Spring 5-2-2022

The Modern Keyboardist in Commercial Music

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THE MODERN KEYBOARDIST IN COMMERCIAL MUSIC

By
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A RECITAL PAPER

Submitted in partial fulfillment of the requirements for the degree of
Master of Commercial Music
in the School of Music
of the College of Music and Performing Arts
Belmont University

NASHVILLE, TENNESSEE

May 2022

Submitted by Cooper Thompson in partial fulfillment of the requirements for the degree of Master of Music in Commercial Music.

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Chapter 1

Introduction

The keyboard has transitioned from acoustic instruments (organ, harpsichord, piano) to electronic instruments (synthesizers, samplers) to the modern standard interface for producing music (MIDI controller for Digital Audio Workstations, or DAWs) over the past 450 years (Pressing 1992). In particular, the onset of synthesizers in the late 1960s and 1970s brought entirely new sounds, textures, and timbres to commercial music. These sounds expanded the boundaries of the keyboardist's function, similarly to the changes brought about by the emergence of the electric guitar with its wide range of expressive devices and tone pedals. Armed with new possibilities, the keyboardists' role in song arrangements expanded. New timbres, sounds, and textures allowed the keyboardist to function in numerous ways at any given time: background pads for thick texture, sparkling synthesized "ear candy", synth bass for extremely low pitches, rhythmic stabbing synths, and more. In this paper, I explore many of these sounds and discuss their impact on commercial music. I discuss three main aspects for each sound used in my recital program: first, a brief history of the instrument; second, how the sound contributed to the overall arrangement of the song; and third, a closer look at how that sound could be replicated today to aid new keyboardists in recreating these iconic sounds.

It is essential that the modern keyboardist grasp the general history and evolution of keyboard instruments over the last 450 years. Beginning with the harpsichord and clavichord in the fourteenth century, keyboard-based instruments began to grow in their dynamic and timbral capabilities. The piano marked the next milestone in keyboard development, which gave the performer larger dynamic control over each note (the full instrument name is “fortepiano,” which means “loud-soft.”) The twentieth century saw an immense increase in the experimentation and invention of new keyboard instruments, from the Hammond B3 organ to the Fender Rhodes to early Moog synthesizers. Synthesizers have been an integral part of commercial music since the early 1970s (Jenkins 2007). The types of instruments used and the sounds that they generate have only increased since that time (Vail 2000). For each of the instruments used in my recital, I investigate the actual instrument used on the recordings by researching the keyboardist who played on the record as well as their primary gear that they used on the recordings. I also provide a brief overview of the specific instrument used, its features, and its function in the industry.

A primary function of the modern keyboardist is to contribute thoughtfully and skillfully to the overall arrangement of the song. Keyboards today have an incredibly wide variety of sounds available to them, and each of these sounds can be used to promote the arrangement. Each of the songs in my program included prominent keyboard parts on the original recordings that contributed greatly to the commercial success of each recording. The keyboard parts often functioned in various meaningful ways, including as a lead rhythmic instrument, a prominent texture, background colors, or melodic hooks. This paper examines the usage of each sound and how it contributed to the arrangement of these very successful songs.

The modern keyboardist must also be thoroughly well-versed in the skills needed to replicate these iconic sounds, as well as having the ability to use those skills to create new sounds. Today's professional keyboard workstations are equipped with a variety of sound generation tools, including additive synthesis, subtractive synthesis, wavetable synthesis, frequency modulating synthesis, and sample playback (Jenkins 2007). It is crucial for the modern keyboardist to understand these methods of sound generation in order to capture the sound that he or she desires. For each of the sounds in my paper, I discuss the parameters and settings that could be used to recreate the sound today, including parameters such as ADSR, LFOs, cut off filters, oscillators, and more. These recreations are primarily executed on a Nord Stage 3 keyboard. Research of the actual settings used in the recordings has also been conducted by searching for interviews with the musicians as well as through hands-on experience with the specific instruments (when possible) to attempt to recreate the sounds.

This paper combines the knowledge and understanding of the history of keyboard instruments, arrangement techniques, and the re-creation of iconic sounds in order to equip the modern keyboardist to successfully function in the commercial music industry. This paper will also demonstrate the enormous and lasting impression that the keyboard has had on commercial music.

Chapter 2

Piano

The piano is the most well-known keyboard instrument of all time, and it is a pinnacle of hundreds of years of mechanical development of keyboard instruments. Pipe organs were among the first keyboard-based instruments with other instruments, such as the harpsichord and clavichord, soon to follow. Prior to the invention of the piano, keyboard instruments were largely mono-dynamic and therefore only capable of producing one volume or dynamic level. Around the year 1700, Bartolomeo Cristofori invented the foundation of what we now know as the piano, which was originally named "fortepiano" (literally "loud and soft"). Although the production process and mechanical precision has developed since the 1700s, the inner workings of the piano have remained the same.

Six songs on my recital program use piano on the original recordings, and the piano is the lead instrument on two of these songs. In both "Overjoyed" and "The Way It Is," the piano serves the same arrangement function of lead rhythmic, harmonic, and even melodic instrument. The pianists, Stevie Wonder and Bruce Hornsby respectively, both play full chords with rhythmic density appropriate to their songs. They also use the piano as the main melodic hook instrument by doubling the vocal melody and playing turnaround hooks. These two songs are excellent examples of using the piano as a lead instrument. Another song on my program, "Fortune Smiles" by Keith Jarrett, features an extended solo piano introduction. In the 1971 recording, Jarrett plays the B section of the tune repeatedly with many embellishments and rhythmic intensity before the band joins in at the top of the song form. During the sections that follow, Jarrett drops back to textural comping while the band plays the main melody.

The next two songs on my program that feature the piano are “September” and “Sing A Song” by Earth, Wind & Fire. As with “Overjoyed” and “The Way It Is,” the piano serves the role of lead harmonic and rhythmic instrument during the verses of the songs. However, unlike “Overjoyed” and “The Way It Is,” the piano does not cover any melodic functions. Instead, the piano remains in the mix as a texture when not providing harmonic content during the verses.

The final song on my program that employs the piano is “It’s Not All About You” by Lawrence. Clyde Lawrence uses the piano uniquely in this song by playing primarily unison lines with the bass and other instruments, generally in the piano’s lower octaves. This use of the piano causes it to function more like the bass guitar as a rhythmic and driving instrument. The most unique aspect of Lawrence’s piano part is his use of a compression effect on the piano. Compression flattens a signal’s volume level by boosting the quiet parts and softening the louder parts. When used to an extreme, compressors can also artificially remove the natural attack and decay of an instrument. Lawrence’s use of compression alters the piano’s sound to be more like the bass guitar’s sound, which is the instrument that it doubles throughout most of the track. This alteration extends the piano texture through the bass guitar’s sustained notes, which creates a unique sound throughout the song.

