ANALYSIS OF MUSICAL KEYBOARD INTERFACE DESIGN:

A STUDY ON KEYBOARD – PERFORMER INTERACTION

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ANALYSIS OF MUSICAL KEYBOARD INTERFACE DESIGN:

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ABSTRACT

ANALYSIS OF MUSICAL KEYBOARD INTERFACE DESIGN: A STUDY ON KEYBOARD – PERFORMER INTERACTION

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Dynamophone was patented as the first electronic instrument of the history, and then whether their looks are similar or not, many electronic instruments have been manufactured whose sound production or modification principles are dependent on frequency and voltage control. Almost all of these electronic instruments designed in the first half of the 20th century couldn't survive after 1950s. However, in the way they opened other keyboard instruments evolved; which resemble conventional acoustic instruments, and therefore regarded as being much conservative in comparison.

These instruments have gained enormous importance after 1960s due to improving technology, and second half of this century witnessed important shifts in the technology, which in turn altered their working principles. These electric keyboards became popular and in a few decades they became rivals of conventional instruments. This research tries to elaborate on the way they evolved and what consequences they have in development of music in our century.

At the turn of the 19th century the invention of the electricity brought about enthusiasm and curiosity which could hardly be predicted before. In a short period of time electricity and its possibilities would start to be adapted to many fields from transportation to telecommunication, and take its indispensible place in future prophecy. In those years the Dynamophone (the first patented electric musical instrument) was invented and then whether their looks are similar or not, many electronic instruments have been designed whose sound production or modification

principles are similarly dependent on frequency and voltage control.

Almost all of these electronic instruments designed in the first half of the 20th century couldn't survive after 1950s. However, in the way they opened other keyboard instruments evolved; which resemble conventional acoustic instruments, and therefore regarded as being more conservative in comparison. One of the most important electric keyboards is Hammond organ, which was designed as a rival to church organ and works with electromechanical principles. These instruments have gained enormous importance after 1960s due to improving technology, and second half of this century witnessed important shifts in the technology, which in turn altered their working principles from electric to electronic and digital circuitry.

After 1970s, the importance of design has been understand better, and that in turn opened new horizons in electronic keyboard design, which stands at the intersection of industrial design and conventional instrument design. Designerly ways of musical keyboard manufacturing has influenced the evolution of music in both positive and negative ways. These electronic keyboard instruments which are designed by specialised designers without many limitations of conventional instruments and supported by major investments in order to improve their capability and performance have important outcomes on composition and virtuosity. This research tends to elucidate on the influence of industrial design on the evolution of music in the context of musical instrument interface design.

Keywords: Interface Design, Interaction Design, electronic, digital, musical keyboard, piano, organ

ÖZET

MUZİK KLAVYELERİ ARAYÜZ TASARIMININ ANALİZİ: KLAVYE – İCRACI ETKİLEŞİMİ ÜZERİNE BİR ÇALIŞMA

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19. yüzyılın sonunda elektriğin icadı o günlerde pek de tahmin edilemeyen ölçüde bir merak duygusu yaratmıştı. Kısa zamanda elektrik ve potansiyel olanakları, ulaşımdan iletişime kadar birçok alanda kullanılacak, insanların gelecekteki hayata dair tahminlerinde vazgeçilmez bir unsur olarak yerini alacaktı. Böyle bir merak ve ilgi ortamında ilk elektrik müzik aleti olarak patent alan Dynamophone icat edilmiş ve ardından görünüşleri benzesin veya benzemesin, benzer prensiplerle, elektriğin frekansı ve voltaj kontrolüne dayalı olarak çalışan müzik aletleri art arda tasarlanmaya başlamıştır.

