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Piano Performance and Technique: A Study of the Modern Grand Piano

by

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ABSTRACT

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The study of how the modern grand piano functions from a construction standpoint has been overlooked by modern pianists. This dissertation explores how an understanding of the inner workings of the piano will lead to more healthy, efficient, and purposeful approach to the performance of the piano. It examines how the piano is constructed, how the piano functions, and how the pianist can apply this knowledge to better advance their overall understanding of piano performance.

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I owe a debt of gratitude to the members of my extended family and friends that support my musical career. My parents have given me loving support and encouragement for my music education from a very young age. They continue to be my biggest fans. My sister, Sachiyo, having written three of her own theses, gave me confidence that I could complete this dissertation. My professor uncle, Noboru Sakata, has written countless textbooks and has always had a special place in my heart: he has been a great role model. I also thank my mother-in-law, Janice Behrendt, for constantly inquiring about my progress: “Kana, how is your paper coming, so when do you think you will be done?”

Above all, I would like to thank my husband, Bradley M. Snook, who has actively been involved in helping me develop as a professional pianist. As one of the finest concert piano technicians, he has made it possible for me to practice on the best instruments in the world. He has taught me many things about piano; it will forever change the way I am able to relate to the piano.

They, and many others, have encouraged me to achieve my goal to complete my dissertation. Thank you all!

Kana Mimaki

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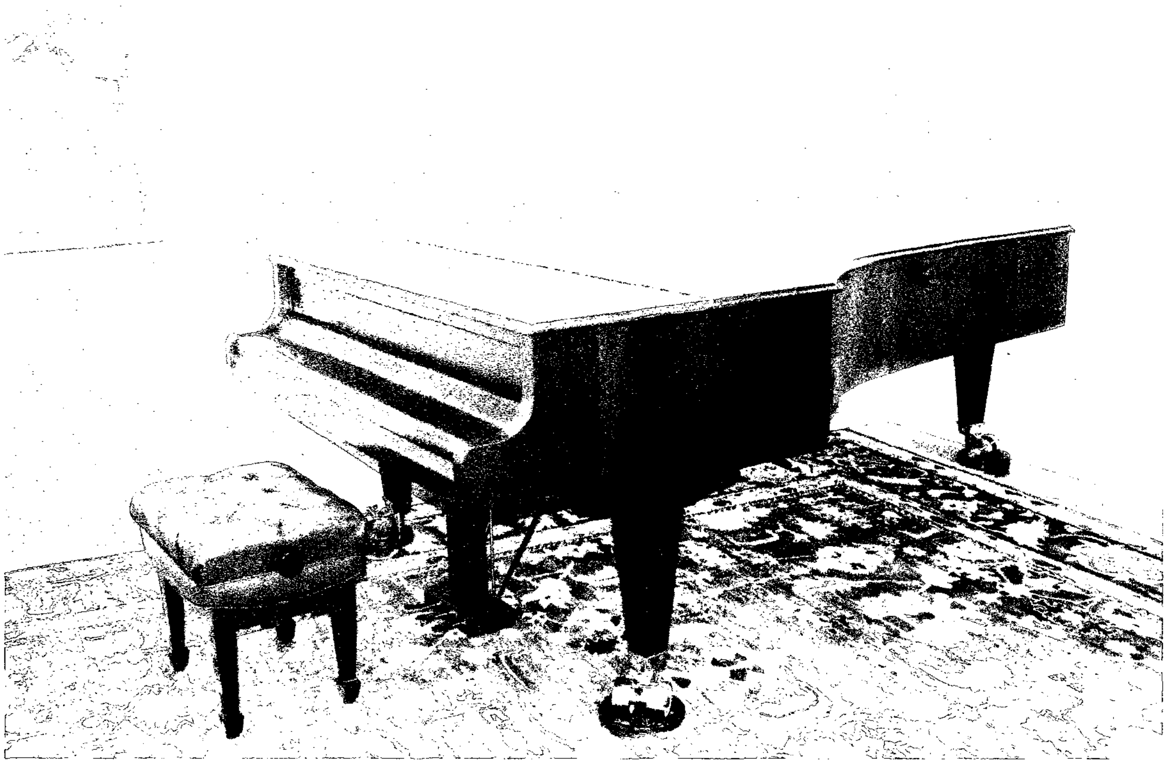

Figure 1: The Modern Concert Grand Piano, a Bösendorfer 290 (9'6")

The modern grand piano (Figure 1) is one of the most complex musical instruments in the Western world: it is made up of thousands of moving and adjustable parts. Each of the piano's keys is connected to an elaborate system of levers and dampers, allowing for subtle control over both dynamics and articulations. Only a few pianists understand how this mechanism works, which leads to many misunderstandings about the nature of piano technique.

Alfred Brendel conveyed the following remarks in his essay on piano performance: "much of the uncertainty and indifference of [piano] tuners, has its roots in the ignorance of pianists, who are unable to perceive clearly and put into words what worries them about an instrument. Many pianists do not even realize how much they are entitled to expect from a concert grand (Brendel 2001, 342)."

This lack of understanding leads to four problems: 1. pianists misunderstand the physiology of piano technique (i.e., what will produce a difference in the sound of the piano), 2. pianists lack the ability to diagnose technical problems with the piano and make adjustments to their technique, 3. pianists do not have the vocabulary to communicate their needs and wishes with the piano technician, and 4. pianists don't listen to the sound that the piano is producing, relying more on touch than on sound. Piano technicians themselves state that, "pianists are the most ignorant of all musicians about the workings of their own instrument (Smith 2006, 20)."

The modern grand piano has developed into such a complex instrument that it requires constant attention from a highly skilled piano technician. The apprentice traditions of Europe can require as many as seven years to become proficient in tuning, regulating, and voicing; mastering the art of concert piano preparation takes even longer. Vladimir Horowitz said, "all pianos are more or less good, but they need constant care and don't often receive it. At least every month or two they should be tuned and voiced. If this isn't done, within a year's time the piano will run down like a human being who neglects his health. Pianos change timber and tone with the weather, the atmospheric conditions, or movement ... a piano has some eleven thousand parts, and, if one of those goes awry, then the piano doesn't function right. A piano is very vulnerable (Mach 1991, 21)."

The majority of the parts that go into producing sound are hidden from the pianist: they are contained within the piano's action cavity. The pianist is left with what they are able to see and touch: the keys, the dampers, and the pedals. Pianist Henry Levin wrote, "in order to play intelligently and musically, we should have a clear understanding of how these hidden parts of the piano action can be properly (and even improperly) activated by the key. And we should develop a discriminating touch sense and a keen sense of timing, in order to put into play what we know (Levin 1967, 20)."

Even the parts that have the potential to be seen by the pianist, like the dampers, are usually blocked from sight by the music desk. Even though the music desk is customarily removed during concerts, pianists need to use music while practicing the piano; without being able to see the dampers while practicing, it is impossible for pianists to refine pedal work by varying small amounts of damper weight on the strings. This pedaling technique produces many shades of color that goes virtually unexplored by pianists. The result is that most pianists rely on various styles of on/off pedaling.

Pianists, teachers, and pedagogues have long discussed musical interpretation and the execution of proper kinesiological performance technique. Most, however, do not emphasize the importance of understanding how the piano works in terms of the physiology of piano technique: a technique that is based on how the piano functions internally. Heinrich Neuhaus wrote, "the player does not give sufficient thought to the extraordinary dynamic wealth and diversity of tone which the piano provides.... just as any workman knows the limits of power and productivity of the machine he is operating, so also a pianist who 'operates a piano' must know his instrument, his machine (Neuhaus 1989, 58)."

I often use my marathon experience to help my students understand the importance of understanding the inner workings of the piano: a professional runner must understand how the upper and lower body works together to create maximum efficiency and increased stamina; the runner cannot focus on the foot without understanding its relation to the rest of the body. As pianists, we must understand the inner workings and limitations of the piano in order to produce the same kind of stamina and efficiency necessary for performances. Pianists must understand how the machine works as a whole.

Academia has not done enough to encourage pianists to learn about the inner workings of the piano. It is standard for piano performance programs to require classes in piano pedagogy and piano literature, yet courses in piano technology are not required in the majority of performance schools (e.g., The Julliard School, Eastman School of Music, Curtis Institute, San Francisco Conservatory, Indiana University, Peabody Institute, etc.).

Education and training for piano technicians is currently almost non-existent: Florida State University is currently the only institution in North America that offers a degree program in piano technology. The lack of qualified technicians is a significant factor in why pianists have no choice but to become complacent about the condition of pianos.

Ultimately, it is the responsibility of the pianist to have sufficient technical proficiency to be able to perform on any piano, no matter its condition. When a piano is not properly cared for, two main issues typically result: 1. a loss of control over smaller gradation in sound quality, and 2. a lack of color throughout the dynamic ranges. For the pianist, this usually means a greater amount of energy needs to be exerted, which is almost always at the expense of subtle artistic nuance.

Even a rudimentary understanding of how the piano works can help the pianist better deal with problems encountered with a piano. This understanding can help the pianist compensate by either being able to communicate their needs to a piano technician, or when all else fails, by knowing how to use a different technical approach to overcome the given problems. Even with brand new instruments, it can take hundreds of hours to get a piano up to concert level standards. It is important to note that concert technicians are usually only paid for a few hours of service for each concert. Anything that pianists can do to clearly define their needs can help to produce better results.

Let us examine a hypothetical situation: a pianist performs Ravel's *Gaspard de la Nuit* as a part of program and experiences difficulties with repetition during the dress rehearsal. The pianist mentions this to the technician, but does so without any qualifiers as to which section of the piano, at what dynamic levels, or in what part of the key the problem with the repetition is taking place. This, in turn, sets the piano technician to work overclocking the regulation throughout the entire piano to try and gain additional speed; this process takes a significant amount of time!

Had the pianist articulated that they were having difficulty with soft, in-the-key repetition (i.e., specifically on the quietly repeated D#$_3$ in *Scarbo* (Figure2)), this problem could have been quickly resolved, and the technician could have better used the rest of the time to deal with other technical issues.[1]

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[1] *Gaspard de la Nuit* uses one of the largest ranges in tonal color and texture in the entire piano literature. This can only be achieved if the concert piano is well-prepared, using a very specific style of concert voicing: the voicing of the una corda pedal must be dark and dense, but the piano-pianissimo in the normal position must remain clear, with a warm texture.

Ravel - Gaspard de la Nuit

III. Scarbo

Il regarda sous le lit, dans la cheminée, dans le bahut - personne. Il ne
put compendre par où il s'était évadé. —Hoffman, Contes nocturnes

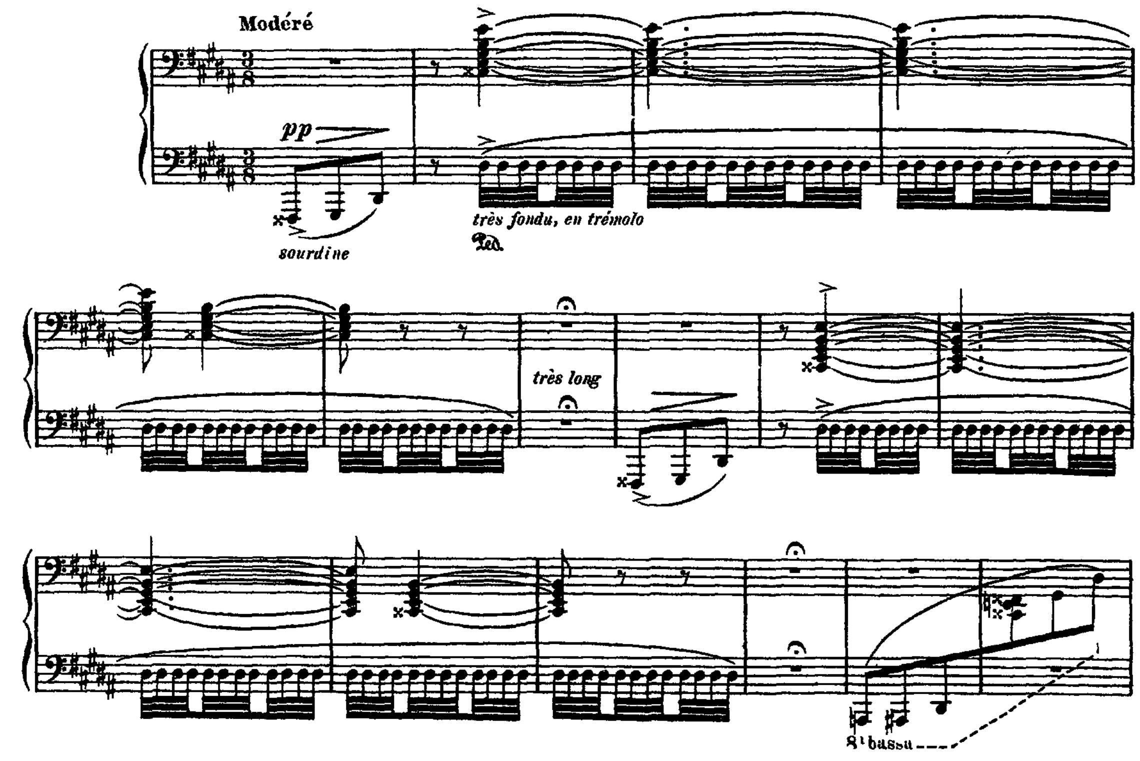

Figure 2: III. *Scarbo* from Ravel's *Gaspard de la Nuit*, mm.1-16

Even without the assistance of a piano technician to solve the aforementioned problem, pianists should be able to diagnose the problem so that they know what to do to compensate for the condition of the piano. With the *Scarbo* example, the letoff was low, there was excessive aftertouch, and the hammer was checking too far from the string: these conditions make in-the-key repetition very difficult for the pianist. The pianist should have altered their technical approach by repeating the note at the top-of-the key instead of near the bottom of the keys. It is difficult to control in-the-key repetition at soft dynamics, but with judicious use of the pedal, the limiting factors of this particular piano could have been overcome for the performance. Pianists must have a technique that is flexible in order to be able to perform in any given situation.

Pianists may intuitively deal with a piano in performance. Despite the fact, it is necessary to have enough experience to be able to control any problem intuitively. Pianists should learn how the instrument functions, what causes a problem, what can be done to adjust. This preliminary knowledge will help pianists anticipate what to look for and how to deal with a given problem in performance.

CHAPTER 2: INSIDE THE PIANO

While it was once shocking to dissect the human body, modern medicine has gained immeasurably from a better understanding of the human anatomy. In this chapter, we will go where few pianists ever look: we will open up the lid of the piano and study the anatomy of the modern grand piano (Figure 3).