The replication of a piano sound in the modern commercial keyboard world is different from the replication of the other instruments discussed in the following chapters of this paper. Piano sounds in keyboards play back recorded samples of real pianos, and the keyboardist usually has limited options when modifying these samples. However, certain setups allow for more detailed modifications to the sound. Three main setups exist for recording and playing piano. These setups include playing a real piano (recorded using microphones), playing electronic keyboards, and playing virtual instruments through MIDI and computer software. Each method has distinct advantages and disadvantages in both studio and live performance settings.

Properly recording a real acoustic piano is the most effective method of capturing the nuances of the piano's sound. Microphones can record every overtone and mechanical sound (including pedal noise) on the instrument. Unfortunately, using an acoustic piano in a live performance setting can be quite difficult. The number of microphones allotted for the piano in live performances is usually limited, and many acoustic sacrifices must be made in order to avoid feedback in the sound system (closing the piano lid, applying effects to the signal, etc.). Athough it is possible to mic an acoustic piano for a live performance setting, using a high-quality keyboard is often preferred in order to avoid feedback and to simplify amplification.

Keyboards with built-in piano samples have the distinct advantage of offering a zero-feedback and zero-noise signal for live performances. High-quality keyboards will often sound as good or better than an acoustic piano during live performance due to the difficulties and complexities of amplifying acoustic pianos. In addition, the keyboardist may apply various effects to the piano sounds such as delay, chorus, compression, and equalizers. When recording in the studio, however, keyboards do not offer as "real" of a piano sound as can be achieved by properly recording an acoustic piano. Keyboards are limited to stereo signals, whereas any number of microphones may be used on an acoustic piano. Electronic keyboards are also limited by the number of velocity layers, sample size, overtone algorithms, voice polyphony and more. Because of the simplicity of amplification and available effects, keyboards are well-suited to live performance settings but lack the nuances of recording when compared to an acoustic piano.

The third option for producing piano sounds for both recording and live performance situations is the virtual instrument. Virtual instruments (VIs) are often extremely large and complex sound libraries with thousands of samples that provide substantially more realism and accuracy to the original instrument than built-in keyboard sounds. High quality VIs are capable of replicating an immense range of recording setups pertaining to the exact piano from which the library was created. These setup options include the ability to adjust lid positioning, mic positioning, room noise and reverberation, room size, listeners' perspective, and more. This precision comes at the cost of digital storage size: VI piano libraries are often in excess of one hundred gigabytes of storage and require a very powerful computer to process the data. Due to the limited storage capacity and the possible unreliability of computers, VIs are not generally used for performance scenarios. VIs excel in controlled recording environments, such as home studios, and their relatively low cost (usually ranging from $100-500) is affordable for the average user.

Chapter 3

Fender Rhodes and Wurlitzer Electric Piano

The Fender Rhodes piano and the Wurlitzer electric piano are both electromechanical keyboards. Both instruments use mechanical elements to generate sound and electronic elements to amplify that sound. Because of these similarities, their respective sonic qualities are somewhat similar, although each instrument has its own unique and defining characteristics. The Rhodes piano (hereafter referred to as Rhodes) uses hammers to strike thin metal tines, and a pickup system converts the sound into electricity and transmits it to external speakers for amplification. The sound of a Rhodes, like an electric guitar, can be heard at very low volume without amplification. The Wurlitzer piano (hereafter referred to as Wurlitzer) uses hammers to strike metal reeds that induce electrical current into its pickup system. Unlike the Rhodes, a Wurlitzer cannot be heard without amplification. The specifics of both instruments will be discussed in more detail throughout this chapter.

The Rhodes was invented by Harold Rhodes to aid in soldiers' recovery from World War II, and the instrument saw great commercial popularity starting in the 1970s. The Wurlitzer was invented by Benjamin Miessner in 1954 and was produced over the span of thirty years. The Wurlitzer was most commonly used as a portable replacement of an acoustic piano for traveling musicians, which eliminated their need to rely on the often poorly-maintained pianos owned by the venues.

My recital program features a Rhodes on four songs and a Wurlitzer on one song. The Rhodes is used on “Rock With You” and “P.Y.T.” by Michael Jackson, and “Isn’t She Lovely” and “I Wish” by Stevie Wonder. The Rhodes functions very similarly in each of these songs by providing harmonic texture comparable to that of a synth pad. The keyboardists mostly played sustained chords that allowed the full tone of the Rhodes to ring. In “P.Y.T.,” the Rhodes can also be heard following the rhythmic pattern of the band during the choruses of the song. These shorter, louder notes punch clearly through the mix. Stevie Wonder plays all keyboards, including Rhodes, on his hit songs “I Wish” and “Isn’t She Lovely.” Wonder played sustained chords in “Isn’t She Lovely” as similarly used in the Michael Jackson tunes. The unique element of Wonder’s playing on “I Wish” is the doubling of the bass guitar line, adding the Rhode’s special timbre to the repeated riff. He also adds rhythmic interest with short percussive chords throughout the song.

In “Shining Star,” the biting tone of the Wurlitzer is heard very clearly immediately following the introduction by the electric guitar, and the same musical figure is played throughout the first verse. The keyboardist uses the Wurlitzer as a rhythmic accompaniment to the overall funk groove with a short, repeated figure. The chorus of “Shining Star” also highlights the Wurlitzer’s unique tone, which is placed in the right side of the stereo field.

Authentically replicating a Rhodes or Wurlitzer in the modern keyboard era is straightforward with professional-grade keyboards and virtual instruments. As discussed in the piano chapter, the most authentic sound will come directly from the real instrument. However, digital alternatives in keyboards and virtual instruments are abundant and feature extremely detailed sound samples that provide high-quality replication.

Rhodes and Wurlitzer virtual instruments are less complex to create than acoustic pianos because they do not require microphones to capture the sound: the built-in pickups, an important quality to their respective sonic characteristics, transmit the signal directly to recording interfaces for sampling without the factors of room size, acoustics, and more being taken into account. Because of the increased simplicity of sampling, Rhodes and Wurlitzer virtual instruments are more widely available and largely high-quality by nature. An important element of professional-level sound libraries is the ability to adjust the settings and effects originally found on these instruments including vibrato, tremolo, and tone. The ability to adjust these parameters is essential in order to accurately replicate the instruments and should be desired when choosing a keyboard or virtual instrument to replicate either instrument.