Yirminci yüzyılın ilk yarısında üretilen bu müzik aletlerinin hemen hiçbiri 1950'lerden sonraya kalamamış, tarihten silinip gitmişlerdir. Fakat onların açtığı yolda geleneksel müzik aletlerine, onlara oranla daha çok benzeyen, bu anlamda daha tutucu, elektrik-akustik prensiple çalışan müzik aletleri büyük bir ivme ile üretilmeye başlamışlardır. En önemlilerinden biri Hammond firmasının ürettiği kilise orguna oranla çok daha küçük olan ve temelde küçük kiliseler için üretilen elektrik org diye isimlendirilen bu çalgı aletleri 1960'lardan sonra çok büyük bir gelişme göstermiş, kısa zamanda elektrikten elektroniğe ve sonra da dijital prensiple çalışan müzik aletlerine dönüşmüşlerdir.

1970'lerden itibaren tasarımın bir meslek olarak öneminin anlaşılması, bu müzik enstrumanı ve endüstriyel ürün arasında yer alan elektronik klavyeli çalgılara yeni bir boyut getirmiş ve müziğin evrimine de olumlu veya olumsuz etkileri olan sonuçlar doğurmuştur. Akustik müzik aletlerine göre birçok kısıtlayıcıdan bağımsız olarak üretilebilen, performansları ve kapasitelerini arttırmak adına büyük yatırımlarla desteklenen ve özelleşmiş tasarımcılar tarafından tasarlanan bu

çalgılar icracılık ve bestecilik alanlarında önemli etkilere sahiptir. Bu çalışma klavyeli çalgı arayüz tasarımı bağlamında endüstriyel ürün tasarımının müziğin evrimine olan etkisine ışık tutmayı hedeflemektedir.

Anahtar Kelimeler: Arayüz Tasarımı, Etkileşim Tasarımı, elektronik, dijital, müzik klavyesi, piyano, org

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CHAPTER 1

1. Introduction

"*Music is born free; and to win freedom is its destiny… In the new great music, machines will also be necessary*" (Busoni quoted in Holmes, 2002, p.12). Ferrucio Busoni's foresight in 1907 can summarise the argument of this research well. When Busoni wrote this statement in 1907, he had made a prophecy about nearly fifty years onward from his time. We must assume that it was only a curiosity in the beginning, which generally grabbed the attention of engineers; because the first electric instruments were closer to machines than instruments. The Dynamophone for example, used to incorporate dynamos (more than 14 for one pitch) and since its dynamos made so much noise, Thaddeus Cahill, the engineer of Dynamophone, preferred putting its machinery part at the bottom of the concert hall.

Every period in music has its specific instruments. In the Renaissance, the luth and guitar were popular instruments due to their capability of expressing humane feelings and logic with their simple and sweet sound. In Baroque music the cembalo was dominant due to its advantage on ornaments. The piano could successfully express melancholic and deep meanings of Romantic music. In the Modern era, using means of electricity got serious attention especially in France, Germany and the United States. Radio Television of France and Cologne Radio in Germany made serious investments in electronic music studios in the first half of the 20th century pioneered by Edgard Varèse, Karlheinz Stockhausen and Pierre Schaffer. Varèse named his music *Organised Sound* (Son Organisé) while Schaffer preferred *Concrete Music* (Musique Concrete). Vladimir Ussachevsky and Otto Luening working at Columbia-Princeton Electronic Music Centre introduced their work as

Tape Music. In 50s and 60s, an increasing number of musicians were deeply influenced by new sound worlds introduced by these composers; so was the listener.

In the second half of the 20th century, first electronic instruments of the century became extinct but they managed to contribute to the development of new keyboard instruments, which were conservative in attitude and appearance. These electric keyboards became popular and in a few decades they became rivals of conventional instruments. What concerns me most in this thesis is how they evolved and what consequences they have in the development of all styles of music in our century. Undoubtedly, their evolution has been reflected on their interface[1], as well as size and dimensions: for instance the digital principle is explicit on the interface. This thesis is intended to trace the evolution of the keyboard instruments through their interface design.