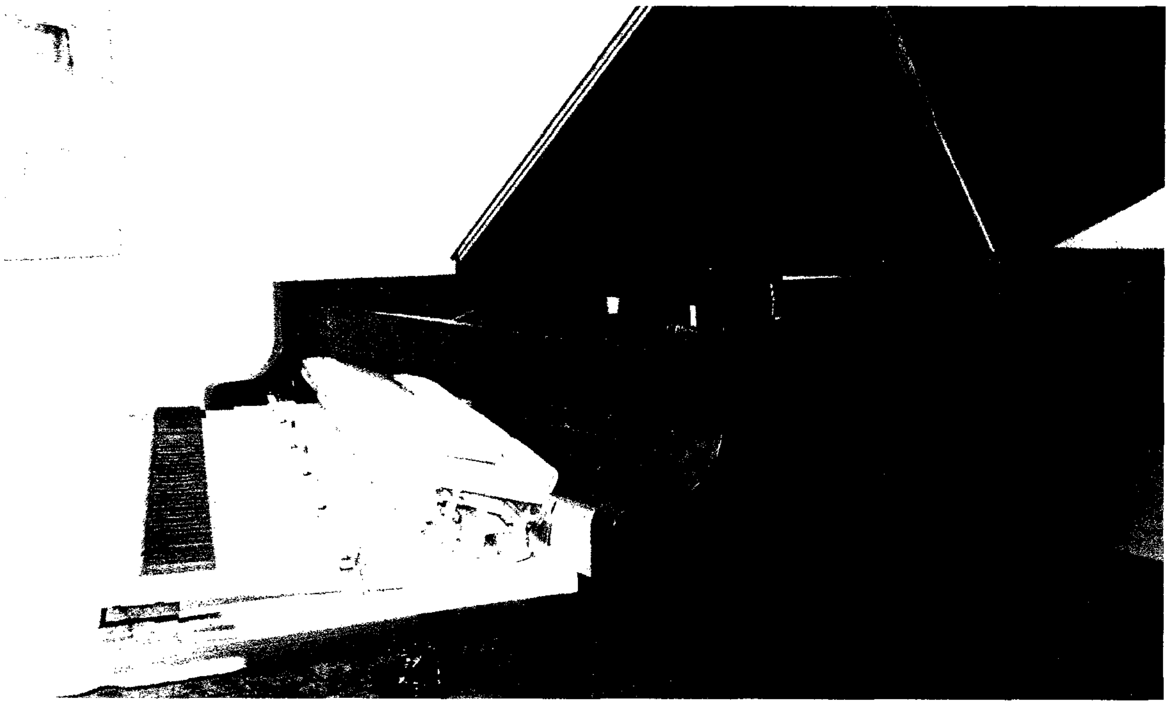

Figure 3: The Keyboard Assembly

2.1. The Main Structural Components

The main structural components of the piano consist of the casework (i.e., the subframe, inner and outer rim, lid, legs, and fallboard), the soundboard (i.e., the soundboard panels, ribs, bridges, and bridge-pins), and the iron frame (i.e., the metal harp, pinblock, tuning pins, strings, agraffes, and hitchpins).

The wooden structures of the piano should be made of high quality wood: it is important that this wood is properly seasoned and dimensionally stable. This is the foundation on which all the other components are built. It is important that piano manufacturers do not cut corners on this aspect of the manufacturing process; those that do are plagued with unstable tunings, unstable regulation, and an overall limited lifespan. A quality piano starts with quality materials.

Since most of the structural wooden components are hidden by veneer or lacquer/polyester, it can be difficult for a pianist to discern a sound structure from one that is not. In general, size is a good indication of quality. When viewed from underneath the piano, a thick inner and outer rim with substantial bracing is a good indication that the piano has the potential to be a quality piano. Wood, after all, is a relatively inexpensive part of the manufacturing process; if a manufacturer cuts corners here, they are probably cutting corners throughout the rest of the construction (Snook 2009).

There are differing subframe construction methodologies; the most important aspect to pay attention to is that the structure is dimensionally solid enough to withstand the test of time. There are two points that should be noted: 1. high-quality laminated lumber is dimensionally VERY stable,[2] and 2. the entire wooden foundation should be glued together using strong wood joints that will be stable over time.[3]

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[2] Steinway's outer rim is made out of horizontally laminated sheets of wood that are glued and bent into shape; laminated wood does not mean that it is inferior in quality to that of a solid piece of wood. High quality laminated lumber is structurally more stable over time than one solid piece of wood.

[3] It is not wise for manufacturers to save on construction costs by using simple butt joints. Because of the inherent weakness of butt joints, they need to be reinforced by metal screws.

2.2. The Soundboard

The soundboard (Figure 4) is a wooden panel that reinforces the mechanical wave energy of the string through sympathetic resonance (Snook 2009). The art of soundboard design is a highly evolved mechanical system that remains shrouded in mystery; its development has been based on a simple method of trial and error.

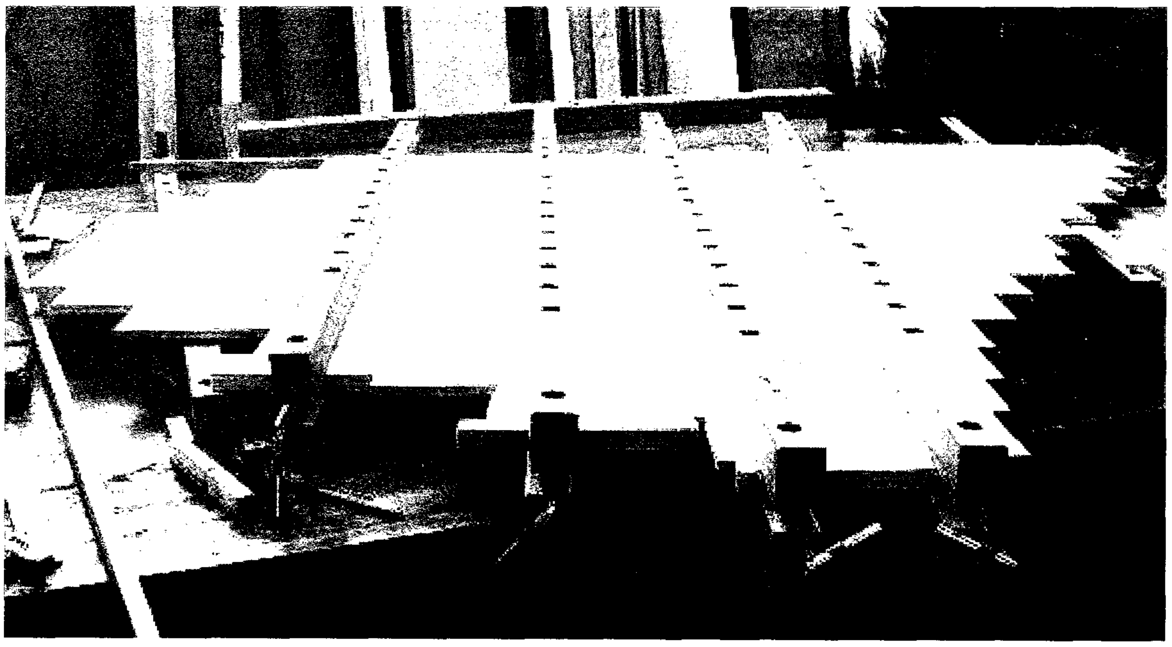

Figure 4: The Soundboard Panel

The typical soundboard is made up of multiple pieces of spruce: the thickness of the soundboard can vary from 5mm-15mm from manufacturer to manufacturer. It is common for soundboard makers to seek out boards with straight even grain lines that are close together.[4] Soundboards are typically reinforced with 15-20 ribs on the underside board, which gives the soundboard its upwards crown when glued together[5].

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[4] Ten or more growth rings per square inch are an often stated requirement for soundboard makers. The idea is that the more growth rings there are per square inch, the stronger, and in turn more stable, the soundboard will be.

During the late 1860s, the Mathushek factory experimented with various soundboard designs by varying the thickness of the soundboard panels and ribs. They experimented with soundboards as thick as 25mm and soundboards as thin as 4.8mm. Mathushek reported all of the soundboards producing slightly different, yet completely satisfactory tone quality. Based on their experiments, they concluded that the most satisfactory tone quality came from a soundboard tapering from 9.5mm in the treble to just over 6mm in the bass (Dolge 1911, 109).

Steinway & Sons has a different approach to soundboard design: in 1935 the company patented a "diaphragmatic soundboard" that is thickest in the center of the soundboard, and progressively gets thinner towards the edge of the soundboard. The soundboard thicknesses progress in a radial pattern from 9mm-6mm in the model D, and 8mm-5mm in the model B (Steinway Musical Instruments, Inc. 2009).

Many contemporary soundboard makers argue against the Steinway design noting that thin soundboards [6] are commonly plagued with tuning instability problems. Contemporary soundboard makers often prefer uniform soundboards that are approximately 10mm thick; some makers, however, will taper the bass area of the soundboard, believing that it will improve the bass sound by allowing the soundboard to flex better at the lower frequencies.

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[5] Many soundboard makers emphasize the importance of pre-crowning the ribs (i.e., cutting a radius on the side of the rib that is glued to the soundboard). The other common methodology is to use straight ribs and then compress the soundboard into a crowned shape. This is known as in the industry as "compression crowning," and it is often criticized for its inability to withstand the test of time.

[6] A thin soundboard typically measures in the 5-6mm range.

2.3. The bridge

The main function of the bridge is to set the termination length of the strings, but it also transfers the mechanical wave energy from the strings to the soundboard. While the quality of the soundboard might not be of great significance, the termination points at the bridge are of great concern to the overall sound quality of the piano. It is critical that the termination points on the bridge are cleanly cut in the middle of the bridge pins, there are no visible cracks emanating from bridge pin holes, the side bearing is consistent note-to-note, the bridge pins are not excessively large, the height of the bridge pins are not too tall, and the bridge pins are tightly fit in the bridge pin holes (See Figure 6).

The easiest way to determine quality is to take a close look at the bridge: pianists need only to look for visually impeccable workmanship to judge what will produce quality sound.

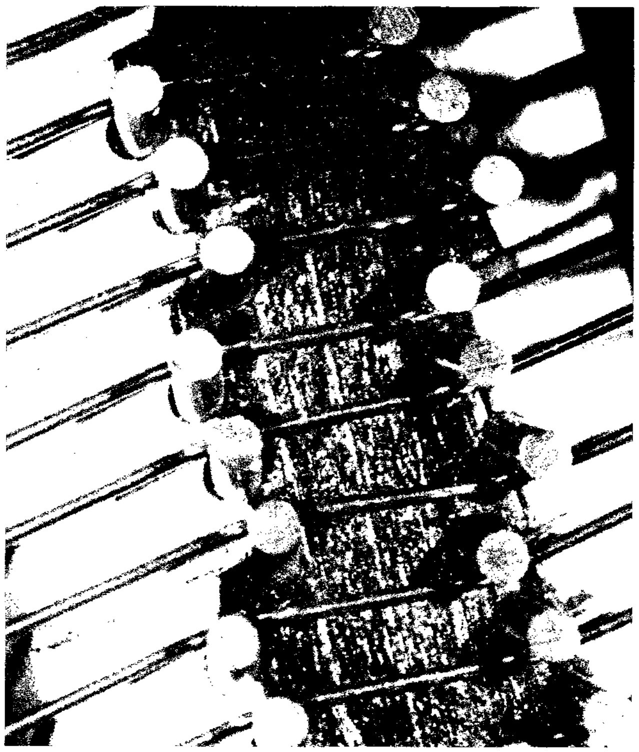

Figure 5: Bridge of Baldwin SD-10

Figure 6: Bridge of Bösendorfer 290 (9'6")

Figure 5 is the bridge of an American manufacturer's concert grand piano. Notice that termination cuts are not consistently in the middle of the bridge pins, there are numerous cracks, the sidebearing angles between the pins are inconsistent, and many of the holes have been enlarged (i.e., you can visually see the gaps between the bridge pin and the wood). Figure 6 is that of a Viennese manufacturer's concert grand piano. These are both very expensive pianos that represent the upper-end piano market, but there is clearly a vast difference in the quality of workmanship between these two pianos. One piano is riddled with false beats, inconsistent tone from string to string, and has problems with tuning stability; the other piano has none of these problems! Quality materials are an important start, but it will never overcome poor workmanship; what you see is what you will end up hearing in the sound (Snook 2009).

2.4. The Iron Frame

Bartolomeo Cristofori di Francesco was an Italian instrument maker who worked under the patronage of Prince Ferdinando de Medici. By 1711, Cristofori had built three pianos and had established all of the basic design elements that make the modern grand piano what it is today. Cristofori's piano was ground breaking for many reasons, but the significance of higher string tension is often overlooked. This precedent towards louder pianos has dominated the piano builder's mindset for more than 300 years. String tension is a matter of physics: higher string tension produces louder volume. The iron frame (Figure 7) is a direct result of this seemingly unending need for more volume.

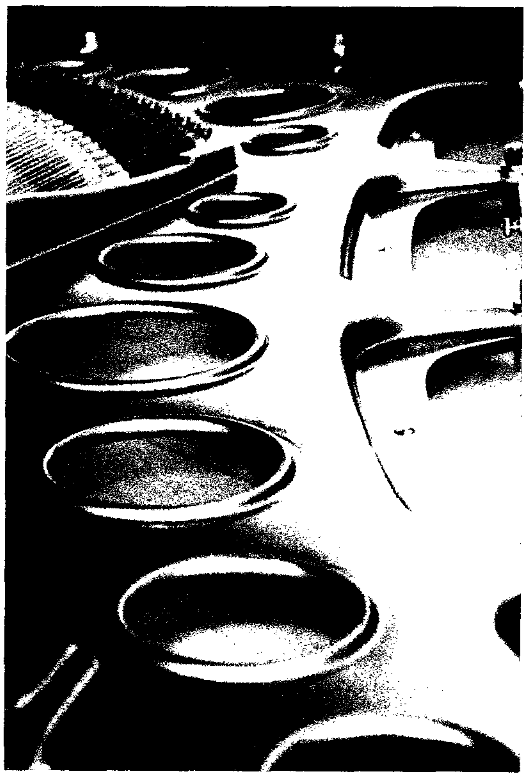

Figure 7: Iron Frame

In order to withstand higher tension wire, it was necessary to introduce metal support structures to the construction of the piano. This first appeared as simple bracing, but quickly necessitated a single piece iron frame that was able to withstand the entire load of the string's tension.

From a structural standpoint, the introduction of the single piece iron frame means that the wooden subframe no longer needs to withstand the tension of the wire; instead, the subframe is responsible for resisting the downbearing force of the strings.

To increase the overall rigidity of the piano construction, the iron frame should be attached directly to the top of the soundboard. Large bolts anchor the iron frame and soundboard to the subframe (see Figure 8). Not all manufacturers attach their iron frame to the soundboard in this manner, but it is the preferred method of construction because of its added stability (Snook 2009).[7]

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[7] It might seem counter-intuitive that such a massive piece of iron would get placed directly on the soundboard, and then bolted into place, but it MUST be remembered that we know very little about how and why the soundboard actually works.