Professional keyboards (such as the Nord Stage lineup) feature exceptional high-quality samples of various models of Rhodes and Wurlitzers. These samples include many “velocity layers” which allow the player a wide range of dynamic articulation. For example, an instrument with five velocity layers means that each key of the instrument was recorded at five different dynamic levels, while an instrument with eighteen velocity layers includes eighteen recordings per key, which allows much more precise dynamic control. Additionally, the previously mentioned effects, such as vibrato and tremolo, can be applied to these samples within the keyboard as originally found on the real instruments. These factors, combined with practiced articulation and technical ability, all contribute to creating an accurate representation of the original Rhodes and Wurlitzer.

Chapter 4

Clavinet

The Hohner clavinet is an electromechanical keyboard instrument that debuted in 1964. The instrument produces sound by striking strings with metal blades similarly to the action of an acoustic piano. However, the metallic nature of the blades exaggerates the attack of notes played: the harder the keys are struck, the more attack is heard and greater volume is produced. All sounds are amplified by pickups inside the clavinet and transmitted to external amplifiers for a more usable volume level. The sound of a clavinet is most often compared to an electric guitar. It is capable of both cutting through the mix with melodic phrases and of laying down a funky rhythmic foundation. The clavinet is also the rarest instrument discussed in this paper. It is estimated that about 25,000 clavinets were produced between 1964 and the late 1980s, which equals approximately seventeen percent of the number of Rhodes electric pianos ever manufactured (Lenhoff 2019). Hohner produced multiple versions of the clavinet during this time frame. Stevie Wonder used the Clavinet C on his famous hit “Superstition,” a song that is forever associated with the clavinet.

Three songs make use of a clavinet on my recital program, and each employs the clavinet in a very similar function. “Coffee Break is Over” by Dirty Loops and “Superstition” and “Higher Ground” by Stevie Wonder all use the clavinet as the driving harmonic and rhythmic force. Dirty Loops’ keyboardist, Jonah Nilsson, plays a clavinet sound for the song's verses, during which the clavinet is the only harmonic instrument present. Nilsson revolves around a two-bar riff played in a short, detached manner, and this riff locks into the drum pattern and bass line to form a cohesive funk/rock groove. However, Stevie Wonder preceded Jonah Nilsson by many decades in using a clavinet as a primary instrument, and he is, perhaps, the artist most associated with the instrument.

"Superstition" is the most widely recognizable use of a clavinet in recorded music (Lenhoff 2019). The opening riff of the song immediately following the four-bar drum introduction is the most iconic example of a clavinet. Wonder recorded multiple layers of clavinet throughout "Superstition" to create an intricate mix of rhythms. Some added effects, such as delay and reverb, can be heard on the record, but otherwise the sound is a fairly untouched clavinet model C (released in 1968). "Superstition" was released in 1972, and the following year Wonder released "Higher Ground" which also featured his clavinet. Another highly recognizable two-bar riff starts the song and is maintained for its entirety. Stevie Wonder elected to process the "Higher Ground" clavinet through the Mu-Tron III filter pedal, known as the world's first envelope-controlled filter (Lenhoff 2019). This "wah" sound was used by many funk musicians and has remained a signature sound since the 1970s. Both "Superstition" and "Higher Ground" are iconic examples of the clavinet being featured in commercial music.

In the modern keyboard world, creating a high-quality replication of the clavinet is slightly more challenging than replicating pianos, organs, and other synths. In the consumer-level keyboard industry, clavinets are not highly sought after as part of the digital keyboard. When these consumer-level keyboards do include a clavinet sample, they are often extremely limited in expressive range and tonal quality. The best clavinet samples are currently found in Nord keyboards or, in virtual form, from companies such as Waves Plugins. These professional methods of replication include details such as the ability to emulate the various pickup selection options and timbre.

Several factors are important when considering how to replicate a clavinet. The first important element to consider is amplification. The original clavinet instrument was created with the intention of being amplified, and the amps that were used often had their own tone settings and adjustments. Intentional use of an amp (or digital replication of an amp) is essential to replicating a clavinet. Additionally, processing effects such as wah, chorus, reverb, delay, overdrive, and more are frequently paired with the clavinet to create a sound that emulates an electric guitar. The final and perhaps the most important aspect of replication is the keyboardist’s technical ability, skill, and execution. Similarly to the piano, the clavinet is capable of dynamic contrast. However, playing harder is not only equivalent to more volume. A greater dynamic-to-tonal contrast exists in an amplified clavinet than in an acoustic piano. The keyboardist’s touch is crucial to generate the desired tone and articulation. A clavinet will respond very differently than a piano when played with extremely detached staccato notes, producing a tone that “bites.” The clavinet is also capable of greater sustain than an acoustic piano due to the electronic pickups amplifying the signal. The player must also increase focus on their articulation due to the lack of a sustain pedal on a real clavinet. The choice of amplification, processing effects, and articulation are extremely influential to the authentic replication of a clavinet.

Chapter 5

Hammond B-3 Organ

The Hammond B3 organ is the most common model of organ used in commercial music. Mark Vail states that ". . . the Hammond tone-wheel organ, epitomized by the B-3, is the most loved, respected, and recorded keyboard instrument – outside the acoustic piano – in history" (Vail 1997). The Model B-3 was first manufactured by the Hammond Organ Company in 1954 and remained in production until 1975. B-3s that were produced during this timeframe are now considered to be the original Model B-3. In the late 1990s, Hammond released portable versions of the B-3, and in 2002, Hammond re-released the original B-3, with one small but crucial difference: the inclusion of digital technology. The first B-3s were electromechanical and used electricity to move physical parts called tone-wheels to produce sound. B-3 organs that were produced after 2002, however, began reproducing the sound digitally, which cut down manufacturing costs and reduced product weight (Hammond Company n.d.). Although tonal qualities between the electromechanical vintage B-3s and newer digital B-3s are extremely similar, if not indecipherable, understanding the mechanical differences between iterations is essential when purchasing the instrument and replicating its sound.

The Hammond B-3 did not achieve the fame for which it is now credited on its own. Another essential invention was almost always paired with the B-3 to give it the sound it is known for today: the Leslie speaker cabinet. Developed by Don Leslie, this

110-pound cabinet employs a speaker assembly that rotates at various speeds to apply a doppler effect to the B-3's otherwise static sound. The rotational speed can be adjusted during performance, which gives the B-3 a large range of expressive abilities.