1.1. Definition of the Problem

In the 20th century music, composer and performer had to work with the engineer to use electronically produced sound, because the engineer used to be the key person in the development of electric devices. However, the designer started to gain importance in this field after the 1960s, too. Since then electric instruments started to be developed and manufactured under the inspection of the designer, those instruments showed great progress in usability and flexibility matters. Especially

[1] Interface: the point where two subjects, systems, etc. meet and affect each other (Wehmeier, 2001, p.626). The main goal of user interface design is to make the interaction between the user and the object as simple, efficient and effortless as possible.

interaction designers[2] were successful in improving electronic instruments, which had to have a better interaction with the performer. Keyboard instruments had an extensive evolution period in the 20th century with the improving possibilities of technology. They were subjected to such deep changes and modifications that their inheritors had to be given different names such as electronic keyboards or synthesizers. These electronic keyboard instruments evolved from mechanical keyboard instruments such as the piano, organ, cembalo or clavichord and started appearing in 1930s. Their interface and interaction with the musician have been evolving and developing since then. Since 1990s their interface has nearly been reduced (or simplified) to only an LCD screen. This great evolution from mechanical to digital has enabled those keyboards to serve as smart and capable music machines. Although any synthetic sound produced by any means of electronic or digital technology can not be as humane, artistic and creative as an acoustic instrument's timbre (unless it is used in the way that Edgard Varèse (1883-1965 for example "Integrales") or Karlheinz Stockhausen (1928-2007 for example Klavierstucke composed music). They are even very fruitless when they are used to imitate *real* instruments such as violin or piano. But they also may have advantages; for instance the performer can increase the speed easily, add sounds later, use MIDI and samples. This ability of digital musical keyboards has sometimes enabled them to take over a band, and here the instrument designer or engineer is the key person.

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[2] Interaction Design refers to the act of defining or shaping interactive products, systems or services focusing on their use. Interaction Designers deal with devices or systems with which the user can interact.

1.2. Aim of the Study

This research aims to understand the influence of the use of electricity in musical keyboard instruments. Electricity enabled instruments to be amplified resulting in higher sonorities of instruments and some sound modifications. Those alterations and sound shaping facilities led composers to explore different musical worlds. Conventional keyboard instruments and music composing-performing customs profited from those innovations. This led towards a new musical scene and tradition while changing existing conventions in both negative and positive directions. Since those innovations and developments would not be possible without efforts of engineers and designers, one can conclude that design and engineering are important professions in the evolution of musical structure and instruments. The main target of this research is to understand the importance of design for performer and keyboard instrument interaction and changing musical identity in 20^{th} century.

1.3. Methods of the Study

This research firstly aims at understanding the basics and principals of sound production in keyboards. This issue will be covered in first part of Chapter 2. Observation of keyboard instruments and musicians in order to understand the characteristics of the instrument can be of help in this stage. Literature and documentation review is also intended for this part. Then the thesis proceeds to the structure of music and its components such as Melody, Harmony, Rhythm and Dynamics. Second part of Chapter 2 tries to explore the evolution of keyboard instruments from mechanical to digital period.

Chapter 3 focuses on the design considerations of musical keyboards. This part is the

largest section of the research and includes two methods which are case studies and focus group interviews. Focal point is the interface of the instrument and its evolution over time, because, it is the interface and usability-flexibility-simplicity of the instrument which enables the performer to obtain the most from the instrument. Case studies will be done about four artists who are regarded as star keyboardists of their time. These are Ethel Smith, Vangelis, Rick Wakeman and Derek Sherinian; and these case studies try to explain their musical character, instrumental preferences and instruments' intervention (or dictation) on these artists' musical identity. Focus group interviews will be done with keyboard instrument players, especially electronic or digital keyboard players in order to understand their preferences and expectations from the instrument. Data obtained from focus groups is thought to be helpful in order to evaluate different models and brands of keyboards on the basis of perceived usability, flexibility and fail and error in interaction with the keyboard. Interviewees include instrument makers, musicians, music critics and conservatory students. Main target is to understand their ideas and define the specialist opinion.

The last chapter aims to render a long conclusion, which is followed by a summary of the conclusion. Chapter 4 intends to elaborate on keyboard instrument and its consequences on production and consumption of music. This chapter is basically constructed on data obtained from this research and literature review.