Figure 8: Bolts Anchoring the Iron Frame Directly to the Soundboard

2.5. Agraffes and Capo d'Astro

The strings are anchored to the iron frame via agraffes and/or a capo d'Astro bar, and by means of a metal hitchpin at the opposite end of the iron frame. The traditional method of stringing a piano uses a separate string that is individually tied off at the plate (see Figure 9).[8] It has become commonplace for many manufacturers to use one string that wraps around a hitch pin to form speaking segments to produce the pitch. This means

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[8] Bösendorfer and Bechstein use a method of single stringing.

that one string is often tuned to two separate pitches. The other downside of this method is that if a string breaks during the performance, the pianist loses two speaking segments.

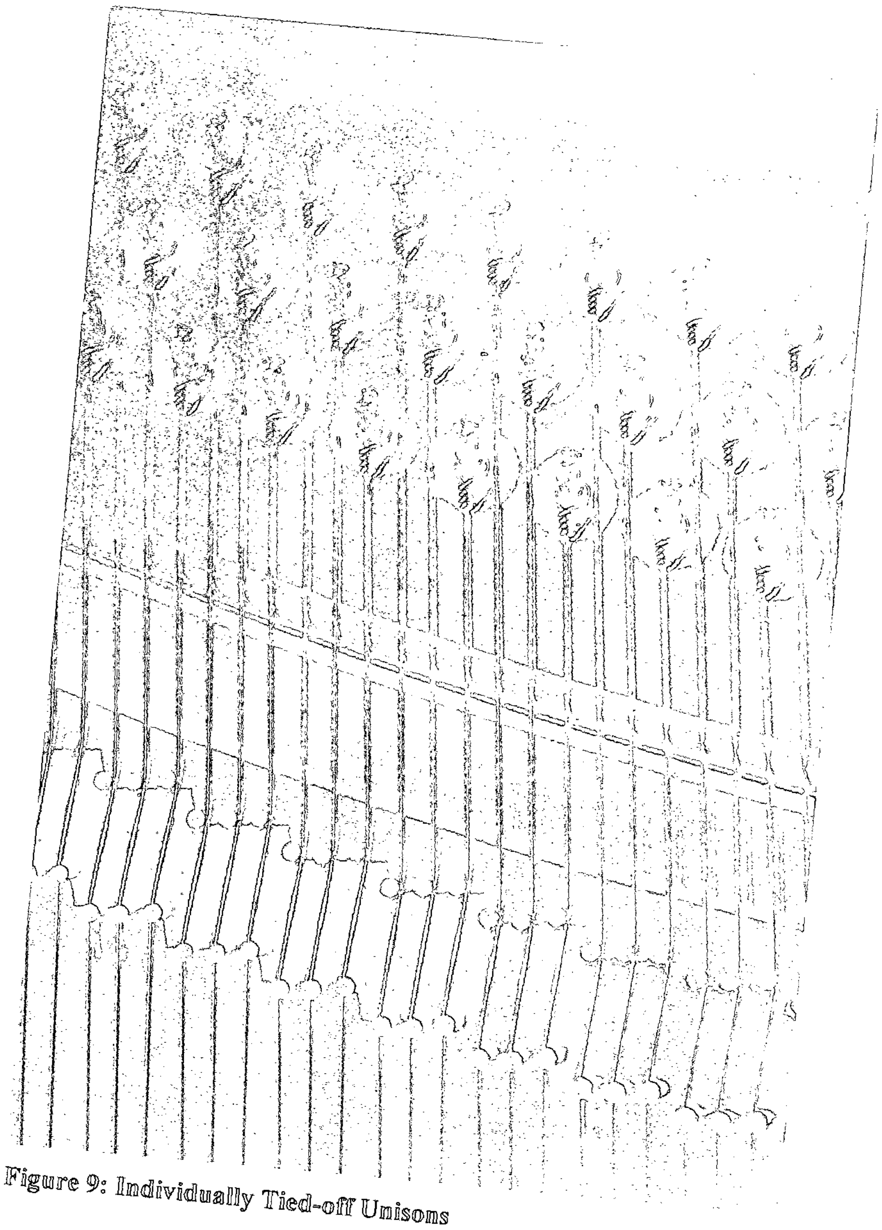

Figure 9: Individually Tied-off Unisons

Agraffes (Figure 10) are brass screws that establish the front termination point of the strings[9]. One, two, or three holes are drilled in each agraffe, for the unachords, bichords, or trichords respectively. In the past, agraffes have been used throughout the entire compass of the piano. This method is ideal for the pianist, as it does not block the sound from the pianist as significantly as capo d'Astro bar does. This method, however, is far more challenging for the manufacturer to produce. Tolerances are very small; it is difficult to get the hammer to strike as close to the termination point as is necessary. A much easier method is to hold the strings down from above with the use of a capo d'Astro bar (Figure 11). This has now become the standard for the top one or two sections of the piano.

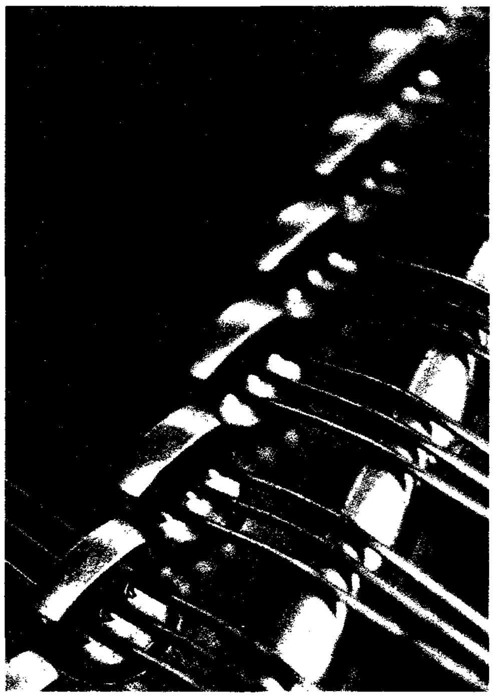

Figure 10: Agraffes

Figure 11: Capo d'Astro

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[9] The height is adjusted by means of preinstalling metal washers of various thicknesses.

2.6. Unisons and Tuning

Each note on the piano is a unison consisting of one, two, or three strings: the unachord, bichord, or trichord respectively (see Figure 12, 13, and 14). All three styles of unisons can be found in the bass section of the piano (i.e., the wound copper strings). Plain wire trichords are found throughout the remaining sections of the piano. Every manufacturer and model has a different scale design and approaches transitions in a slightly different manner.

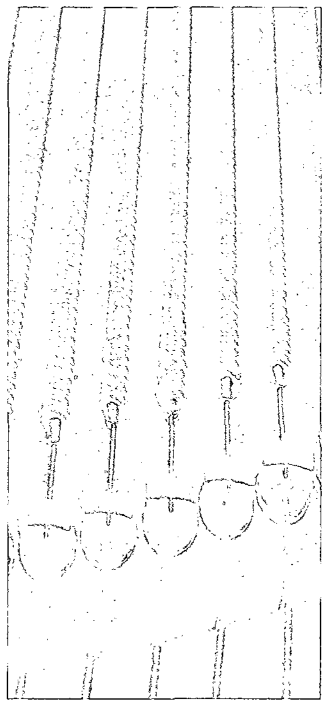

Figure 12: Unachord

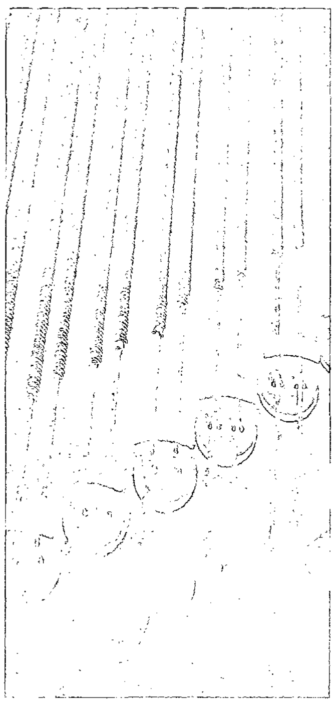

Figure 13: Bichord

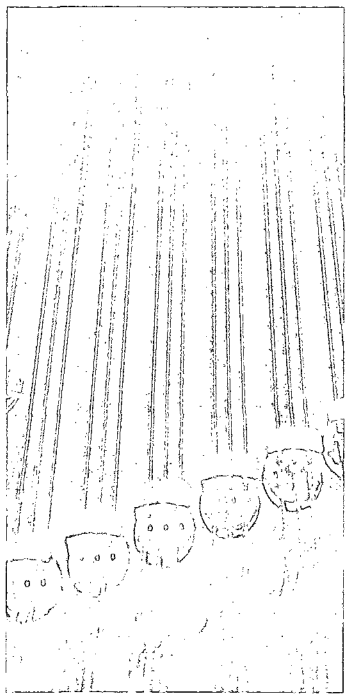

Figure14: Trichord

If the strings of the unison are not in-tune, the coincident partials of the strings will phase in-and-out with each other creating an audible roll; the further the strings are out-of-tune, the faster this "rolling" effect will be.

A phenomenon known as “false beats” is the result of a single string sounding as if it is out-of-tune with itself; false beats make it impossible for the unison to be tuned perfectly clean. Many pianos have serious problems with false beats. It is unfortunately a problem that is not easily corrected.

2.7. The Piano Key

The piano key controls the movement of the hammer via the whippen; it uses a mechanical advantage to aid in lifting the whippen[10] (Figure 15). The key itself consists of a wooden lever, the keytop, the keybutton,[11] the capstan, the backcheck, and the action felt that makes contact with the damper lever.

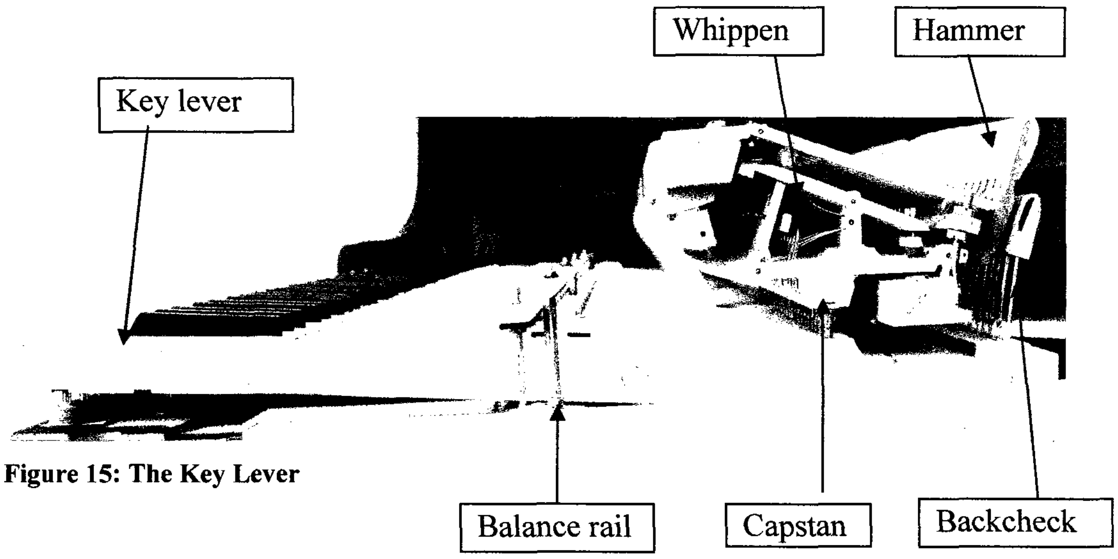

Figure 15: The Key Lever

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[10] The front of the key moves down 10mm, while the capstan, on the opposite end of the fulcrum, pushes up on the whippen only 5mm.

[11] A piece of wood attached to the top of the key that holds the balance-rail bushing cloth

The piano keys rest on top of the balance-rail punchings (Figure 16) made from cardboard, paper, and felt. These punchings play an important role by setting the height of each key while at rest. The thinnest paper punching used in the key leveling process is 0.02mm. The thickness of a typical 24 lbs. copy paper is 0.12mm; 0.02mm is six times smaller! Leveling the keys to a consistent glass-like surface is a very time consuming process of regulation; many piano manufacturers consistently gloss this over in the manufacturing process. As an experiment, put your eye at key level and look down the keyboard; it is easy to notice irregularities that pianists normally never even noticed were there.

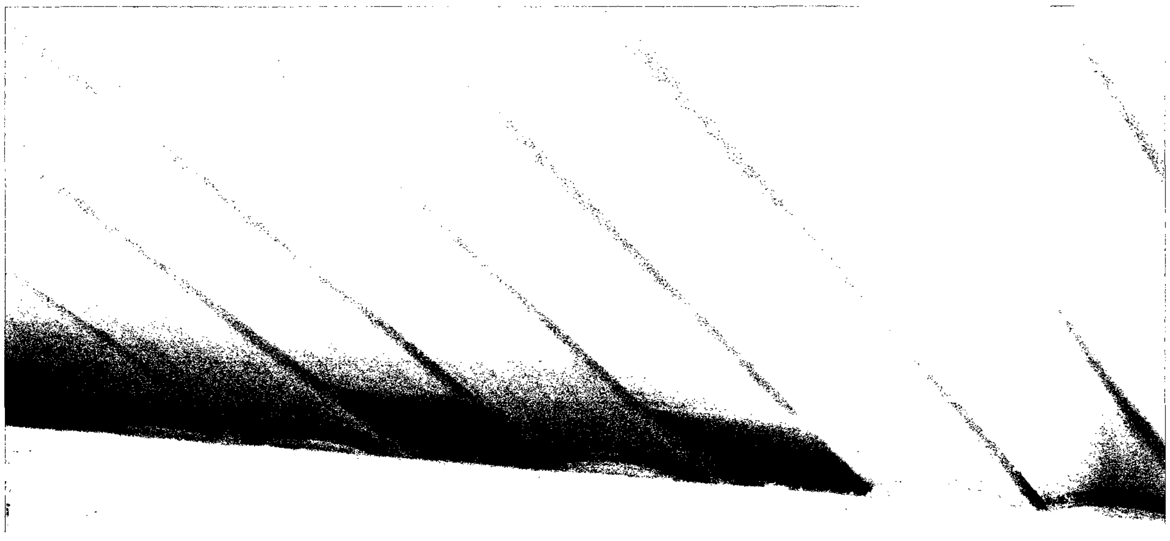

Figure16: Balance Rail Punchings that Set Keylevel

The keytop material glued to the wooden key has traditionally been made from ivory;[12] a material preferred by many pianists because of its softer tactile sensation, its

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[12] Pre-ban ivory can still be installed in the US as an after-market upgrade; prices typically range from $3000-$6000.

ability to allow the finger to easily glide along the top of the key[13] and to absorb moisture during performance. Due to continued import/export restrictions on ivory, virtually all new pianos are made of various synthetic materials. The black keys/sharps are usually made of an ebony-like wood substitute, or various black synthetic materials.

2.8. Keydip

The distance the keys travel is known as the keydip: standard specifications range from 9.4mm-10.7mm, depending on action geometry. The keydip is adjusted by means of installing cardboard, paper, and felt punchings of various thicknesses at the front rail keypin underneath the key (see Figure 17).