Two songs on my recital program use the B-3 organ. The first is "It's Not All About You" by Lawrence. Clyde Lawrence orchestrates the keyboard parts for "It's Not All About You" with great precision and detail, forming the majority of the harmonic content with only keyboards. The B-3 plays a small but significant role in the arrangement of this song. One may not notice the presence of a B-3 during the first few listens to "It's Not All About You." The first entrance occurs at 1:47 on the original record and it is very faintly audible in the left side of the mix. More noticeable is the glissando slide down which occurs at 1:51. Throughout the rest of the track, Clyde Lawrence uses the organ in similar ways, often sliding into or out of the downbeats of phrases or sustaining single, very high notes for many measures at a time. The slides into and out of phrases help to accentuate the form of the song and arrangement by adding emphasis to these phrases. Sustained, higher notes add extra energy and vibrance to the arrangement. Both playing methods contribute to the overall arrangement by further elevating the end of the song.

To successfully replicate a B-3 sound, the keyboardist must understand the function of the organ's drawbars, which are the foundation of creating organ tones. These drawbars, which are physical sliders on a real B-3, control which overtones are heard when a note is depressed. For example, in Figure 1, the drawbars are all the way down, which indicates that all overtones are sounded at full volume. Figure 1 indicates which harmonics or sub-harmonics are being sounded for each drawbar when middle C is played.

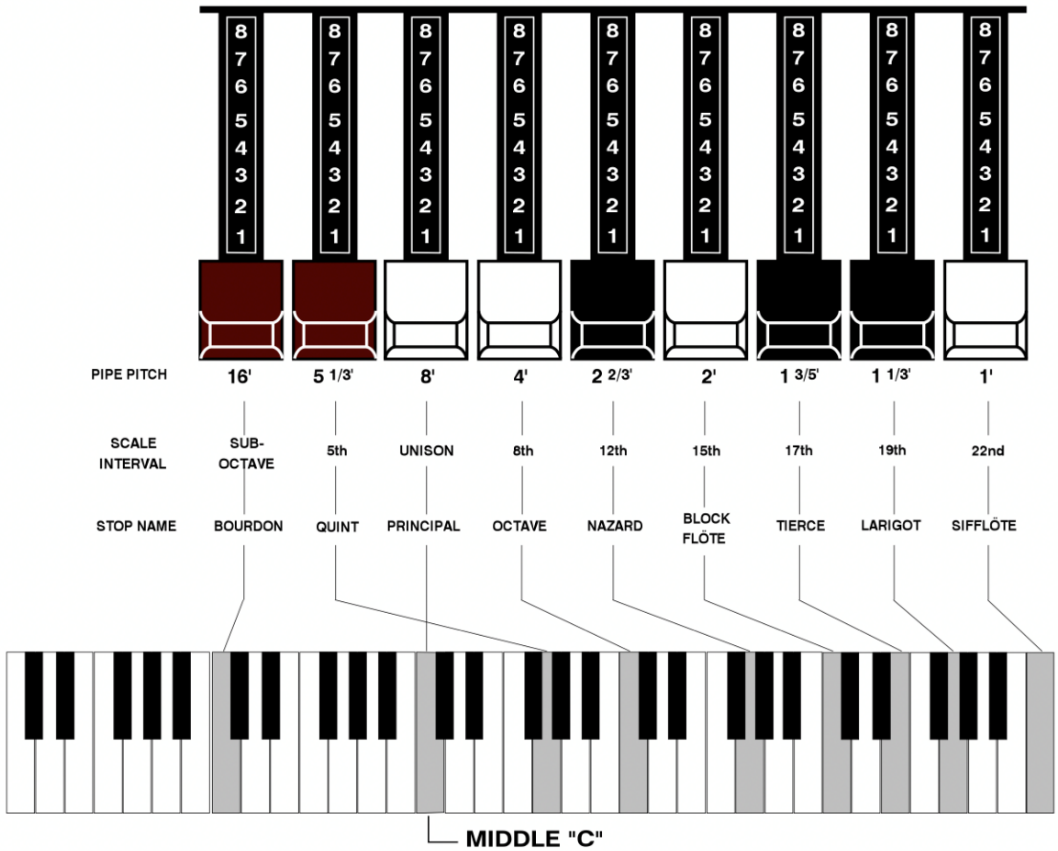

Figure 1. B-3 Harmonics (Hammond Organ Company User Manual)

Figure 2 shows a replication of the organ sound for “It’s Not All About You” on a Nord Stage 3 with standard drawbar controls and vibrato added. Additional “percussion” effects are available to add punch and attack to the sound. However, due to the high range of the organ part in this song, the percussion effects were not needed because they are most noticeable when the middle and lower registers are played. As shown in Figure 2, not all of the harmonics were needed to replicate the sound of the organ in this song. The tone of this organ can be described as thin and slightly nasal sounding. The Leslie rotary speaker remains on the fast speed for most, if not all, of the song.