Chapter 2

2. Evolution of Keyboard Instruments from Mechanical to Digital

1951: Music is dead. Long live electronic music.
2001: Electronic music is dead. Long live music.

Thom Holmes, 2002

"*A new world of sound created by electricity was predicted in the 19th century and investigated by experiment in the early 20th, but it was not until the 1920s that there appeared several instruments for the electrical production of tones*" (Sadie, 1980, p.106). First electric instruments designed in the first half of the 20th century such as Dynamophone and Theremin, besides getting lost in fifty years, gave a colour and liveliness to European Classical Music in their time. One of the most influential examples of the first electric instruments, Dynamophone, also known as Telharmonium, "*was the first electronic music sytnhesiser … patented by Thaddeus Cahill in 1896 … using a dynamo with rotating pitch shafts and tone wheels*" (Holmes, 2008, p.36). Other important examples include Theremin (1924), Spharaphon (1927), Dynaphone (1927-28), Ondes Mertenot (1928) and Troutonium (1930). What interests me most here is the way they contributed to the development of electric-electronic keyboards, synthesizers and other electro-acoustic instruments such as electric guitar. Electronic keyboards and synthesisers profited from these technological innovations; for instance, Laurens Hammond picked some ideas from Dynamophone when he was designing the tonewheel Hammond organ.

In 1907 Ferruccio Busoni writes "*In the new great music, machines will also be necessary*" (quoted in Blacking, 1995). When the Dynamophone, invented by

Thaddeus Cahill, is considered, Busoni sounds reasonable. This instrument was nearly two hundred tons in weight and in order to prevent its noise, *machinery* part was placed at the basement of the structure where it was played. "*Pressing the keys caused current produced by dynamos (more than 140) to be converted into musical sound*" (Blacking, 1995, p.129). Music composed for these instruments[3] in the first half of the 20th century in especially France, Germany and the United States grabbed a lot of attention and applause at first. First electric instruments, besides providing different timbre alternatives in comparison to the acoustic orchestral instruments, couldn't play together with conventional instruments as well as being unable to offer new possibilities to musical creativity (Mimaroğlu, 1993).

2.1. Music and Fundamentals of Sounding

> *"In a certain sense, the physical attitudes taken towards a musical instrument, like one's attitudes towards one's body and the material world more generally, and the intuitive sense of style that one develops only through living in a particular musical culture, are elements of what Bourdieu refers to as the habitus of a given social group or class" (Théberge, 1993, p.220).*

Each instrument has its characteristics and these characteristics are important in shaping the particular style and sense of the performer. These characteristics are due to some possibilities of instruments and are generally learned by observation. For instance when a guitarist and a pianist are accompanying the same singer at the same

[3] Here it should be clear that Electronic Music (at least in this thesis) does not mean music composed for electric, electronic or digital instruments; rather it is a kind of music, which is composed on tape concretely instead of paper. The composing medium is generally the magnetic band; sound samples collected from many different sources are processed according to the musical creativity of the composer and used as the body of the work.

song with chords, both of them do it differently because the *habitus* they come from is different. This is basically due to the design of the instrument: the guitar by nature imposes some distinct chords and positions different from the piano and these characteristics spread by memes from one guitarist to another.

2.1.1. Sound Design in Instruments

Each instrument is a designed object, which has its unique principles to produce sound. In addition, characteristics of each instrument have their roots in those sounding principles. Although there is no absolute classification, this thesis intends to classify instruments in four groups: wind, string, rhythm and keyboard instruments. However, in some sources they might be classified different.

Instruments from the string family appeared in the East some centuries before they started to be used in the West (Mimaroğlu, 1993). The most advanced string instrument before the modern violin is called *viol*. In the 17th century the *viola da gamba* (ancestor of today's violoncello), the *viola da braccia* and the *violina piccolo* (little violin) took part in the orchestra. The *Pochette* (pocket violin, another string instrument of that period) used to be played by dance tutors, by tradition. String instruments that were used in the Medieval Era and the Renaissance until the 17th century are far from today's string instruments in terms of timbre and sound: they were not able to supply detailed timbre, different colours in the sound and high sonority. In Italy Gasparo de Salo in the first years of the 17th century produced violins and violas which fascinate experts even today with their flawless quality and timbre incomparable to their contemporaries (Mimaroğlu, 1993). In Cremona, Andrea Amati and his family produced high quality violins, violas and violoncellos.