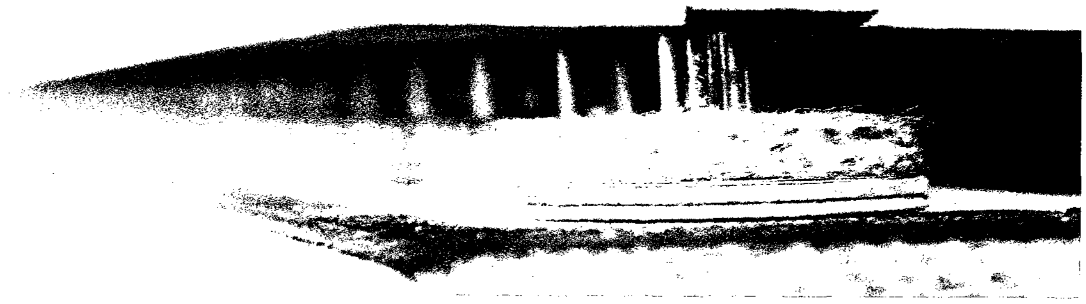

Figure 17: Felt, Paper, and Cardboard Keydip Punchings

Since the motion of the key is disconnected from the hammer during the final moments of the keystroke, pianists generally are not able to differentiate inconsistencies

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[13] Plastic has a much higher friction component as compared to ivory keytops.

in the amount of keydip for each note. Observant pianists are, however, able to notice aftertouch inconsistencies from note to note (see Figure 18). Aftertouch is the distance the key travels after the hammer escapes from the position where it strikes the strings. The main reason a technician will vary keydip from note to note is to compensate for inconsistencies in the aftertouch. Ideally, the keydip should not vary by more than 0.20mm to correct for aftertouch problems (Snook 2009).

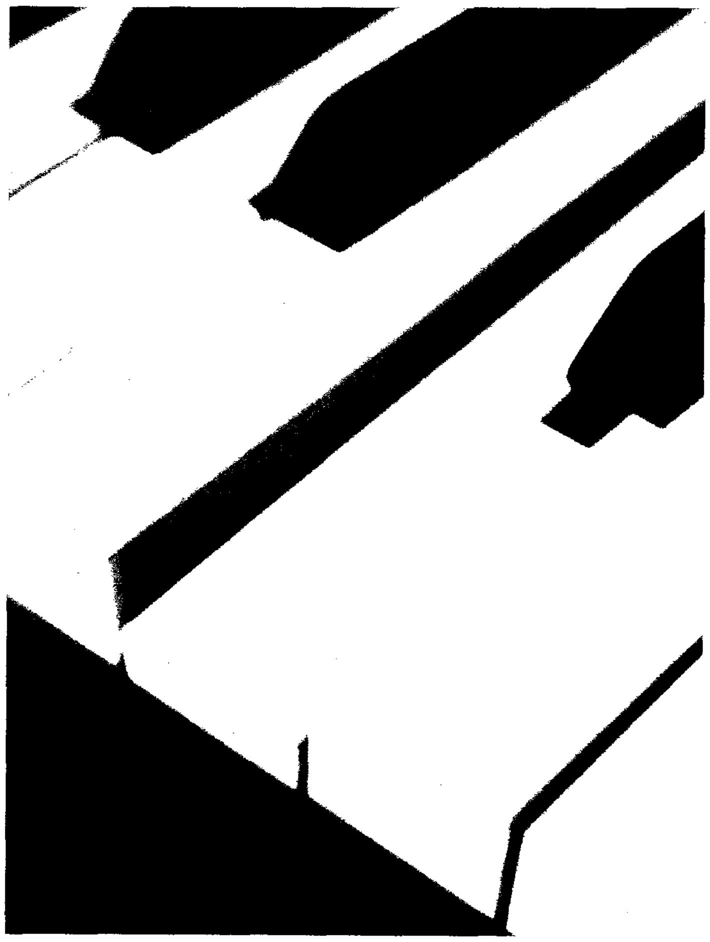

Figure18: Keydip

2.9. Piano Action

The term "action" is often used by pianists to describe the overall sense of touch of the piano (e.g., a light action, a responsive action, an uneven action, etc.). The action geometry, the weight of the hammers, the individual friction components of the rotating parts, the balance weight of the keys, the total mass involved in the system, the quality of the regulation, and the style of the voicing all combine in a complex manner to form a pianist's perception of touch.

Piano technicians, typically refer to the piano's "action" in terms of the components that make up the action geometry: the key, the whippen, and the hammer assembly. The top-action[14] is a subset of the action geometry components that are mounted on the action rails and brackets: this includes the whippens and the hammer assemblies set at a specific distance from each other known as the action spread. Piano technicians will sometimes refer to the entire "keyboard assembly" that slides in-and-out of the piano as the "action."[15]

2.10. Whippen

The term "action" is also synonymous for "whippen:"[16] a third-class lever that transfers a mechanical advantage from the key to the hammer (Figure 19). The modern whippen is nearly identical to Sébastien Érard's original "double repetition action" design of 1821. A few minor modifications were introduced during the following few decades,

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[14] The top action is also known as the "action stack."

[15] The keyframe, action felts, keys, backchecks, keystop rail, action brackets, action rails, whippens, and the hammer assemblies (i.e., the hammers, shanks, and flanges).

[16] The whippen is also known as the balancier, the repetition, the action, the double repetition action, etc.

but since 1850, there have not been any significant change made to the grand piano whippen; the whippens found in every piano being built today have not changed for the past 160 years (Dolge 1911).

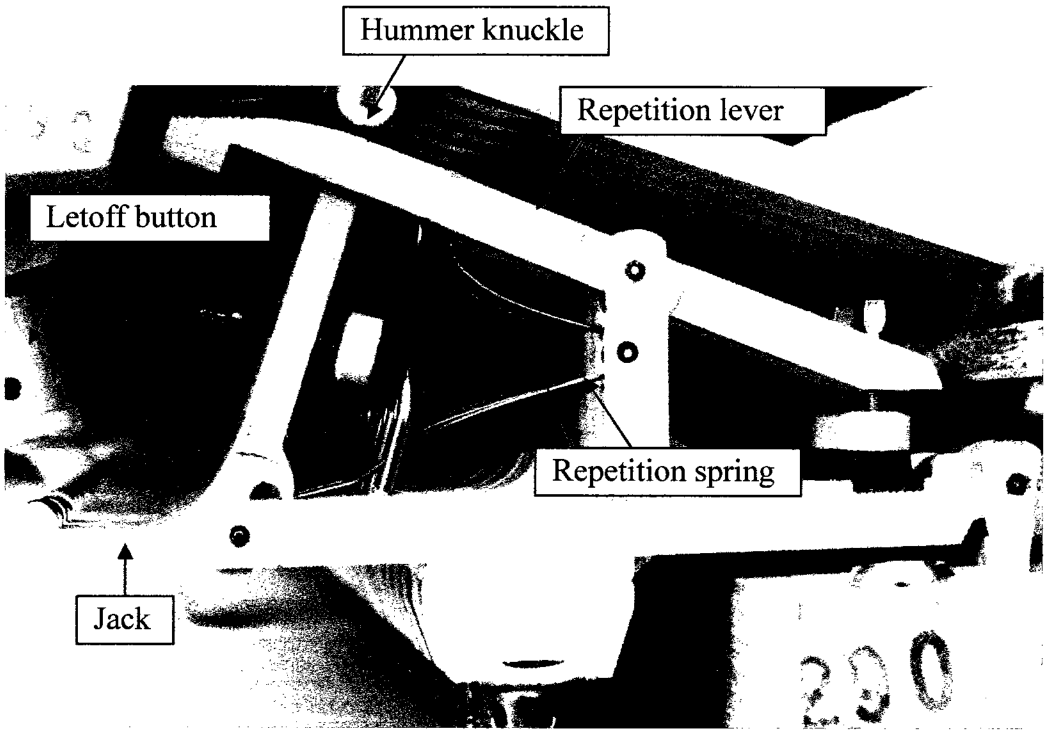

Figure 19: Whippen

2.11. Hammers

Prior to Henri Pape's 1826 introduction of the felt covered hammer, piano hammers were made by assembling various densities of leathers: this was done separately for each piano hammer. Modern hammers, on the other hand, are produced from a single sheet of felt pressed around precut wooden moldings; the felt is then cut into individual hammers once the glue has had a chance to dry.[17]

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[17] Modern hammers often include colored underfelt that is first glued onto the molding. This denser felt is a throwback from early hammer design; it is said to provide a transition in density from the wood to the hammer felt.

There are two prevalent schools of modern hammer design: the low tension hammers used by New York Steinway & Sons, and the high tension hammers that are used by almost everyone else in the world (i.e., including Hamburg Steinway & Sons).

High tension hammers are made by compressing hammer moldings onto a triangular sheet of felt; the sides of the felt are glued down around the molding to maintain the internal compression of the core. This is accomplished by increasing the external tension near the surface of the hammer; this provides the necessary density for the hammer to be able to maintain its shape. When the hammer deforms upon impact with the string, the external tension increases as the core compacts. This allows the hammer to push back and rebound off the string faster.

Low tension hammers require chemical hardeners to stiffen the felt. Without the use of chemicals hardeners, the hammers would have a mellow tone throughout the entire range of dynamics.

High tension and low tension hammers are analogous to throwing a fully-inflated basket ball vs. throwing under-inflated basket ball against a wall. Each ball has a different speed at which it is able to return from the wall, based on how fast it is thrown. Accordingly, each ball also produces a different range of sounds based on how fast it is thrown against the wall.

Figure 20: Dampers

2.12. Dampers

The damper (Figure 20) is a piece of felt that controls the cessation of the string's vibrations. Dampers are individually raised and lowered by the back of the key as they cross the halfway point of the keystroke. The speed and timing of the damper return makes a big difference in the quality of the articulation (i.e., the length of the note's decay). The dampers can be raised as a unit by pressing the damper pedal, or using pressing the sostenuto pedal to sustain specific notes once they have been struck.

The weight of the dampers varies throughout the piano by adding lead to the damper levers: heavier dampers are found in the bass and lighter dampers in the treble. The damper is weighted according to the length and mass of the strings. It is important to note that the top 1-1½ octaves on the piano do not have dampers to stop the sound of the vibrating strings. Without dampers, it is impossible to create any differences in articulation: the acoustic difference between *legato* and *staccato* does not technically exist in this section of the piano. In terms of sound production, it is meaningless for the pianist to hold the keys down to create longer durations in the highest octave of the piano.

CHAPTER 3: HOW THE PIANO WORKS

The basic operation of the piano action is a system of three levers that produces a mechanical advantage by providing rapid acceleration of the hammer from a small amount of motion at the front of the key.

Upon close inspection, we can say that pianos are made from the same materials, using the same parts, and put together, essentially, in the same manner. How then, can there be such substantial differences between the touch and sound qualities of pianos? In order to help explain this, I would like to reference a study that looked at the functional DNA differences between humans and chimpanzees. The study found that 99.4% of the critical DNA sites are identical in the corresponding human and chimpanzee genes (Hecht 2003).[18] Only 0.6% of the critical DNA sites accounts for the obvious biological differences between us and the chimpanzees!

This poignant example emphasizes that the critical parts of the DNA structure that makes us so strikingly different is proportionally so tiny, but it also acknowledges that the "junk" parts to the chimpanzee DNA genome, while technically different from human DNA, is "non-coding" and thus "non-biologically critical."[19]

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[18] The 2003 Newscience article looked at what the author considered the most functional DNA sites (i.e., the bases which cannot be changed without a consequent change in the amino acid coded for by the gene). He found a lower correspondence for bases that could be changed without affecting the amino acid, with 98.4 percent identical for chimps and humans; he found the same for the "junk" DNA outside coding regions. Goodman believes the differences are larger for non-coding DNA because their sequences are not biologically critical.

[19] These differences are not the active parts that biologically make us different from chimpanzees.

What makes a piano feel and sound different is proportionally just as small as the DNA example. The critical differences in the piano are found in small variations in leverage throughout the action geometry. Visually, the action parts look identical in nearly every piano; without using a micrometer and scale, these differences would go unnoticed by even the trained eye of a piano technician. A very small error in the action geometry alignment can have a huge impact on the feel and resulting sound of the piano. In my view, New York Steinway does not make actions that feel and sound consistent from piano to piano; each of the action parts differ slightly in dimension, weight, and alignment to produce a different overall feeling and sound.

3.1. Levers

A first-class lever has the fulcrum (i.e., balance rail) located between the input effort and the output load (see Figure 21). When the fulcrum is off-center, as it is in the piano action, the output load (i.e., the capstan) moves a smaller distance than input effort (i.e., the keydip). Other examples of first-class levers are a seesaws, scissors, and pliers.

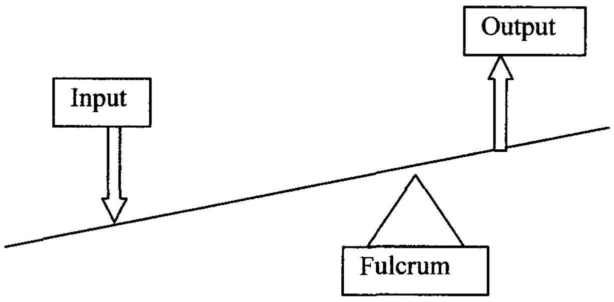

Figure 21: A First-Class Lever

Third-class levers have the input effort between the fulcrum (i.e., the centerpin, in the case of the whippen and the hammer assembly) and the output load (see Figure 22). For both the whippen and the hammer assembly, the input effort, whippen heal and the knuckle, is between the centerpin and the output load. All third-class levers increase the output load. Other examples of third-class levers are tweezers, tongs, boat paddles, and staplers.

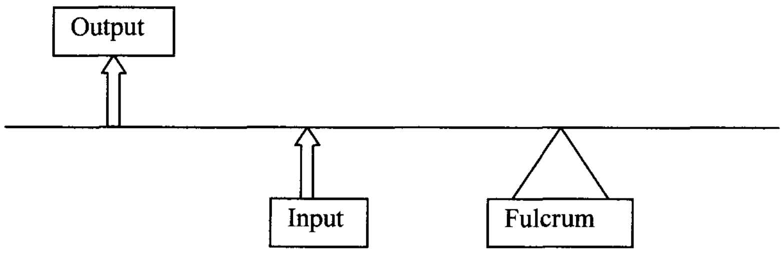

Figure 22: A Third-Class Lever

3.2. Action Geometry

The leverage ratio can be defined as a ratio between the speed of the hammer and the speed of the key. Generically, we can talk about the potential leverage that the action geometry is able to produce at the beginning of the keystroke. This is calculated using a very straightforward mathematical model. Because the contact points travel in arcs, and not straight up-and-down, this ratio decrease throughout the keystroke.