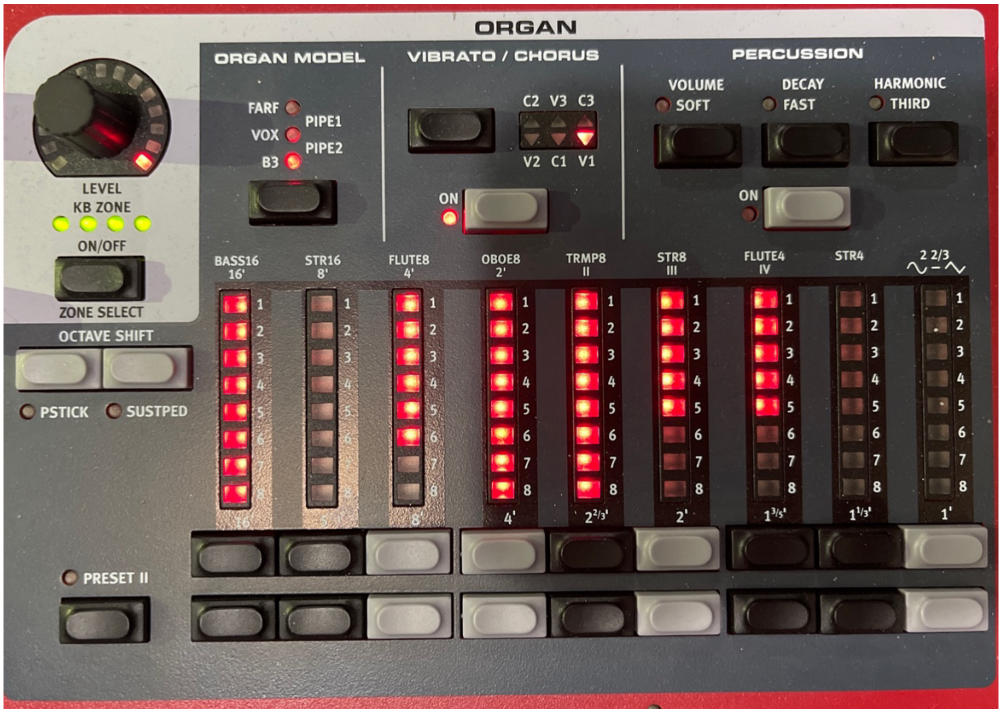

Figure 2. “It’s Not All About You” Organ

The second song that features an organ on my program is “Coffee Break Is Over” by Dirty Loops. Unlike “It’s Not All About You,” “Coffee Break Is Over” uses the organ as a primary instrument: it is one of two harmonic instruments on the record (the other is a clavinet), and it is also the lead melodic instrument for most of the song (choruses, bridge, and solo section). The organ is extremely rhythmically active. Jonah Nilsson who plays keyboards in Dirty Loops, has mastered the technical ability of playing very staccato chords in quick succession without straying from the grid of sixteenth notes. Nilsson also demonstrates a thorough improvisational skillset during the solo section that follows the bridge of “Coffee Break Is Over.” The main functions of the organ in this arrangement are to project the melody clearly over the bass and drums and to solo for an extended period of time.

Figure 3. “Coffee Break Is Over” Organ

Figure 3 shows the parameters used to replicate the organ tone for “Coffee Break Is Over.” Percussion effects are in full use, which gives the midrange a bite and punch to Nilsson’s comping patterns. The Leslie speaker is generally moving at a slower pace, with periodic switches to fast rotation during the solo section.

The B-3 organ is a highly effective and energetic instrument and is capable of producing over 134 million unique tones using only the drawbar combinations. However, this tonal freedom can be daunting to navigate when seeking to replicate a sound. There are three important steps to replicating B-3 sounds effectively. The first step is to understand the timbre and tone of every drawbar and effect available by repeatedly experimenting with and taking detailed note of the sounds that are created by each one.

The second step is to listen extensively to the sound to be replicated and to strive to grasp every nuance of the sound's texture. The final step is to merge the first two steps: use the tools available (drawbars and effects) to recreate the sound from the ground up. Successful replication will occur much more quickly when the keyboardist fully understands how each drawbar and effect changes the sound and fully comprehends the target sound and its tonal qualities.

Chapter 6

Synthesizers

The first synthesizer was invented by Harry Olson and Herbert Belar in the 1950s under the Recording Corporation of America (RCA). This instrument was enormous, somewhat limited in its synthesis abilities, and it relied on hundreds of vacuum tubes and mechanical punch cards to create sound. Throughout the late 1950s and early 1960s, more synthesizers were created and the instrument began to increase in popularity. Robert Moog created the Moog synthesizer and debuted the instrument in 1964. Moog is credited with inventing the foundational elements of analog synthesis, and the Moog synthesizer is considered to be the first commercially viable synthesizer. A huge growth in digital synthesizers occurred in the 1980s with the release of the Yamaha DX7. The DX7 is the best-selling digital synthesizer of all time with over 200,000 units sold. Many models of synthesizers have been created and used by numerous popular artists, and each instrument relies on the same methods and concepts of creating sound.

The methods of sound synthesis are numerous and can be extremely complex. Because of this complexity, many books and sources have explored each method and its finer details in great length. Rather than discuss individual synthesizer instruments in detail, this chapter focusses on the most common method of sound synthesis used in today’s modern keyboard instruments — analog synthesis — and relates it to popular keyboards. Discussion of the various musical uses of these sounds are also included;

additionally, the pertinent tools, controls, parameters, and concepts are expounded upon as they relate to modern keyboards. A few other notable methods of synthesis are also referenced. One may determine their own keyboard's synthesis method(s) by referencing the owner's manual or product description.

The core foundation of analog synthesis begins with waveforms. A waveform is a generated electrical signal that oscillates back and forth to create sound. The shapes of these waveforms affect the sound that is heard when amplified through a speaker. Many variations of waveforms have been created, each deriving from four main waveforms: sine, square, triangle, and sawtooth. These four waveforms are named from the shape that they resemble when shown on a graph, as seen in Figure 4.

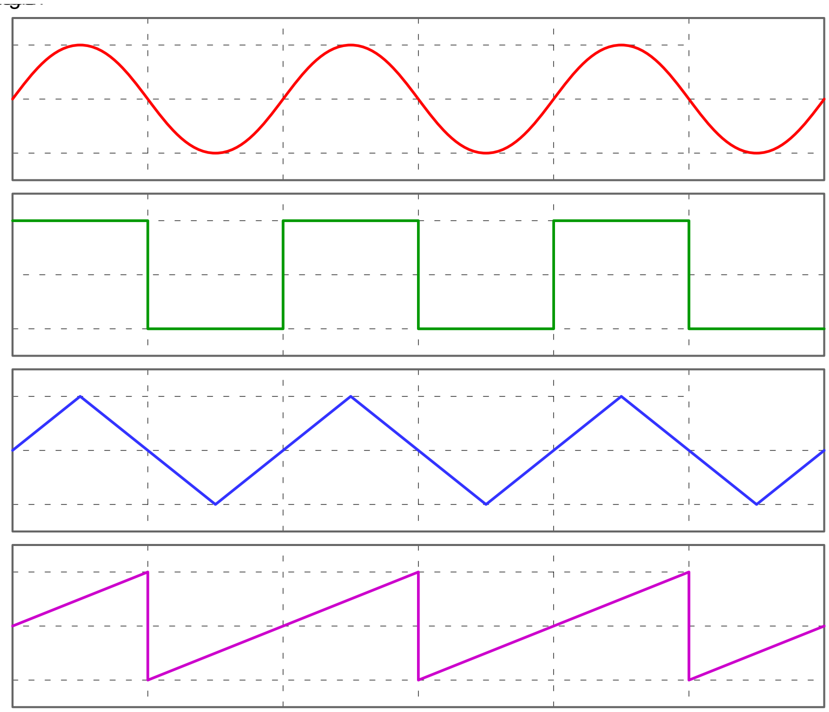

Figure 4. Four Basic Waveforms

Each of these waveforms has a distinct and unique sound which is corelated to the harmonics and overtones that are generated by the waveforms. The sine wave is the most basic waveform. It is a pure tone with no harmonics or overtones and the only pitch generated is the fundamental frequency (for example, 110Hz, A2 on the piano). Harmonics are frequencies that are whole-number multiples of the fundamental frequency (220Hz, 330Hz, 440Hz etc.). For example, the triangle and square wave generate odd-number harmonics along with the fundamental frequency — if the fundamental frequency is 110Hz, the third (330Hz), fifth (550Hz), seventh (770Hz) etc. harmonics are generated All of these waveforms can be used, often in combination with each other, to generate the desired sound in a synthesizer.