Also, Antonio Stradivari, who is known as the symbol of perfection in violin making, was born in Cremona.

Wind instruments produce sound by sympathetic resonance of air in a tube called as resonator. Pitch of the sound is defined by the length of the tube which is altered manually. Generally length of the tube is changed by valves and keys or sliders. Wind instruments that use keys are fretted instruments while those having sliders are fretless. The oldest known wind instrument is the flute which was fairly different from modern flute. The *Syrinx*, the oldest flute, was found in graves in Egypt and is thought to have been a common instrument in Ancient Greece. The first key mechanism was added to the flute in 1677, though that craftsman is unknown. According to Carse, keyboard instruments contributed to the development of chromaticism in Western Music as well as wind instruments: "*improvements in the technical design of woodwind and brass instruments, specifically the addition of key mechanisms and valves during the nineteenth century, were a direct response to the increasing demand of chromaticism in orchestral and chamber music of the same period*" (Carse, 1964, p.219).

The family of percussion instruments includes instruments of stable frequency such as campane, vibraphone and xylophone. Also this family has some instruments whose pitch is not stable such as drum, castanet and bell. "*These instruments are thought to have been imported to Europe from the East. Existence of the cymbal in European Music comes from the Turkish Janissary Band*" (Mimaroğlu, 1993, p.206). Percussion instruments are generally used for putting the rhythm forward and sometimes for timbre effects.

Through history, each instrument has contributed to the evolution of other instruments even when they are from different instrument families. Besides, each instrument imposes its characteristics coming from the nature of the instrument. Marion Thede (1967) maintains a perspective discussion on the similarity and differences of a violinist and folk fiddler. She argues that the musical attitude and approach of the musician can transform the instrument and sound produced as the fiddler's playing would be very different from the violinist. If we consider their playing postures, hand movements and arch style, we may conclude that the only difference is not music style; the fiddle and violin should not be considered to be the same instrument although, technically speaking, they are. Despite this serious training, when a violinist tries to imitate the fiddler, "*it will sound wrong*" (Thede, 1967, p.14).

In the analysis of music four components should be considered: melody, harmony, rhythm and dynamics. Melody and rhythm are compulsory basic elements while harmony and dynamics give the sense of touch and feel. All this above is recorded on paper which we call today notation or scores. The first notation dates back to 10^{th} century; Guido D'Arezzo (991-1033) is the first person who gave names to notes although before notes used to be indicated by letters such as A, B, or C. Before him, other techniques were used by different composers such as Tablatures and Neumatic Notation, which are still in use after today especially in pop music, although they are primitive and far from being able to represent the idea of the music piece. As can be seen from the score below, D'Arezzo used first syllables of each line in a hymn as names of seven notes. However, it took almost six centuries before a notation system close to that of today was introduced. Flat and sharp symbols were first used by

Bach in the 17th century, and in the 19th century, notation came to a point which might make sense for today's musician.