Assuming the standard blow distance and keydip,[20] the extremes in action geometry leverage can range between 3.9-7 times the speed of the key at the beginning of the keystroke. The amount that this ratio decreases throughout the keystroke can be as little as 0.7 to as much as 2 (Snook 2009). (e.g., Action geometries that are set at 3.9

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[20] 45-47mm for the blowdistance and 9.4-10.7mm for the keydip.

times a difference at the top of the keystroke may only be 3.2 times at the bottom, whereas actions geometries set at 7 times may be around 5 times at the bottom of the keystroke.)

In high leverage, there is a big difference between the top and the bottom of the keystroke. The pianist will feel that the keys are very heavy at the start of the keystroke. High leverages makes soft playing very difficult; this effectively decreases the potential range of softer playing dynamics and increase the potential range of the louder dynamics. If a pianist is after the loudest possible sound from the piano, as is the case with the piano concerto, a high action geometry leverage is ideal. It does, however, require a more aggressive style of playing in order to draw the most sound out of the piano.

Lower leverages, overall, produce a much more satisfying result for both the pianist and the audience. The only drawback to lower leverages is a difficultly in achieving and maintaining very loud dynamic levels; this should not be an issue as long as the piano is not in a huge performance space or fighting against other loud instruments (e.g., brass instruments). Lower leverages produce a smaller difference in ratio throughout the keystroke. This makes repetition in-the-key easier at louder dynamics and gives overall greater control at the bottom half of the keystroke. The initial resistance of getting the key to begin moving is significantly reduced, which significantly aids in soft passages that use only the top half of the keystroke. The most important aspect of having lower action geometry leverages is that the softer dynamic ranges are dramatically expanded using the typical keyspeeds; louder dynamics are also possible, since there is less resistance (i.e., but the pianist really needs to work hard to create a fast keyspeed). Since lower leverages require slightly more keydip (i.e., 10.7mm as opposed to the 9.4

with the higher leverages), the pianist also has a longer distance under which they are able to control the hammer via the keystroke. This effectively increases the pianist's overall ability to create a larger range of artistic nuances.

3.3. Hammer Weight

Modern hammers are significantly heavier than their earlier predecessors: hammers graduate from around 11gm at the lowest bass note to 5gm at the highest treble note. Piano hammers in the 1850s had less overall in mass: 4gm to 2gm. The earliest fortepiano hammers weighed even less: 1gm to 1/2gm in the last treble (Forss 1998).

Hammer weight has a significant impact on how heavy the keys feel to the pianist, how much volume the piano is able to produce, and how fast the piano is able to repeat. The action is designed to accommodate only a certain amount of weight at the end of the hammershank. Once this weight limit is reached, there is not enough blow distance to accelerate the hammer to the required velocities. Action geometries with higher leverage ratios will feel disproportionately heavy to the pianist. This can make the keys difficult to control, especially during the beginning moments of the keystroke. Even 5gm already begins to test the boundaries of how much weight the piano action can fully accelerate. The modern action is significantly over loaded, which explains its heavy feel and overall poor performance as compared to earlier pianos.

3.4. Continuous Repetition Speed

The following repetition data was complied on a Bösendorfer 290 concert grand piano that is kept in concert level conditions. The data represents the upper limit of continuous repetition possible in each section of the piano; shorter bursts of additional speed are possible, but are not easily sustainable. The amount of keydip was varied in order to obtain optimal results in each section: repetition near the top of the key is necessary in the bass, repetition near the middle of the key is necessary in the middle sections, and repetition near the bottom of the key is necessary in the descant section. These repetition speeds are based on a well-regulated instrument using standard hammer weights; if the regulation is not absolutely perfect, the pianist should expect repetition speeds to be significantly slower.

Descant Section 9 ½ repetitions/second (M.M. ♩ = 144)

Melodic Section 9 repetitions/second (M.M. ♩ = 135)

Middle Section 8 ½ repetitions/second (M.M. ♩ = 128)

Bass Section 8 repetitions/ second (M.M. ♩ = 120)

Experiment: Speed of Continuous Repetition

3.5. Continuous Playing Speed

The next experiment represents the upper limitations of continuous playing speed. It is a good indication of how fast the instrument is able to be played. A continuous descending and ascending scale in C-Major was played in each octave of the piano.

Octave 7 = 25 notes/second (M.M. the half note = 184)
Octave 6 = 19 notes/second (M.M. the half note = 144)
Octave 5 = 16 notes/second (M.M. the half note= 120)
Octave 4 = 15 notes/second (M.M. the half note = 112)
Octave 3 = 14 notes/second (M.M. the half note = 104)
Octave 2 = 13 notes/second (M.M the half note= 96)
Octave 1 = 12 notes/second (M.M. the half note= 90)

Experiment: Speed of Continuous Playing Scale in C Major

Notice that the playing speed drops off dramatically after the first octave, a 24% reduction in speed, and then again for the next octave, an additional 12% reduction in speed. Pianists should demand that piano manufacturers use lighter hammers that conform with the original design limitations of the 1850s whippen. Repetition and playing speeds are much easier to control once the pianist is accustomed to the overall lighter touch response.

Horowitz was well-known for having extremely light hammers installed in his piano: "Horowitz required precisely 44 grams of key resistance, but full-size hammers were too heavy for an action of this gram-weight; the average Steinway is weighted to approximately 50-55 grams. The result is an extremely fast action that is difficult for most pianists to control at first because they are accustomed to other pianos that have greater resistance to the fingers (Hughes 1996, 32)."

If pianists begin requesting lighter hammers again, overall repetition speeds can be improved. Increased repetition speeds are always welcomed by pianists, so lighter hammers are usually desirable.

3.6. Jack Position

If all of the components of the action geometry are set up correctly, the back of the jack should line up with the back of the knuckle when in the rest position. The jack should also line up with the mark that is indicated in the repetition lever window; this usually forms a 90 degree angle with the repetition lever.

The picture (Figure 23) is an example of proper jack-to-knuckle alignment. The action spread[21] has been modified on this piano so that the parts line up correctly. It is rare to find a piano where these parts line up correctly; it serves as visual confirmation that refining the alignment of the action geometry will produce a better result for the pianists at the keys.

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[21] The distance between the hammer shank and whippen centerpins: typically set around 111-113mm.

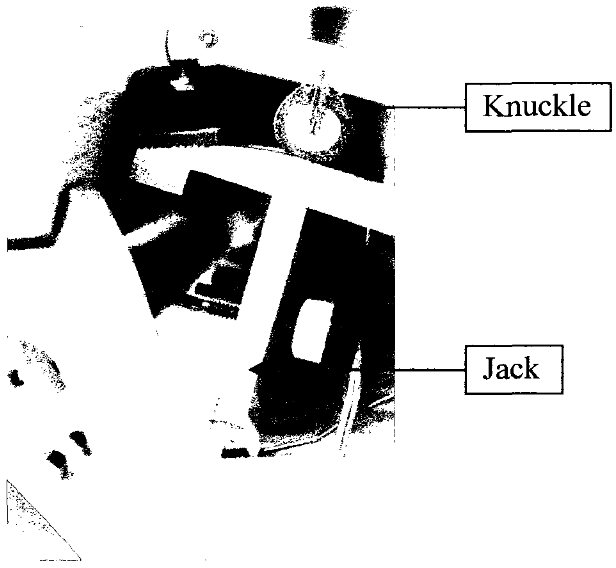

Figure 23: Jack Position

3.7. Aftertouch

Aftertouch can loosely be defined as the distance that the action parts continue to travel after escapement has occurred. From the standpoint of function, aftertouch is the means by which the jack sufficiently clears the knuckle (see Figure 24); this prevents the knuckle from rebounding off the top of the jack and causing the hammer to restrike the string. Aftertouch is the result of adjusting the height of the hammers at rest, the point at which escapement occurs, and the total distance that the keys are allowed to travel.

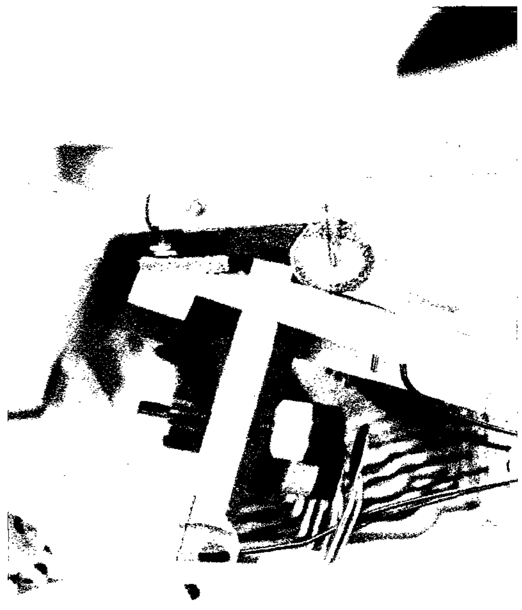

Figure 24: Average Aftertouch

Larger aftertouch adjustments begin with overall changes to the height of the hammers, followed by finer adjustments to the keydip to compensate for key-to-key irregularities; small irregularities in the dimension of the parts and in the alignment of the action parts account for aftertouch variation proportionally. Letoff has the largest effect on aftertouch, but it is an aspect of regulation that generally should remain unvaried. Concert pianos typically have letoff set so that it is extremely close to the string. This allows for the best control during soft passages and in-the-key repetition.

Minimal aftertouch produces the fastest possible repetition and best control over the hammer as the key nears the bottom of the keystroke. During loud passages, however, the sudden impact can feel jarring to pianists. Minimal aftertouch also has the tendency to make the action feel heavier than it actually is; pianists are taught to relax after they hear the sound, not after they feel the impact with the bottom of the key. This results in the pianist pushing down on the key for longer than is necessary and quickly begins to manifest itself in the form of excess body tension.

Adding more aftertouch better offsets the time delay produced by the sound of the hammer and the impact of the key during loud playing. The more aftertouch that is present in the action, the later the impact of the key will be in relation to the sound of the hammer during loud playing. This additional timing produces a cushion-like effect that pianists with a heavier-handed playing style generally prefer. It is especially helpful in large concert halls when the piano is being used in a concerto setting.

As long as the knuckle can push the jack forward and not rebound off the top of the jack [minimum aftertouch (see Figure 25)], and the hammer does not re-rise to contact the string [maximum aftertouch (see Figure 26)], everything in-between is really up to personal preference and playing style of the individual pianist.

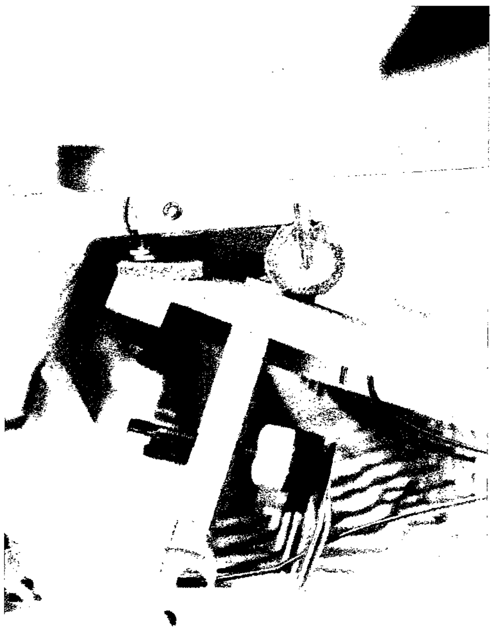

Figure 25: Minimal Aftertouch

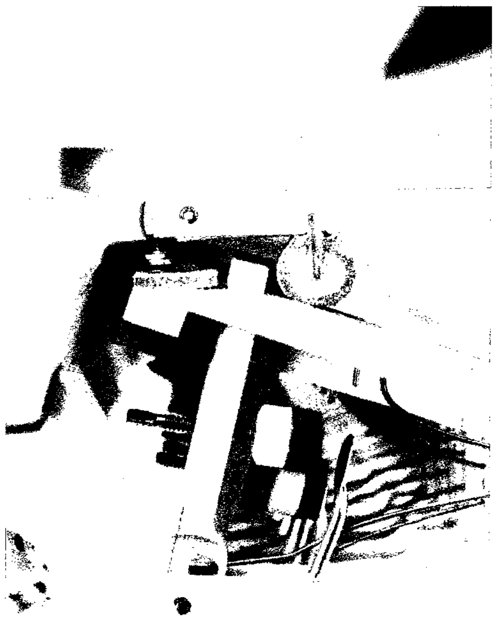

Figure 26: Maximum Aftertouch

The problem with maximum aftertouch is less control over the hammer as it nears the bottom of the keystroke, a worse response with in-the-key repetition, and an increased difficulty in controlling softer dynamic levels.

Franz Mohr described Glenn Gould's obsession for excessively shallow aftertouch in his book. Gould's aftertouch preference gave him many advantages (e.g., control over the key for a longer period of the keystroke, better in-the-key repetition, better control over the hammer speed near the end of the keystroke, better control in the softer dynamic ranges, etc.), but it also pushed the piano to its limits. Mohr constantly had to deal with the problems associated with not having enough aftertouch: when the jack does not clear the knuckle, it causes the hammer to rebound off the jack and "dance between the strings and the back-check (Mohr 1996, 77)," but it also causes the action parts to wear out prematurely and need more frequent attention to the regulation.

3.8. Backcheck

The backcheck (Figure 27) is a fundamental component of the action that dates back to the origin of the piano, Cristofori's fortepiano. The backcheck is essential to prevent the hammer from rebounding uncontrollably between the string and the restfelt. Without the backcheck in place, there would be nothing stopping the movement of the hammer and preventing it from rebounding into the string.

Figure 27: Backcheck

With the advent of the double repetition action,[22] the backcheck took on an important secondary function. In order to allow the double repetition action to function properly, the hammer needs to be caught high enough so that the action is allowed to reset itself low in the keystroke.

The angle and position of the backcheck is regulated by placing bends in the wire. When caught by the backchecks, the height of the hammers should be 15mm from the strings; hammers can be set to check as high as 10mm to accommodate for personal preference.

Consistent backchecking is hard to achieve on most pianos. Ideally, pianists should see the hammers checking consistently throughout the entire piano, and

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[22] Sébastien Érard double escapement action of 1823

throughout each of the dynamic levels. The most important concern is that the hammers go into check even at the softest dynamic levels.

Aftertouch has a significant impact on backcheck functionality. A small amount of aftertouch means that the key will bottom-out immediately after escapement occurs. This necessitates the backcheck being regulated closer to the hammer when at rest to accomplish sufficient height when in check. Doing so, however, has a tendency to cause the hammer tails to rub against the backchecks on their way towards the string. This is especially apparent on loud blows (Snook 2009).

Additional aftertouch allows the key to continue to rotate after escapement. This puts the backcheck in a position that is proportionally higher and closer to the hammer, as compared to the rest position. This allows for more consistent results throughout the action.

Pianists should routinely check for backcheck consistency. The height of the hammer in check is critical for proper repetition and the pianist's perception of touch (Figure 28). If hammers check inconsistently, the resultant uneven "bumps" felt by the pianist in the key can be misinterpreted as inconsistent action response. Even though this occurs after the sound is produced, and has no direct effect on the sound, pianists may still try to compensate for this unevenness.