Once the desired tone is created with the desired waveform (or mix of multiple waveforms,) the next important step in the synthesis process is to shape the sound with an ADSR modulator. This device modulates or controls the level of signal produced across time with four main parameters: attack, sustain, decay, and release (ADSR). The graph of this function is shown in Figure 5.

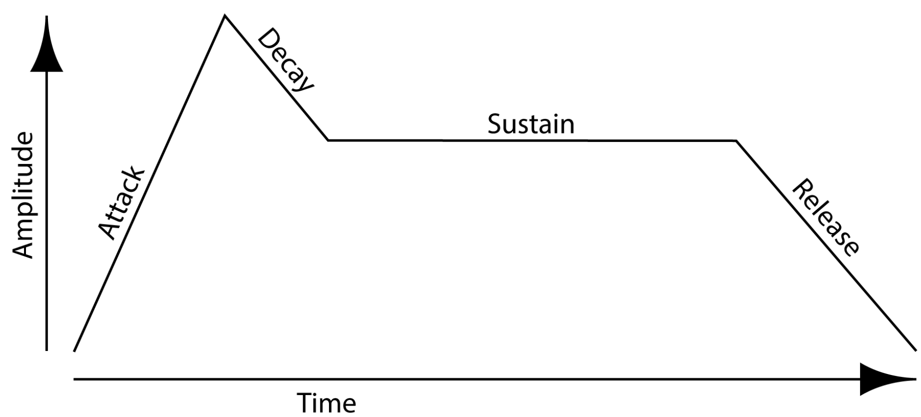

Figure 5. ADSR Envelope

Each value is usually measured in milliseconds (ms). Attack indicates how much time is required for the sound to reach full volume. The value of decay begins after the attack has finished and indicates how long the sound softens before reaching its next value, sustain.

Sustain determines how long (and how loud) the sound may continue to be generated, and the release value determines the time needed for the sound to fully stop after the key is released. If the key is released during or prior to any of the first three parameters, the ADSR modulator immediately moves to the release phase. ADSR modulators are often referred to as amplification (amp) envelopes because they control the amplitude of a given signal (like an envelope opening and closing). Amp envelopes allow for the given tones to be extensively shaped as punchy, percussive, smooth, legato, and more.

Once the waveform(s) are generated and the sound is processed through the amp envelope, the next crucial element of synthesis is the frequency envelope. The frequency envelope controls the levels of frequencies generated across the audible spectrum by the sound source — in this case, the waveform(s). This control is achieved using frequency filters. A few of the most common frequency filters are shown in Figure 6.

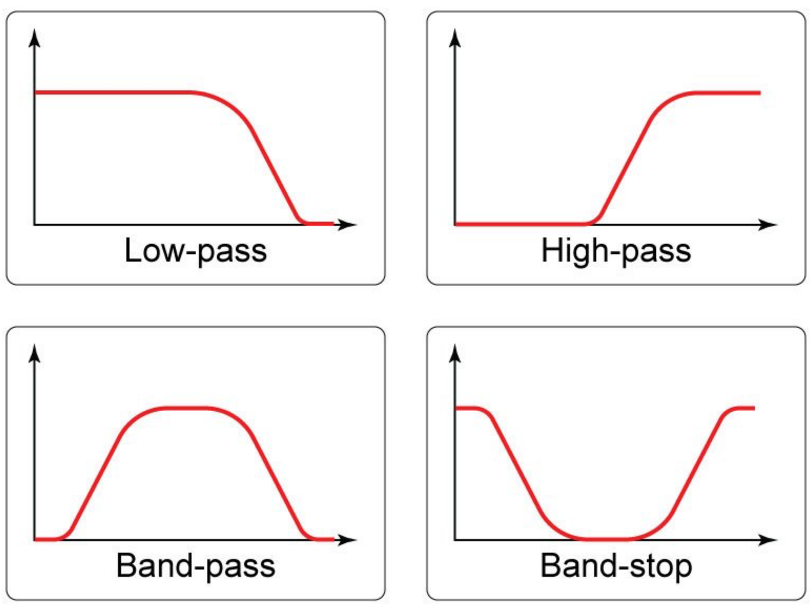

Figure 6. Filters

These graphs represent amplitude (y) over frequency in hertz (x). The crucial parameter within a frequency filter is the cut-off. The cut-off is assigned to a frequency value and used to determine where the filter begins to take effect in the frequency spectrum. For example, a low-pass filter with a cut-off at 1,000Hz allows all frequencies below 1,000Hz to "pass" and begins to attenuate (or lower) the amplitude of frequencies above 1,000Hz. A high-pass filter allows frequencies above the cut-off point to pass and attenuates the frequencies below the cut-off point (the opposite of a low-pass). Band-pass and band-stop contain two cut-off points and these points either allow (band-pass) or stop (band-stop) frequencies within that range to be heard. All filters reduce frequencies using their parameter of a cut-off point; however, filters do not *add* level to any given signal — they only remove unwanted frequencies. This concept is a key component of subtractive synthesis: waveforms produce sound across the entire frequency spectrum, and that sound is processed and subtracted from in order to create the desired outcome. Subtractive synthesis is the most common form of sound synthesis due to its relative simplicity. Other forms include additive, frequency modulated (FM), and wavetable synthesis.

A few other factors are important to consider when creating a sound that are particularly relevant when purchasing a synthesizer. Choosing an analog or a digital instrument is an important choice and each has advantages. A truly analog instrument relies on physical knobs, buttons, and switches to control its various parameters and, because of this, analog instruments are often very limited in their ability to save and recall a specific setting or program. Digital synthesizers rely on carefully-constructed algorithms to recreate the analog waveforms and process them with digital replications of the previously-mentioned elements such as amplitude and frequency envelopes. The digital technology allows the instruments to save, recall, and modify settings with great ease at the sacrifice of the "authentic" analog sound that is created without digital aid.

The sound produced digitally and the sound produced by analog are, in reality, extremely similar when using a modern professional digital synthesizer. Because of this level of quality, a digital synthesizer is most commonly used when touring or playing in live performance settings. Analog synthesizers offer a more in-depth and nitty-gritty approach to synthesis; as a result, these instruments are still found in studios and in personal collections.