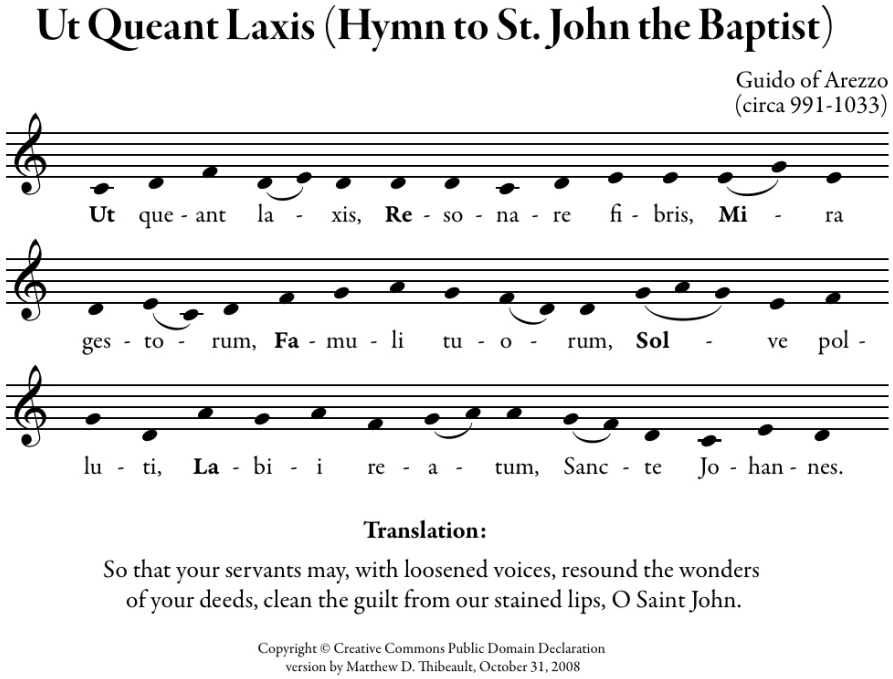


Figure 1 The First Syllables in the Hymn

Scores can convey information about melody, harmony, rhythm and dynamics; they are written forms of music. A relation could be made between notation, automatic piano rolls and MIDI files. They all convey datum about musical ideas. It is arguable that from scores to MIDI a rationalisation in principle is apparent. Scores are abstract counterparts of music; however rolls and MIDI files are concrete as they don't offer personal interpretation.

2.2. Evaluation of Keyboard Instruments

The musical keyboard has two interfaces: One is the keys for playing the instrument which have been stable for centuries (except for some experimental examples such as the Janko Keyboard), and the other is the buttons for shaping or modifying the

Evaluation of Interface Design Elements in Keyboard Instruments

Evolution of Organ

1741 Pipe Organ, Église Saint-Thomas, Strasbourg, France

1912 Harrison and Harrison Organ

Hammond Model A 1934

Hammond BA 19374

Hammond B-3 1955

Hammond X-66 1965

Hammond N 300-600 1968

Hammond B400 1983

Hammond Xb2 v2 1991

Hammond XH-200 1998

Hammond XK-3 2004

sound. The second group has an important role on the interaction; this interface gives the performer access to a wide range of modifications and alterations of the sound. This ability of sound shaping opportunities made the keyboard smart and popular among musicians. As a result, music has been deeply influenced in 20th century: Identity of both music and musician have been exposed to strong alterations. Music has approached being a designed experience instead of an art happening.

2.2.1. Mechanical Keyboard Instruments

Epoch chooses its instrument. Each period in music has always promoted its unique instrument. In Renaissance Music, guitar (slightly different from modern guitar first introduced by Torres de Jurado) was prominent and luth was of great importance in Early Baroque Music due to its great capability for ornamentation which was later displaced by the cembalo (harpsichord). Romantic Music, since it expressed strong feelings, a deep melancholy and bliss, required a strong and potent instrument; the piano. When the piano was introduced, it became an indispensable instrument and preserved its prominence as an education and concert instrument for centuries.

2.2.1.1. Organ

The organ, with the harpsichord, was the most important working area of the Baroque composer. "*Since both are keyboard instruments, music composed for harpsichord and organ has much commonality in touch and sense*" (Mimaroğlu, 1999, p.45).

Organ is one of the oldest instruments. Although there is not a valid document when and where it first emerged, it is known that an instrument similar to the organ was built by Ktesibios the Alexandrian in the 2nd century BC. Although it is known as

church organ today, it took six centuries for this instrument to appear in churches; the organ was first used in churches in the 4th century due to instrument prohibition of Christianity.