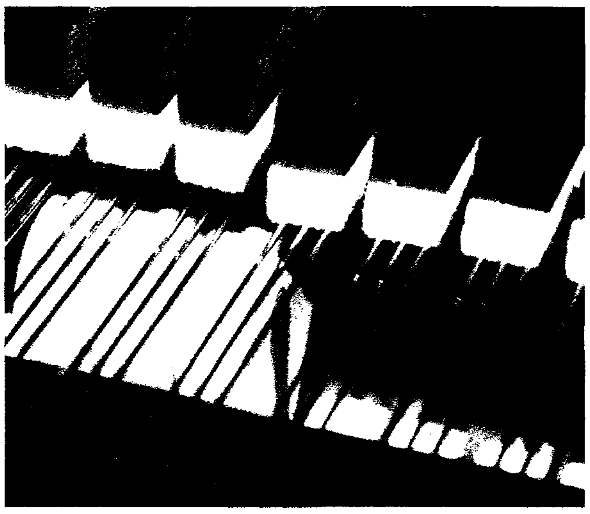

Figure 28: Backcheck Height

3.9. Repetition Lever and Spring

The repetition lever is the crux of the double repetition action design. The repetition lever, in conjunction with the repetition spring, supports the weight of the hammer and is what allows the jack to slide underneath the knuckle during mid-keystroke.[23]

The repetition lever is under constant tension of an upward pushing spring. The natural tendency for the repetition lever is to creep higher as the piano ages and the felts compress. Remember: the jack propels the hammer towards the string, not the repetition lever, so any space between the jack and the knuckle represents wasted energy/time/space for the pianist. If the jack is set slightly higher than the repetition lever, the system will not function: the jack will not be able to slide underneath the knuckle. To ensure the piano always functions, it is standard for the technician to err slightly on the side of a

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[23] Other popular action designs, like the Viennese action necessitated a full key return before the note could be replayed.

high repetition lever height. This, however, is at the expense of ideal repetition and consistent touch. Concert pianists should ask that the repetition lever be regulated so that the jack and repetition lever are at the same height (Snook 2009).

The repetition spring is an important aspect of the double repetition action design. Without the repetition spring, the system would not function: there would be nothing pushing up on the knuckle, allowing the jack to slip back into position. The repetition spring, however, was not a significant development in action design. The "English action[24]" has always required the use of a spring to reset the jack after escapement. The double repetition action design extends the functionality of the jack spring by requiring it to perform a secondary responsibility: the same spring pulls back on the jack and pushes up on the repetition lever.

The significance of the double repetition action is that it allows the jack to reset after escapement, without necessitating a full return of the key. This is accomplished through the repetition lever and spring: the spring supports the weight of the hammer, allowing the jack to slip underneath the knuckle, after only a few millimeters of key return. This double repetition action design is what makes in-the-key repetition possible.[25]

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[24] Cristofori's laid the foundation for what would later develop into the "English action." Silberman developed a different action design during the same period of time; this action later develops into "the Viennese action." While the English action finally won out, these two schools of action design existed side-by-side from the beginning.

[25] In-the-key repetition is "sustained" because the damper is not allowed to fully return to the string.

3.10. The Damper System

The damper system is responsible for bringing the string vibrations to a controlled stop. Felt that is too hard lacks the ability to create the necessary amount of distinct shading variations, but it is also accompanied by audible noises on contact; felt that is too soft deform quickly under the weight of the dampers and becomes compressed prematurely, but it also takes longer to come off the strings.

The damper assembly[26] consists of the damper felt, the damper head, a bendable wire, and a weighted damper lever (see Figure 29). Pianists should be aware that the damper system is easily misaligned when the damper heads are handled. The wire that connects the damper head to the damper lever is intentionally malleable; the wire is bent in various directions to regulate the orientation of the damper head and allow for proper damper travel.

Figure 29: Backaction

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[26] The damper assembly located in the action cavity is often referred to as "the back action."

The damper lever has two important responsibilities: 1. coordinate the individual damper timings so that the levers make simultaneous contact with the damper tray, and 2. set the individual damper timings at the key to ensure that each damper begins to lift at half the distance the key travels.

The back actions of some well-known piano manufacturers continue to be significantly outdated. Manufacturers such as Bösendorfer and Kawai that pride themselves in the functionality of their damper system install capstans and bendable-spoons on each damper lever (Figure 30). The capstans allow for very fine adjustments that ensure a perfect timing with the pedal, and the bendable spoons allow for a separate adjustment for the individual damper timing at the key. The outdated system allows for only one, rather crude, means of adjustment; it is practically impossible to compensate for both adjustment issues.

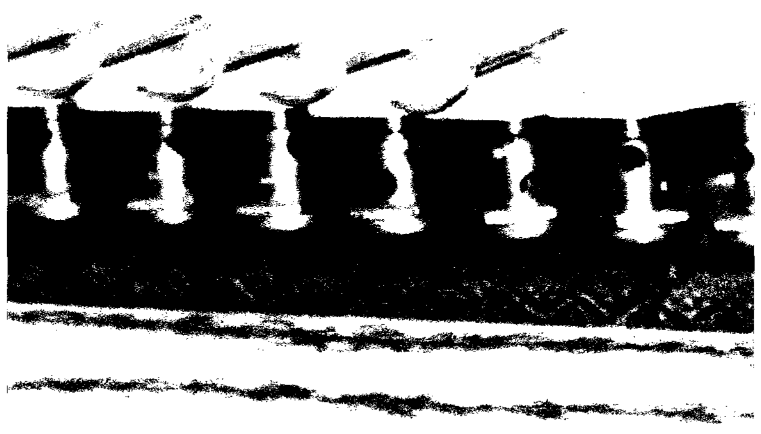

Figure 30: Damper Levers

The speed and timing of when the felts begin to touch and when their full weight is resting on the string can make a big difference in the cessation of the sound. This is true for both the damper pedal and the damper timing at the key. The standard specification for damper timing at the key is half the distance of the keydip (i.e., typically around 5mm).

The damper timing at the key has significant impact on how reverberant the piano sounds, the ease at which a pianist is able to finger pedal a repeated note, and how heavy the keys feel to the pianist during playing. The damper should begin to come off the string as the key crosses the halfway point of the keystroke; the damper returns at this same point as the key to returns to the rest position. The speed at which the damper felts touch the string and when their full weight is resting on the string makes a substantial difference in how the cessation of the sound is created.

The damper timing at the key is not an absolute setting; there is flexibility to accommodate personal preference or to match the acoustical requirements of the performance space.

Earlier damper timings at the key facilitate easier finger pedaling, especially the sustained in-the-key type of repetition. The two main drawbacks of early damper timings are 1. an increase in the overall note durations, but more specifically, an increase in the length of the shortest note that is able to be articulated, and 2. the pianist must lift the weight of the damper assembly from an earlier point in the keystroke without being able to rely on the momentum of the key. This type of damper timing is useful in a non-reverberant space, where a wetter sound can be used to the advantage of the pianist.

Later damper timing at the key makes finger pedaling much more challenging; it also makes sustained in-the-key repetition impossible. The upside of later damper timings is that the overall note duration is decreased; it specifically allows for a much shorter articulation than what is normally possible. Since the damper assembly is lifted late in the keystroke, the pianist is able to rely more on the momentum of the key to help lift the weight of the damper, making the keys feel lighter. This type of damper timing is helpful in performance spaces that are particularly reverberant.

3.11. The Damper Pedal

The right pedal is the most overused pedal on the entire piano: the damper pedal is responsible for lifting all of the dampers off the string as a single unit. The main function of this pedal is to add reverberation to the sound of the piano. It is not intended to "connect the notes." Its use should typically change based on the acoustical requirements of the performance space: a dry space will necessitate using more pedal and a live space will necessitate using less pedal.

In order to facilitate fine pedal work, it is essential that the damper pedal controls the simultaneous movement of the dampers; the dampers must come off of the strings at the exact same moment in time, but equally as important, the dampers must make contact with the strings at the exact same moment in time on the return. The ability to control the initial movement as the dampers begin to move away from strings deals with controlling tonal resonance; the ability to control the final movements of the pedal as the dampers are allowed to return to the strings deals with controlling the cessation of sound. Pianists should be mindful that this one pedal serves these two functions every time the pedal is engaged. Good pedal technique includes the ability to control very fine gradations of engaging AND disengaging the damper pedal using various speeds.

The damper pedal and the keydip are both typically set to move the same distance about 10mm, the length of the thumb nail. The function of the damper pedal changes throughout the pedal stroke and can be divided into three phases: 1. stationary dampers, 2. moving dampers that are in contact with the strings, and 3. moving dampers that are not in contact with the strings.

During the initial movement of the damper pedal, the dampers should remain stationary on the strings. This small amount of wasted-travel ensures that the full weight of the dampers is resting on the strings. When this space is minimized, the piano often develops problems with notes ringing longer than they should; the problem usually is manifest in a few problematic notes. The exact amount of wasted-travel is discretionary, but it typically occupies the first 2-3mm of damper pedal travel.

The second phase of damper pedal travel is very significant: it controls the amount of weight that is resting on the strings. The more weight that is allowed to rest on the strings, the faster the strings will come to a rest; the less weight that is allowed to rest on the strings, the longer the strings will be allowed to speak. The second phase of pedal travel depends on how elastic the damper felt is; the fluffier the felt, the longer it will take for the pedal to clear the strings. Typically, the distance will occupy no more than 2-3mm of the pedal travel. A tremendous amount of fine pedal work can happen in this small amount of space; a well-trained pianist can control five or more distinct shades of variation on a finely regulated piano.[27] Sadly, fine damper regulation is an aspect of concert piano preparation that often gets overlooked. Uneven damper lift is the standard rather than the exception; pianists are then forced into adopting the more common on-off style of pedaling technique.

The final phase of damper travel occupies approximately 4-5mm of pedal travel. This extra clearance ensures that the strings do not touch the bottom of the damper felts on a loud *fff*. Not having enough clearance could weaken the intensity of the sound as the strings oscillate at their maximums. As long as there is enough clearance between the damper and the string, the objective of this phase has been satisfied. Having too much clearance than what is necessary usually results in sloppy pedal work[28]. It should be noted that excess pedal travel adds to the overall length of the resonant sound quality: the longer it takes to reach the bottom of the pedal stroke, the longer it will take for the pedal to return so that the dampers can stop the sound. Even a small amount of excess pedal travel can result in an overall sound that is surprisingly less distinct.

3.12. The Sostenuto Pedal

The middle pedal on the piano is the least utilized and most misunderstood pedal on the piano; the sostenuto pedal allows for notes to be sustained without having to hold the key down with the finger. Instead of raising the dampers, as is the case with the

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[27] Most pianists have heard of at least two of subtle shades of pedal variation: they are erroneously referred to as "quarter pedal" and "half pedal" in much of the piano pedagogical literature.

[28] Just because the pedal can be pressed down further to achieve additional travel, it doesn't mean that the pianist must go to the bottom of the pedal stroke. Feeling the bottom of the pedal stroke, however, is important feedback for the pianist to know when they have reached the necessary limits.

damper pedal, the sostenuto pedal prevents the return of the dampers that were actuated by the key. This pedal is best viewed as an extension of finger pedaling technique. It allows the pianist to connect notes that otherwise would necessitate the use of the damper pedal; the damper pedal adds a sudden spike in moisture to the sound. There are many instances in the piano literature where sound clarity is at a premium; this kind of clarity can only be obtained if the use of the damper pedal is kept to a minimum.

The sostenuto pedal is best utilized in slower tempos; it takes a certain amount of time and coordination to actuate the pedal after the keys have been depressed. The sostenuto pedal is a great candidate for choral-like passages, anytime there are large jumps in register, or even passages that contain double octave movements.

A secondary function of the sostentuto pedal allows for specific notes to be sustained, while other notes, not activated by the sostenuto pedal, are performed with a variety of articulations.

There is one word of caution that should be mentioned about the use of the sostenuto pedal: when the sostenuto pedal adjustments are even slightly misregulated, there are a number of serious problems that the pianist should expect to encounter.

The sostenuto pedal's sweet-spot, which is analogous to a clutch in a manual car, can be significantly displaced, either high or lower, within the pedal stroke. Even when properly regulated, the sweet-spot is likely to be in a slightly different location on every piano. Pianists utilizing the sostenuto in their performances need sufficient time to acclimate themselves to the manner in which that particular sostenuto pedal functions. One common problem with a misregulated sostenuto is that a few individual notes will fail to sustain, or even worse, the sostenuto pedal will sometimes lift the dampers in an entire section.

3.13. The Una Corda Pedal

The left pedal on the piano, the una corda, is responsible for shifting the entire keyboard to the right a few millimeters: it is the most misused pedal on the piano. By moving the keyboard over slightly, we are potentially able to accomplish two things: 1. the strings will make contact with the hammer at different contact points, and 2. only two of the trichord strings will make contact with the hammer.

Changing the contact points where the strings hit the hammer is beneficial in that it allows the technician to create a different style of voicing for this new position. When a technician voices a hammer, they do so at each contact point. This means that the technician can control the voicing profile for each string in each position, as long as none of the contact points for the normal position and una corda are allowed to coincide (i.e., as long as the keyboard is not allowed to shift too far). Ideally, the keyboard is shifted over only so much so that the strings make contact with the hammer at a new point that is exactly in the middle of the contact points of the normal position. This separation helps to ensure that the voicing work that is done for the una corda position does not unduly affect the voicing of the normal position.

Eliminating one of the trichord strings in the una corda position is ideal. The impact of losing one string changes the sound envelope slightly so that there is a little less attack and a little more emphasis on the decay portion of the tone; the perception of how the piano projects is somewhat modified to create a more sustained feeling.

Unfortunately, since modern piano hammers have become so wide, it is not always feasible to create both situations simultaneously. When this is the case, the most important aspect to have is control over the voicing, not the elimination of one string.

Una corda voicing is typified by a mellow, subdued texture throughout the entire dynamic range. The use of the una corda pedal will, by its very nature, bring about a tone on the piano that is softer; this misunderstanding, however, leads many pianists to use this pedal incorrectly. It should not be used as a "soft pedal," or a means by which the pianist forces the instrument to speak at softer levels: it is a tool that gives the pianist access to additional colors and textures that are typically not found in the softer dynamics. The voicing is intended to create an overall diffuse texture; it is not well-suited for dynamic contracts between voices nor is it well-suited for louder dynamics (i.e., it is difficult for the technician to control this mellow texture at the louder dynamic levels).

In order to maintain the necessary clarity in the normal position, and create the additional warmth in the una corda poisition, the una corda should be viewed as an on-off pedal. The use of the una corda pedal should be deliberate and intentional.

Using gradations between the two positions will often result in unexpected colors randomly popping through. This is especially true with pianos that use hammers with artificial hardeners (e.g., New York Steinway). If the technician is not careful to check every gradation of every string, it is common to have a few strings that will strike a hard spot of the hammer at some point of the gradation. This typically manifests itself as a harsh metallic tone quality.

