. Lights are coming up all over the stage and the scenery is quickly removed, leaving nothing more than this one actress belting out her song with the orchestra of 24 musicians supporting her. She hits a crescendo note, then a second of silence, and then she explodes into a huge crescendo. The orchestra follows her and the song ends to thunderous applause. It is massive and ear-crushing applause. This is the release of all the emotion in the show. It is bigger than any spectacle in the show, but it also depends on that spectacle to get the audience to the right emotional place. And their reaction is huge.*
>
> *But there is a problem. At the back of the house, in the mix position, the sound board operator for the show sits in absolute silence with his hands on the faders. He is mentally beating himself up over the last song. Sure, the crowd reaction was huge, but he knows it was off. He knows that on a night when it is perfect, he can hear people quietly start to cry after the first crescendo. He knows that when it all goes right, there is a standing ovation at the end of the number. He knows that the applause normally goes on long enough for him to stretch for a second and drink some water before the next scene. But tonight, even though the audience went nuts at the end, he knows he didn't hear anyone get choked up, the audience didn't stand at the end, and he didn't get a sip of water. And he is not happy about it. As he mixes the next scene, he goes back over it in his head. The audience is completely satisfied and they have no idea that anything was wrong, but the mixer has mixed the show over 200 times and he knows. He wants to know what he did or did not do that changed the response. Did he push the big spectacle scene too loud? If he did, that could've left patrons with fatigued ears not ready for the song. Did he start her too quietly? If he did, the audience might have had trouble hearing her at the top, and that may have thrown them out of the moment. Was she too loud at the top? If so, it wouldn't have been enough of a change to set the audience up for the rest of the song. After going over it again and again, he realizes what went wrong. After the first big crescendo he didn't pull everything down enough, so that left him with nowhere to go for the big finale of the song. The audience has no clue, but he knows their reaction could have been bigger"* (Slaton 3-4).

This exact scenario plays out in every mixer's head constantly with the hope that they will get it right the next time.

It is amazing the impact the slightest move the fader can have on a song. For me, one of these moments where every little move mattered was "Send in the Clowns" from *A Little Night Music*. While I could try to explain what I was doing to enhance the song musically, I believe a video speaks greater than a thousand words: (https://youtu.be/kecxPFXRxGA?t=1966). Starting even from the beginning, I was mentally beating myself up over the level of the clarinet entrance. During this performance, it came in way too strong but how could I have known the level the musician was going to play at that particular night? Even so, I have so many thoughts in my head on how to handle this blunder: "Do I go with it and match the vocals?", "Do I correct it on the next phrase?", "How will this impact the next crescendo?", and "Was the audience removed from the moment and how do I turn invisible again?". Throughout the song there are many subtle lifts and falls at the ends of phrases that visually make the audience lurch forward hanging onto every word. Any small mistake can instantly break this barrier that I spent the entire show creating. One night I made a fatal error; during Desiree's lyrics "quick send in the clowns, don't bother their here" the orchestra must be pulled back heavily at the exact right time for their re-attack on "here." Instead that night, I didn't do nearly enough movement and I was instantly jarred back from a very intimate and gentle moment. These are the moments mixers live for where every little move matters and each move could make-or-break the moment.

In this way, many engineers and designers say that the mixer is performing along with the cast every night and perhaps playing a musical instrument. The job of the mixer is complex and busier than the average theater goer could ever imagine. During the entire show they are managing upwards of one hundred inputs, processing, and gauging the mental state of everyone involved. During the show the mixer never gets a break. As the designer of Wicked, Tony Meola explains, "The sound mixer performs every night and there's no break. There's no break between mixing a musical number and mixing a book scene. It's very similar to the operator because they're bringing one mic up at a time. Every line has one microphone on" ("Wicked: Sound."). Because of this, the operator has to get intimate with the script, the orchestration, and all of the actors. The mixer has to be able to connect and read the actors to predict their every move: when are they going to come in? That effects how fast and exactly when I bring their mic up. What kind of energy will they have? That effects how loud I make their microphone for any given word, phrase, or even consonant. In a video with the mixer of Wicked, he explains that "Someone said, you know, It's really nice, you breath with us. I said you know, you're right because if I didn't nobody would understand what you're saying and you really have to know that when they go 'ugh', leave the mic up a little because they're doing that for a reason" ("Wicked: Sound."). They go on to explain how they will often very quickly ride the mic up to capture just the consonant at the end of a word. There are so many split-second decisions a mixer has to make to create a seamless and beautiful sounding show.

Doing a show in some ways is like running a marathon for your brain and fingers. For over two hours you are "on" 100% of the time. You never get a five-minute break to leave the stage like many actors or a book scene to rest like the musicians. As Meola explained earlier, there are

the fewest number of mics "on" at a time as possible. For the mixer, this means that they must turn the microphone on a split-second before an actor speaks and turn it off once the last consonant sounds. Multiply that by over twenty actors onstage, hundreds of lines, and a full orchestra to manage, mixing a show is not an easy task. Turning to videos again, here are two mixing examples from two difficult moments in *A Little Night Music* (https://youtu.be/O_E8mmacfvo) and *Legally Blond* (https://youtu.be/SUj7w9kFqYY). The twelve faders you see the engineer adjusting are called DCAs. These are assignable faders per console scene that can control any number of inputs or microphones. In the examples above, the first eight faders to the left are either individual vocal mics or groups of them. The four to the right are assigned to either reverbs or sections of the orchestra. Primarily using these twelve faders, the engineer mixes the show while adjusting the qualities of individual inputs scattered around the console when necessary. With so many split-second decisions to make, just like actors, mixers can have an "off-night" that greatly degrades the performance the actors are working to give to the audience. That is why many say the mixer is also performing right-alongside the actors night to night.

Mixing is truly an art form that takes a lifetime to master and without their skills, all of the technology and work done by the sound designer would be useless. In this way, it is only proper to include the role of the mixer in a paper about theatrical sound.

Conclusion

Sound has become an integral part of the modern-day musical. At first, the audience reacted negatively to the inclusion of amplification but it has now become a necessary and expected part of any large-scale musical. As technology improves, designers will find more inventive ways to bridge the gap between the performer and the audience member and create immersive experiences unique to the theatrical environment. As theatrical sound continues to find new inventive techniques, so will the orchestration, directors, and the actors themselves. Many go to the theater to escape reality and sound allows that to happen by making the impossible possible.

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