Synthesizer polyphony is another important feature to consider when purchasing a synthesizer. Synthesizers are either monophonic or polyphonic. Monophonic synthesizers can create sound for one single note at any given time. If another note is played (or multiple notes), the synthesizer generates sound for the last note pressed. Polyphonic synthesizers are capable of producing sound for multiple notes simultaneously, and the number of notes available is given as a voice count (two-voice, eight-voice, sixteen-voice etc.). Playing a monophonic synthesizer requires additional focus to the keyboardist's touch, but also allows the keyboardist to play in ways that are not possible with polyphonic instruments. Most modern synthesizers are capable of both monophonic and polyphonic sound generation, and the ability to switch between modes is a greatly-desired feature.

Synthesizers can produce a very wide range of sounds, textures, timbres and sonic qualities. The effective use of a synthesized sound in a song's arrangement can contribute greatly to the success of that song. My recital program features many types of synthesizers, and each can fall into one of four categories: synth leads, synth pads, synth basses, or rhythmic synths.

Synth leads are, first and foremost, sounds that are designed to cut through the mix of the song. However, synth leads do not necessitate a harsh or piercing sound — the sound may be soft and smooth, but it is played in a frequency range that no other instrument occupies. These sounds are usually played as single-note lines and melodic hooks and can become as iconic as any guitar riff — the opening synth lead line to Michael Jackson's "Rock With You" is an example of both a smooth synth lead that cuts through the mix as well as an iconic riff or hook. A synth pad is most often used to describe an underlying texture that follows the song's harmonic progression with a thick and generally warm sound. These sounds are almost always played as full chords that are sustained and connected to each other in a legato manner. Synth basses are similar to leads in that they are predominately single-note lines, but differ in that they are played in the bass frequencies. These synth basses often function as a substitute for the typically-used electric bass guitar and are played in a similar fashion. Certain technical abilities are allowed a synth bass that a bass guitar cannot replicate, such as indefinite pitch bending, monophonic pitch alternation, and pitch-gliding between notes.

Another category of synthesized sound to consider is that of a rhythmic synth. This broad category includes a variety of sounds and functions, each with its own inseparable rhythmic element. For example, the chordal synth sound heard on Michael Jackson's "Billie Jean" is a rhythmic synth — although the sound's texture resembles a pad, it is played in a short and detached manner, removing it from the synth pad category. The sound's defining characteristic is the rhythmic ostinato, placing it firmly into the rhythmic synth category.

The synthesizer is one of the most versatile instruments that exists. It can produce a wide range of sounds and textures by combining waveforms with amplitude and frequency filters. These sounds can be used to serve a the arrangement of a song in many ways including as a lead instrument, pad, bass, or rhythmic element. The modern keyboardist has a wide variety of synthesis options available, each with its own unique sound and history. An understanding of sound synthesis is crucial for the modern keyboardist.

Chapter 7

Conclusion

The keyboard is an essential component of the commercial music industry as we know it today. A wide variety of keyboard instruments are heard on some of the most popular songs and are played by some of the most popular artists. The piano, B-3 organ, clavinet, Fender Rhodes, Wurlitzer electric piano, and the synthesizer are the most prevalent keyboards in commercial music. Each instrument has unique sonic qualities and arrangement functions. The modern keyboardist must be knowledgeable of each of these foundational instruments and their history, operation, and usage. By combining this operational knowledge, the ability to create and recreate sounds, and relevant technical skills and musicality, the modern keyboardist remains a crucial element to commercial music.

Appendix

Recital Program

- “Coffee Break Is Over” by Dirty Loops
- Michael Jackson Medley
  - “Rock With You”
  - “The Way You Make Me Feel”
  - “Billie Jean”
  - “P.Y.T. (Pretty Young Thing)”
  - “Man In The Mirror”
- “It’s Not All About You” by Lawrence
- EWF Medley
  - “Shining Star”
  - “Let’s Groove”
  - “Sing A Song”
  - “September”
- “Chameleon” by Herbie Hancock
- Stevie Wonder Medley
  - “Superstition”
  - “I Wish”
  - “Isn’t She Lovely”
  - “Overjoyed”
  - “Higher Ground”
- “The Way It Is” by Bruce Hornsby
- “Fortune Smiles” by Keith Jarrett
- Pop Medley
  - “I Wanna Dance With Somebody” by Whitney Houston
  - “My Heart Will Go On” by Celine Dion
  - “Love On Top” by Beyonce
- “Follow The Light” by Cory Wong and Dirty Loops

References

Bates, John. 1988. *The Synthesizer*. Oxford: Oxford University Press.

Beyonce. 2011. “Love On Top.” Track 8 on *4*, Columbia Records 88697 99077 2. Apple Music streaming audio, 320kbps.

Dirty Loops. 2020. “Coffee Break Is Over.” August 28, 2020. Music video, 4:01. https://www.youtube.com/watch?v=aYYFmp9NBTk

Dirty Loops and Cory Wong. 2021. “Follow The Light.” Track 1 on *Turbo*. Not on Label. Apple Music streaming audio, 320kbps.

Dion, Celine. 1997. “My Heart Will Go On.” Track 12 on *Let’s Talk About Love*. Columbia Records 489159 2. Apple Music streaming audio, 320kbps.

Douglas, Adam. 2019. “10 Types of Synthesis, Explained: FM, Vector and More” Reverb.com, June 18, 2019. https://reverb.com/news/10-types-of-synthesis.

Earth, Wind & Fire. 1975. “Shining Star.” Track 1 on *That’s the Way of the World*. Columbia Records 65920. Apple Music streaming audio, 320kbps.

———. 1978. “September.” Track 7 on *The Best of Earth, Wind & Fire, Vol. 1.* Columbia Records 35647. Apple Music streaming audio, 320kbps.

———. 1981. “Let’s Groove.” Track 1 on *Raise!*. Columbia Records 35647. Apple Music streaming audio, 320kbps.

———. 1999. “Sing A Song.” Track 12 on *Gratitude*. Columbia Records 494958 2. Apple Music streaming audio, 320kbps.

Fortner, Stephen. 2009. “Michael Jackson: Keyboard Sounds of his Signature Songs, Then and Now.” *Keyboard* 35, no. 9 (September): 22. https://link.gale.com/apps/doc/A209406896/ITOF?u=tel_a_belmont&sid=bookmark-ITOF&xid=734513e9.