Pianos that are specifically intended for use with orchestra have the potential to be set up with a different style of voicing. From the standpoint of orchestration, the piano plays an entirely different role when it is in a concerto situation. A large range in color from the piano is not the emphasis in a piano concerto: the piano should portray the "stereotypical" piano sound. The expanded range of warmer color that is necessary in the solo piano literature (i.e., the warm, fuzzy qualities of the softer dynamics) would be covered by the sounds of the orchestra. A concerto piano needs to be set up with an emphasis on clarity and maximum volume; a pianist is always in need for more volume in this kind of situation and the voicing should not be sacrificed for a large range in color. In contrast, the voicing of the una corda pedal can then be set up to mimic the sound of a typical solo piano (i.e., access to a wide range of colors throughout the dynamic range). This allows the pianist to engage the pedal anytime throughout the piece to access warmer colors, without including any of the muddy textures that are normally associated with the una corda sound. Use of this pedal becomes especially useful in cadenza-like situations, giving the pianist access to a more typical range of soloistic colors.

CHAPTER 4: PIANO TECHNIQUE

In order to promote healthy technique that minimizes wasted effort and maximizes the control over the sound, pianists need to understand the inner workings of the piano. This chapter is devoted to highlighting the difference between the physiology of piano technique (i.e., what needs to be done to the piano to create sound), and the kinesiology of piano technique (i.e., how the body should move to create sound at the piano).

4.1. The Dynamics of the Descending Key

The quality of sound produced from the piano is based on the speed of the descending key. "Subtle control of hammer speed requires sensitive touch control of the descending key. A fine artist, however, has the sensitivity of touch to get many variations in dynamics through appropriate variations in key-hammer speeds (Levin 1967)." For developing the sensitive touch, we will discuss how different keystrokes can influence a tone quality and piano technique.

The volume of piano sound is determined by the speed of the descending key, and in return, the hammer velocity. Many pianists misunderstand how to make a loud sound on the piano; it does not matter how hard or how heavy the keys are hit. Pianist Gyorgy Sandor states: "It is [key]speed that generates sound, not weight. A maximum fortissimo as well as the lightest pianissimo can be produced…in a completely effortless manner (Sandor 1981, 8). In this context, the speed does not relate to tempo (i.e., the pacing of music). Vladimir Horowitz made the following remarks, "the instrument is capable of sounds which are loud and soft, but in between there are many, many degrees of sounds which may be played. To be able to produce many varieties of sound, now that is what I call technique, and that is what I try to do (Mach 1991, 117)." When one presses the key down quickly, the hammer travels faster to produce louder sounds; when one presses the key down slowly, the result is a softer sound. If one presses the key too slow, however, it may fail to produce sound because the hammer velocity is not fast enough to reach the string. Playing the piano in soft dynamic range is always challenging for pianists.

There is a direct correlation between dynamics and tempo: a pianist is limited to how soft they are able to play based on the tempo of the piece. The faster the tempo, the more difficult it is to press the key down slowly (i.e., there is not enough time to press the key down slowly enough to produce a soft sound). In order to achieve softer sounds at faster tempos, pianists must utilize only a portion of the keydip in order to keep up with the tempo. This adds an extra variable to performance technique that makes consistency difficult.

4.2. The Basic Descending Keystrokes: TBT, TMT, MMM, and MBM

There are two main things that should be paid attention: different key speed, and different amounts of key travel. The key dip is normally allowed to travel 10mm. Pianists are dealing with such a short distance of travel: the thickness of a CD jewel case! Pianists should be able to use different amounts of key travel to their advantage: from the key top to the key bottom, from the top to the middle, from the middle to the bottom, and everything in between.

There are essentially four basic keystrokes: what I call TBT (top-bottom-top), TMT (top-middle-top), MMM (upper/middle-lower/middle-upper/middle), and MBM (middle-bottom-middle). In addition to controlling subtle variations in keyspeed, pianists must also be able to control variations in the amount and position of the keystrokes.

The standard keystroke is the TBT keystroke. This is the only keystroke that uses the entire 10mm of the available keystroke. Pianists are encouraged to pay particular attention to being able to "feel the bottom" of the keystroke in passages that need to be projected. In the opening of Liszt's *Réminiscences de Norma (Bellini)*, the TBT strokes can be used (Figure 31).

Figure 31: Liszt's *Réminiscences de Norma (Bellini)*, mm.1-8

The TMT is the next most common keystroke. When playing fast passages, especially in softer dynamic levels, there is not enough time to press the key down entirely and also create a soft volume in a fast tempo. This is usually used with the damper pedal, but it is also used without the damper pedal in *staccato* passages.

The *staccato* passage written *sempre presto* and *sempre pp* in Liszt's *Gnomenreigen* (Figure 32) is a good example of the TMT stroke. If the pianist uses the full keystroke, the performance will either be too loud, which is typically the case, or too slow. To play this *staccato* passage successfully, the pianist must use the top half of the keystroke in order to create the indicated dynamic and tempo. The finger should be kept close to the key to avoid wasting energy, and to prepare for the next notes. This virtuosic passage is a strong example of how the knowledge of piano technology facilitates better performance technique.

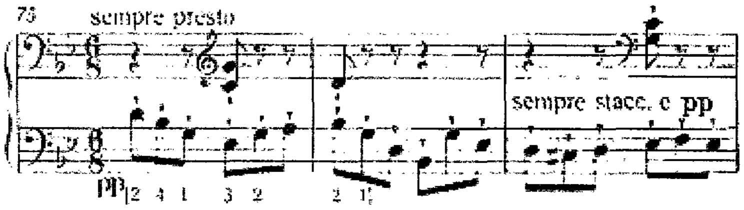

Figure 32: Liszt's Gnomenreigen, mm.75-77

Another example of the TMT stroke can be seen in Ravel's *Alborada del gracioso* from *Miroirs* (Figure 33). This piece has one of the most challenging passages of quickly repeating notes. If this is played at M.M. ♩.=192, the notes must be repeated about 9 times per second. The keystroke should be just fast enough to let the hammer strike, and just deep enough to let the damper barely come off the string. No matter how adept the pianist, performing these notes in *ppp* will always tax the instrument's capacities.

Figure 33: Ravel's *Alborada del gracioso* from *Miroirs*, mm.41-51

The left hand octave passage in Chopin's *Polonaise op.53* (Figure 34) is another great challenge for pianists; it is difficult to keep a consistent tempo, within the same dynamic level. In order to create the effect of *sempre staccato*, the damper rise and fall should be minimized. The only way to do this is to ensure that the fingers do not reach the bottom of the keystroke (TMT).

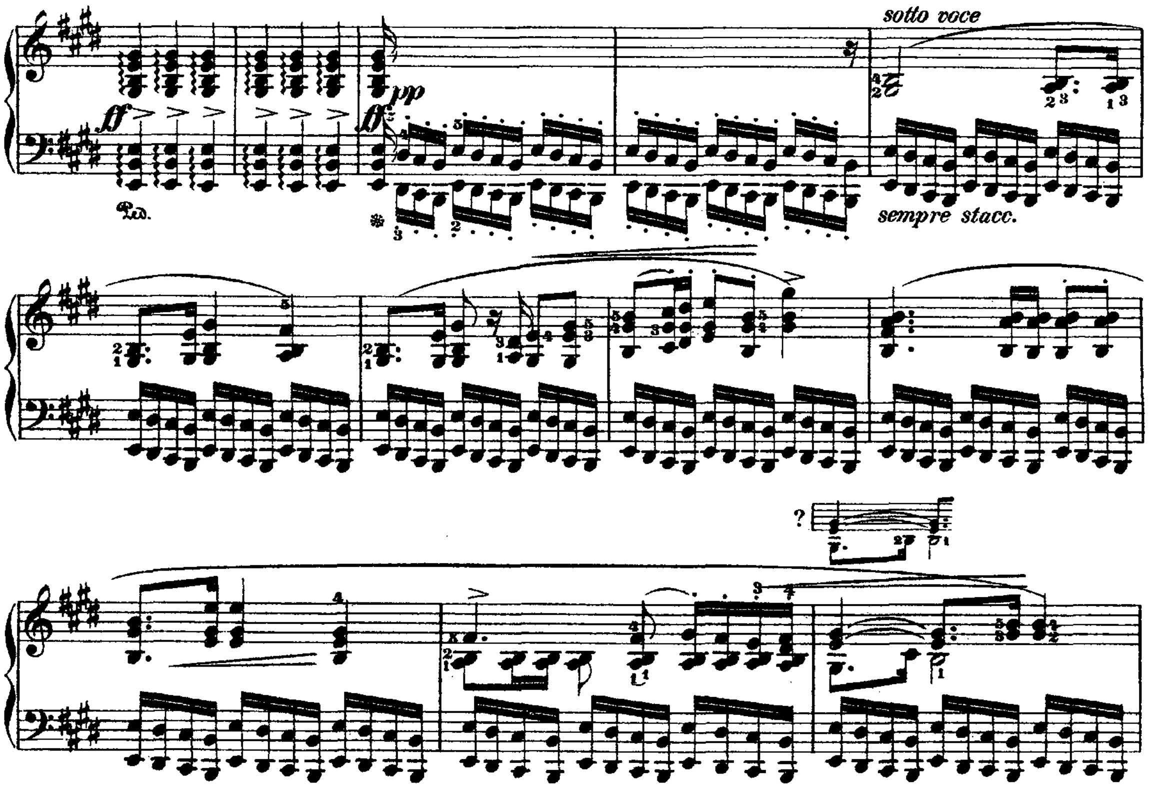

Figure 34: Chopin's *Polonaise op.53*, mm.81-92

There is not enough time to play these chords from above the keys to create a loud sound. Instead, the pedal should be used to accumulate the sound. In doing so, the fingers should not reach the bottom of the keystroke. If the notes are played too deeply in the keystroke, there will not be enough time to re-articulate the notes in tempo.

The MMM and the MBM keystrokes are reserved for two different styles of in-the-key repetition. Repeating from within the middle range of the keystroke, is a very difficult technique to master, but is very useful in tremolo types of situations. The MBM is the standard in-the-key repetition, used especially when clear articulation is necessary.

Repeated notes in Liszt's *Hungarian Rhapsody No.13* (Figure 35) are normally played around M.M. ♩=138; this equates to around 10 single note repetitions per second. Repeating 10 times per second in the middle section of the pianos is over the limits of what the modern piano with standard hammers can do. In order to play *leggiero*, the key motion should be minimized and played as followed: each of the repetitions with upward stems should be played at the bottom (MBM) and the subsequent repetitions should be played in the middle of the key (MMM).

Vivace
v

Figure 35: Liszt's *Hungarian Rhapsodie No.13*, mm165-166

4.3. Loud Repeating Chords

Repeating loud chords in Tchaikovsky's first Piano Concerto (Figure 36) requires great physical endurance from the pianist. It is challenging to repeat quickly at a *fff* dynamic level and also fight against the powerful sound of the orchestra. To save energy and obtain maximum results, each chord should be played using a very quick partial keystroke. The first and last notes of the measure should use the full keystroke (TBT), everything else should use a partial keystroke (TMT). In order to maintain full sound, the damper pedal should be fully engaged and not cleared for as long as possible! (e.g. the first seven measures.)

Figure 36: Tchaikovsky's *Piano Concerto No.1 op.23*, mm. 61-62

Another example can be seen in the ending of Liszt's *Hungarian Rhapsody No.13* (Figure 37). Pianists often fail to play the last two chords loudly and clearly enough. When the key is pressed using too much of the keystroke on the 16th note chord, the key will not return quickly enough to allow the quarter note chord to be repeated. In order to play the last chord powerfully, the preceding chord should be pressed using a TMT keystroke to allow the key to return quickly enough for the last chord. The last chord can be played with a keystroke that is as fast as possible in order to produce a loud sound. One additional note of advice is that the pedal should be depressed before the 16th note chord is struck, not with the quarter note chord.

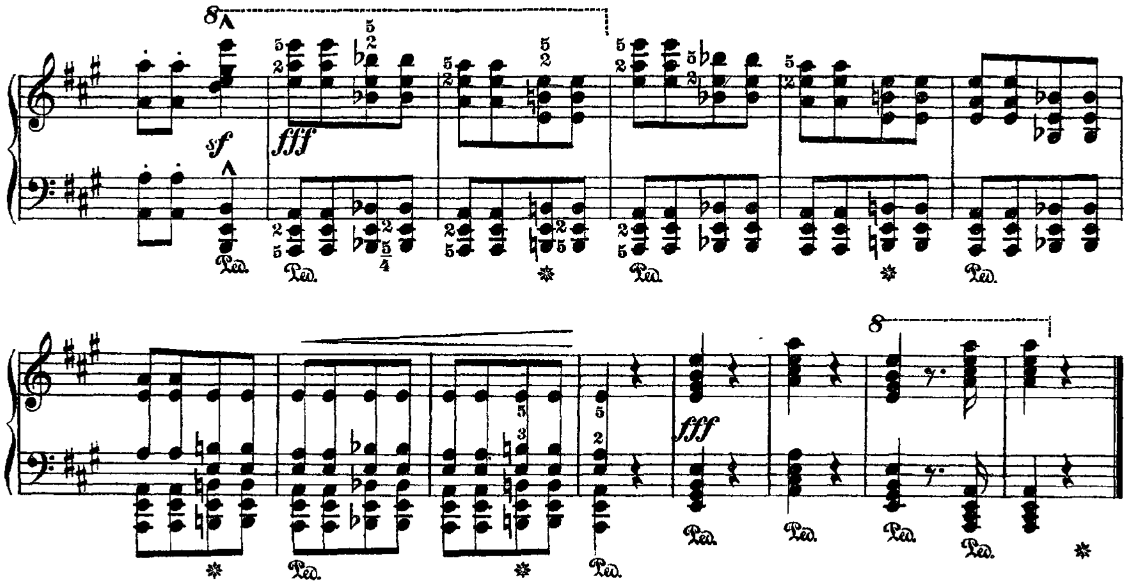

Figure 37: Liszt' *Hungarian Rhapsodie No.13*, mm. 246-259

4.4 Voicing with different keystrokes

Understanding of how the speed of the key controls the dynamic level helps pianists to understand voicing. To bring out a melody from among other voices (e.g., harmony, accompaniment, counterpoint, etc.), one can use a faster key speed in relation to the other notes being played. To make the accompaniment less focused, one can use the slower key speed to create background texture or using the partial key dip. In Rachmaninoff's *Etude-Tableaux in E-flat Minor, op.39-5* (Figure 38), the melody in the top voice should be louder than the triplet chords: the quick TBT keystroke for the first note E-flat and the combination of the slower keyspeed and using TMT strokes for the following chords. Since the repeating chords are written in a thick texture in the bass section, the pianist must pay close attention to ensure that the melody is always heard. In the repeating chords, equal key speed will automatically make *crescendo* when using the damper pedal, so pianists must be careful not over-play the chords.