Gabrielli, Leonardo, Michela Cantarini, Paolo Castellini, and Stefano Squartini. 2013. “The Rhodes Electric Piano: Analysis and Simulation of the Inharmonic Overtones.” *The Journal of the Acoustical Society of America* 148, no. 5 (November). https://doi.org/doi:10.1121/10.0002002.

Gabrielli, Leonardo, Vesa Välimäki, Henri Penttinen, Stefano Squartini, and Stefan Bilbao. 2013. “A Digital Waveguide-Based Approach for Clavinet Modeling and Synthesis.” *EURASIP Journal on Advances in Signal Processing* 103 (May) https://doi.org/doi:10.1186/1687-6180-2013-103.

Goldman, Dan. 2020. "Roland Jupiter-Xm." *Electronic Musician*, February 2020. https://www.proquest.com/magazines/roland-jupiter-xm/docview/2325703679/se-2?accountid=8570.

Hammond Company. n.d. “The Hammond Story.” Hammond and Leslie Heritage. Accessed Feb 12, 2022. https://hammondorganco.com/contact-us/company-profile/

———. n.d. “User Manual.” Downloads. https://hammondorganco.com/wp-content/uploads/2015/06/03-DRAWBARS-PERCUSSION-corrected.pdf

Hancock, Herbie. 1973. “Chameleon.” Track 1 on *Head Hunters*. Columbia Records 65123. Apple Music streaming audio, 320kbps.

Hornsby, Bruce. 1986. “The Way It Is.” Track 5 on *The Way It Is*. RCA Records 89901. Apple Music streaming audio, 320kbps.

Houston, Whitney. 1987. “I Wanna Dance With Somebody.” Track 1 on *Whitney*. Arista Records 258 141. Apple Music streaming audio, 320kbps.

Lenhoff, Alan and David E. Robertson. 2019. *Classic Keys: Keyboard Sounds That Launched Rock Music*. Denton, TX: University of North Texas Press.

Lumma, Carl. 2005. "Audition: Roland Juno-D Synthesizer." *Keyboard* 31, no. 3 (March): 66-68. https://www.proquest.com/magazines/audition-roland-juno-d-synthesizer/docview/1366260/se-2?accountid=8570.

Pressing, Jeff. 1992. *Synthesizer Performance and Real-Time Techniques*. Computer Music and Digital Audio Series. Middleton, WI: A-R Editions.

Jackson, Michael. 1979. “Rock With You.” Track 2 on *Off The Wall*. Epic Records CDEPC 83468. Apple Music streaming audio, 320kbps.

———. 1983. “Billie Jean.” Track 6 on *Thriller*. Epic Records 9771128-608225 - 40003. Apple Music streaming audio, 320kbps.

———. 1983. “P.Y.T. (Pretty Young Thing).” Track 8 on *Thriller*. Epic Records 9771128-608225 - 40003. Apple Music streaming audio, 320kbps.

———. 1983. “Thriller.” Track 4 on *Thriller*. Epic Records 9771128-608225 - 40003. Apple Music streaming audio, 320kbps.

———. 1987. “The Way You Make Me Feel.” Track 2 on *Bad*. Epic Records EPC 450290 2. Apple Music streaming audio, 320kbps.

———. 1987. “Man In The Mirror.” Track 7 on Bad. Epic Records EPC 450290 2. Apple Music streaming audio, 320kbps.

Jarrett, Keith. “Fortune Smiles.” Track 4 on *Gary Burton & Keith Jarrett*. Atlantic Jazz 7567-81274-2. Apple Music streaming audio, 320kbps.

Jenkins, Mark. 2007. *Analog Synthesizers: Understanding, Performing, Buying: From the Legacy of Moog to Software Synthesis*. Burlington, MA: Focal Press.

Jisi, Chris. 2010. "Men In The Mirror: The Bassists of Michael Jackson." *Bass Player* 21, no. 2 (February): 32-34, 36, 38-42, 44, 46. https://www.proquest.com/magazines/men-mirror-bassists-michael-jackson/docview/199951779/se-2?accountid=8570.

Lawrence. 2021. “It’s Not All About You.” Track 7 on *Hotel TV*. Beautiful Mind Records. Apple Music streaming audio, 320kbps

Parakilas, James. 2000. *Piano Roles: Three Hundred Years of Life with the Piano*. New Haven, CT: Yale University Press.

Porter, Martin and David Goggin. 2018. “Stevie Wonder’s super synth: How TONTO made history.” *Rolling Stone,* December 2018. https://www.proquest.com/magazines/stevie-wonders-super-synth-how-tonto-made-history/docview/2211284953/se-2?accountid=8570.

Rideout, Ernie. 2011. *Synth Gods*. Milwaukee, WI: Backbeat Books.

Sigman, Mitchell. 2005. "Vintage Sounds: Big Bottom Drives Me Out of My Mind - the Moog Bass Tones that Rumbled the Earth." *Keyboard* 31, no. 11 (November): 103. https://www.proquest.com/magazines/vintage-sounds-big-bottom-drives-me-out-my-mind/docview/1367532/se-2?accountid=8570.

Vail, Mark. 1997. *The Hammond Organ: Beauty in the B*. San Francisco, CA: Miller Freeman Books.

———. 2000. *Vintage Synthesizers: Groundbreaking Instruments and Pioneering Designers of Electronic Music Synthesizers*. San Francisco, CA: Miller Freeman Books.

Welch, Kelleigh. 2014. "Down the Rhodes - the Fender Rhodes Story." *Pro Sound News*, April 2014. https://www.proquest.com/magazines/down-rhodes-fender-story/docview/1780093685/se-2?accountid=8570.

Wonder, Stevie. 1972. “Superstition.” Track 6 on *Talking Book*. Motown Records 157 354-2. Apple Music streaming audio, 320kbps.

———. 1973. “Higher Ground.” Track 5 on *Innervisions*. Motown Records 3746303262. Apple Music streaming audio, 320kbps.

———. 1976. “Isn’t She Lovely.” Track 2-1 on *Songs in the Key of Life*. Motown Records 012 157 357-2. Apple Music streaming audio, 320kbps.

———. 1976. “I Wish.” Track 1-6 on *Songs in the Key of Life*. Motown Records 012 157 357-2. Apple Music streaming audio, 320kbps.

———. 1985. “Overjoyed.” Track 9 on *In Square Circle*. Motown Records ZD72005. Apple Music streaming audio, 320kbps.

"Yamaha DX7." 2019. *Electronic Musician*, March 2019. https://www.proquest.com/magazines/yamaha-dx7/docview/2304085828/se-2?accountid=8570