Figure 38: Rachmaninoff's *Etude-Tableaux in E-flat Minor, op.39-5*, mm. 1-4

4.5. Avoiding Unnecessary Keystroke Motion

The moment the key impacts the bottom of the keystroke, the fingers should already be relaxed and prepared for playing subsequent keys. After the hammer has struck the string, the sound of the piano will not change with any variation in finger pressure. In fact, once the key has gone through escapement, and is in the aftertouch phase of the keystroke, any energy that the pianist exerts on the key is completely wasted (i.e., there is no connection between the key and the hammer). When you hit a tennis ball, you swing the racket, it strikes the ball and there is a follow-through. Technically, the only effect on the ball is during the brief moment when it makes contact with the racket. Everything else is preparation and release for the stroke.

Using partial keystrokes can save the pianist energy. By manipulating the amount of keystroke, a pianist will be able to create a variety of sound and promote an efficient, healthy technique that minimizes wasted effort and maximizes control.

We often see pianists hitting the loud chords with an excessive amount of energy, and then holding them down with an excessive amount of pressure. This not only causes fatigue but also creates unnecessary physical tension. Good piano teachers teach their students to "relax" after hitting the key. Gieseking explains "once the key has been struck, nothing can be done to change the quality of the tone, nor can a motion of the arm, hand or body have the slightest influence upon it. Most pianists use of striking movements of the body and arms, thinking thereby to impress the spectators. These movements have, as already mentioned, absolutely no influence, either on the tone already struck or on those to follow (Gieseking 1992, 58)."

Holding the key down at the bottom of the keystroke is merely to prevent the individual dampers from returning to the string; holding the note with any extra effort is wasted energy. Going one step further, if the damper pedal is depressed, then there is no acoustical reason to hold the keys down after the notes have sounded. The only amount of energy that is necessary is that which keeps the finger from falling off the keyboard. "Such unnecessary motion represents wasted energy and inhibits the pianist's ease in traveling to the next keys (Maris 2000, 41)." The fingers should relax at the bottom of the key to allow for the preparation of the next series of notes.

4.6. The Natural Sound of the Piano

Changing the speed of the keystroke controls the dynamic levels. However, pianists are not able to directly change the natural decay of sound of the piano, unless the dampers are skillfully lowered back to the strings. After the hammer strikes the strings, the sound of the piano will always naturally die away; unlike other instruments, the piano cannot increase the volume of the note after the string has been struck (i.e. the decay shape of the tone can not be altered independently from the attack).

"Music is an art form that deals with relationship of sounds changing through time. A single note on the printed page represents the beginning of a tone that has a life span. Throughout a note's duration, the sound changes. Each tone has a distinct and predictable shape, known as an envelope pattern, that includes a beginning, middle, and end. Artistic musicians learn to listen throughout the duration of a tone, tracking the sound and responding to it as it changes (Maris 2000, 41)."

4.7. The Articulation of the Ascending Key

The return of the key is responsible for the cessation of the sound. In terms of the piano, the return of the key is what controls the articulation. "A sensitive musician accepts responsibility for the entire duration of a note (Maris 2000, 42)." Pianists must be responsible for the beginning and ending of each note.

Just as there are different speeds of the downwards stroke of the key, so too should there be different speeds of the key return. The return speed of the key is a function of the speed at which the damper is allowed to return to the string. If this is done slowly, pianists can control the *diminuendo* shape of the cessation of sound. When the damper is allowed to return to the strings quickly, in an uncontrolled fashion, the sound stops abruptly.

In *legato* playing, the pianist must carefully listen to the connection between the notes. As Gieseking explains, "To accomplish this [absolute *legato*], the key of the piano must not be allowed to rise to more than three-fourths of its height, so that the tone continues to sound till the key is again pressed down so that tones become closely linked together. In this manner an absolute legato of two consecutive tones can be played on our modern pianofortes (Gieseking 1992, 28)."

While *legato* is based on holding the key down and blurring it with the subsequent note, *staccato* is accomplished by releasing the key and quickly stopping the sound between the notes. The motion of the key affects the timing and amount of the damper rise and fall. "To shorten the duration of the tone, the damper must necessarily be lifted less, by lessening the depth of the key descent. The less the damper rises, the less time it takes to fall, and the shorter the duration of the tone (Levin 1967, 15)."

The finger does not need to leave the key in order to stop the sound; the hands should not jump out of the keys after playing a staccato note. When the damper falls back to the string, the sound begins to stop. This does not happen at the top of the keys; it happens at half of the keystroke.

4.8. The Damper Pedal

The damper pedal is slightly different on every piano; as a result, the timing of the damper rise, the responsiveness of the pedal motion, and the overall pedal travel distance are never consistent from instrument to instrument. There is basic pedal technique that can be practiced. However, the pedal used in practice often will not work in performance on a different piano. The amount and timing of the pedaling will need to be changed according to the condition of the piano and the acoustics of the space.

The damper pedal has the added advantage of using different depths which controls the amount of weight of the damper on the string. Similar to the key motion, the damper pedal can control the timing and travel distance of the damper rise and fall. In order to use less amount of pedal, the right foot on the pedal must control the vertical motion very precisely. While using the damper pedal, look at the inside of the piano and observe the movement of the dampers. Check the level of the damper pedal and how far you need to press the pedals to lift the dampers. Pianists should be able to control the level between where the damper begins to lift and where it lifts completely away from the string. Like the finger motion, the right foot should keep in close contact with the pedal while in use.

4.9. The Damper Pedal *Crescendo*

Pianists are highly criticized for the misuse of the damper pedal. This is often stated in terms of using too much damper pedal, in the wrong way, and at the wrong time. However, just as "no pedal" is useful in creating articulate textures through finger pedaling, "full pedal" can be a useful tool in creating colorful textures, as well as creating a more sustained and powerful tone. When the dampers are completely lifted off the strings, and the 220+ strings are allowed to vibrate sympathetically and energy builds up as the pianist continues to play. Since all of the strings are already in motion, the ability to connect and increase the sound becomes much easier. The opening of Tchaikovsky's first Piano Concerto is an excellent example of how the pianist can put this type of pedaling into use. Many pianists clear the pedal every 2 measures. Not only is this not necessary, but it is actually counterproductive: Because the piano's volume weakens in the high register, Tchaikovsky's rising gestures lose intensity. Pianists can remedy this by not clearing the pedal: When the composer's pedal indications are observed (i.e., every 4 measures), maintaining the *fff* volume—which is necessary to compete with the orchestra—becomes less of an issue. It also gives the pianist the opportunity to allow the sound swell up and produce a wave of sound, instead of creating choppy chordal attacks.

4.10. Damper Pedal Weight

In playing the quick notes such as trills, tremolos, and ornamentations, pianists should take advantage of using the damper pedal; this is more efficient than lifting individual dampers with each keystroke. Debussy's *l'isle joyeuse* (Figure 39) is an effective piece to depress the damper pedal before the trill starts. Playing the trill on C#$_6$ with the damper pedal is much easier. The pedal should be pressed down as little as the damper slightly lifts to stay in a soft dynamic range.

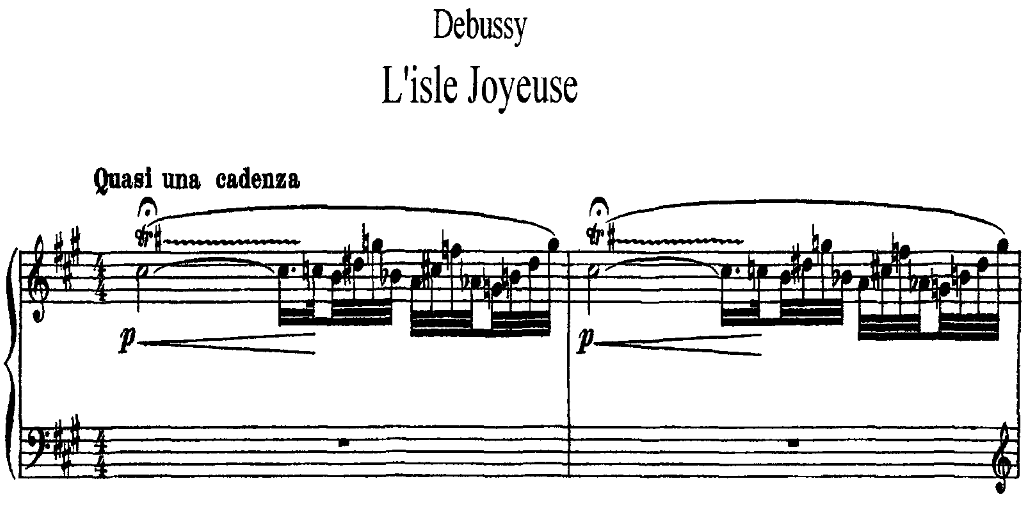

Figure 39: Debussy's *L'isle joyeuse*, mm.1-2

4.11. Repeating Note with the Damper Pedal

Repeating the single note with or without using the damper pedal requires different finger technique. Without the damper, the finger must connect each note with careful control over the key motion. With damper pedal, for example, in the beginning of Chopin's *Ballade No.2 in F minor, op. 38* (Figure 40), the finger does not need to keep in contact with the key in repeating the note. Since the dampers are lifted by the damper pedal, the note is sustained while the pedal is depressed.

Using a half-pedal that slightly raises the dampers allows them a minimum contact with the strings. This produces a delicate, soft sound that sustains the line without blurring the texture.

Figure 40: Chopin's *Ballade No.2 op.38*, mm. 1-5

4.12. Damper Pedal Sonorities

The main purpose of using the damper pedal is to create a wide palette of sonorities. Ravel's *Jeux d'eau* (Figure 41) demonstrates the great effect of using both the color of the damper pedal and the una corda pedal at the same time. Pianists should use the maximum amount of the damper pedal to allow the textures in this piece swell back-and-forth.

Jeux d'Eau

Figure 41: Ravel's *Jeux d'eau*, mm.1-8

This chapter has explored how the dynamics, articulation, repetition, and sound effects are produced on the piano in terms of piano technique. Pianists should always think about both what needs to be done to the piano, and how the body needs to move to create sound on the piano.

CHAPTER 5: CONCLUSION

The piano is an extraordinarily complicated instrument, with many thousands of moving and adjustable parts. Yet, for the most part, pianists relate to this instrument through only eighty-eight keys and three pedals. With so much concealed from the pianist, they have simply become ignorant of the inner workings of the instrument, just as medieval doctors were ignorant to the inner workings of the human anatomy. Many believe that instinct and careful listening are enough to master the piano. The aim of this document has been to show that a more complete understanding of the piano contributes greatly to an efficient, flexible, and musical technique: it prevents the pianist from fighting against the instrument's limitations and enables the pianist to harness its strengths.

The modern piano is built for a great range of power and nuance; knowing how to harness its ability will help a pianist bring out the best in an instrument. We've explored the ups and downs of piano technique: when and how the key is allowed to return is an issue of articulation, and dynamics are a simple matter of finding the right combination of keyspeed for a given amount of keydistance. The piano's three pedals open the door to a vast range of texture and sonorities that would otherwise not be available in the music making process. Once we understand what needs to be done to the piano to create the desired sound, careful consideration needs to be given to how body movement is incorporated into this process. This understanding promotes an efficient, health technique, minimizing wasted effort and maximizing control in performance.

Every piano has its own personality. Just like people, the inherent strengths and weaknesses of each piano need to be dealt with on its own terms. If pianists can diagnose these limitations, it will allow them to perform without frustration. If the piano does not have enough power, don't fight it; play into this limitation by exploring the softer dynamics level. "The artist knows and feels how far the responsiveness of his instrument, at any particular part of his piece, will allow him to go without violating aesthetics, and without stepping outside of the nature of his instrument (Hofmann 1976, 11)."

"The bane of the pianist's existence is the perpetual necessity to adjust to unfamiliar pianos. Very often we do not have a proper rehearsal and need to adjust during the performance. When this happens, we are forced to combine the creative process of performance with the need to observe the peculiarities of the instrument. While playing, we must take note of the unevenness of registers or individual notes or other faults of the instrument and try to compensate for them (Berman 2000, 195)."

Pianists should be able to diagnose what a piano can and cannot do, and then be able to modify their approach accordingly. Before a performance, pianists should not simply run through their program to try and acclimate themselves to the piano and the performance space. More often than not, there is not enough time for this. Instead, the pianist should have a routine approach to being able to explore the piano's potentials and limitations.

When I first sit down to a piano, I look for what the maximum sound possibilities are in each section of the piano. No matter what they are, it is my responsibility to be able to balance each section, as well as ensuring that I don't go past the point at which the sound begins to break apart; pushing the volume past these levels produces an unavoidable ugly sound. The softer dynamics are always difficult to control; I try to find what the softest feasible dynamic levels are based on the tempos of the *p-pp* sections in the program. It takes a great deal of concentration to find a way to produce a soft sound on an unfamiliar piano. It is important to remember that dynamics are relative: the best way to achieve a *ff* sound is by creating enough *pp* to which it can be compared. During this process, I explore the range in color and texture that the piano is able to produce, and I compensate accordingly. Repetition is always an important aspect to check, whether it is isolated or continuous; it is important to have a chance to figure out in which part of the keydip the repetition response is the best. Once I feel like I have a good grasp on the aforementioned issues, I turn my attention to tempo and how the piano is responding in the performance space. It is often necessary to slow a piece down when the keys are heavy and the room is very reverberant; the amount of pedal work and finger technique is adjusted to compensate for the limitations of the piano and the performance space.

Pianists should practice on many different kinds of pianos. Familiarizing themselves with different actions and different sonorities will help pianists develop the skill to be able to constantly modify their technique for the particular needs of the piano. "Try to obtain for your practice a piano the action of which approximates as nearly as possible that of the piano on which you have to play in the concert, in ORDER to avoid unpleasant surprises, such as premature fatigue or a running away of the fingers (Hofmann 1976, 37);" and "The pianist may need to modify his technical approach, sometimes significantly, when dealing with an unfamiliar piano. A very bright instrument will require much less finger work as well as smaller movements of bigger joints. Confronting a stiff or dull piano, one should avoid forcing it (Berman 2000, 196)."

Pianists should be prepared to spend time talking with their piano technician. After spending time exploring the instrument's limitations, pianists should be able to articulate their concerns to the technician. Time will always be limited, and the pianist needs to have a basic understanding of what can be accomplished in a given amount of time. Tuning, regulating, and voicing are the three technical aspects of concert piano preparation that need to be balanced in order for the program to be successful. A tuning can take 30 minutes, or as long as 4-5 hours depending on what needs to be done. A perfectly tuned piano is of little consequence if there is no range in color, and the keys do not function properly to create the necessary sound. The current condition of concert pianos is often so bad that pianists are never assumed that they can get what they need from a piano. Pianists should know what kind of problem is easy to fix before the concert.

Not all pianos are created equally: pianists must be willing to modify their technical approach to music making in order to be successful on a wide variety of pianos. Keeping an open-minded approach to how sound is created on the piano ensures that pianists always have the opportunity to explore new ways of performance.

It is my belief that an understanding of the inner workings of the piano will help pianists practice more efficiently, avoid unnecessary muscle strain and fatigue, and enable them to enjoy long careers of healthy, virtuosic performance.

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