Figure 3 Pipe organ, Église Saint-Thomas, Strasbourg, France

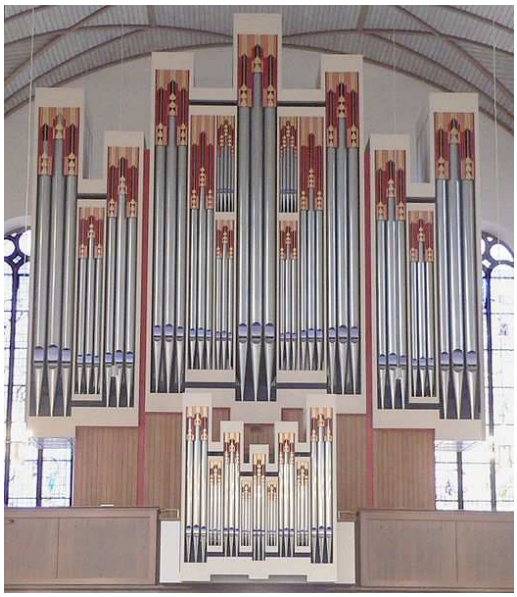


Figure 4 1990 Modern pipe organ, Katharinenkirche, Frankfurt, Germany

Figure 5 Modern pipe organ, Aletheia University, Matou, Taiwan

The pipe organ is mostly a huge instrument which uses a pipe system in order to produce sound. Air required for pipes is provided by a bellow that is incorporated by several people (sometimes up to 26 such as J. S. Bach's organ). Its console is the part with which the instrument is controlled and played. For these purposes, the console has an interface including a pedal system in addition to keys and control knobs; the organ console houses a large amount of knobs and tablets to control stops and dynamics. Pipe organs generally have three or more manuals. The top manual stands for bass keys and the bottom for trebles. In the Baroque, the organist was the maestro at the same time; the conductor of the orchestra used to conduct other musicians from his organ's console.

2.2.1.2. Piano

"*In 1700, the year by which the first piano had been built, European musical life was full of stringed keyboard instruments - spinets, virginals, clavichords, and harpsichords, among others - some providing quiet pleasure in private chambers, others holding their own in crowded opera pits, church choirs, and court orchestras*" (Parakilas, 1990, p.7). Bartolomeo Cristofori is known as the inventor of

Evaluation of Interface Design Elements in Keyboard Instruments

Evolution of Piano

Bartolomeo Cristofori, Grand Piano, 1720

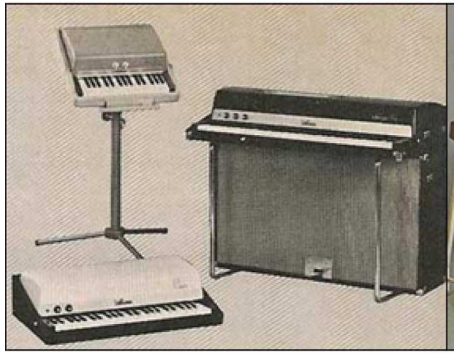
Art Case Steinway, New York, circa 1877

Modern Steinway Grand Piano Model D

Neo-Bechstein Flugel 1934

The Rhodes Pre-Piano 1946-48

The FenderRhodes Electric Piano 1964



The FenderRhodes Celeste 1966-68

The FenderRhodes Electric Piano MkI 1970

Rhodes Electric Piano MkIV 1983

Rhodes Electric Piano MkV 1984

the piano. His invention dates back to 1700 in Florence. He named his instrument as "Arpicembalo … di nuova inventione, che fa' il piano, e il forte" which means "a harpsichord, of new invention, that plays soft and loud". "*It was to take more than a century for the name to be reduced to that form*" (Parakilas, 1990, p.7). Even today in the literature piano is named as "pianofortissimo".

When Bartolomeo Cristofori publicized his invention, he introduced the piano to the public as an invention by an event which caused Cristofori to be accepted as the inventor of the piano by the world. However he did not try to take out a patent, although he could have done. In addition, he revealed all the acoustic structure of the piano; he prepared a brochure and handed it out.

Figure 7 Bartolomeo Cristofori, grand piano, 1720

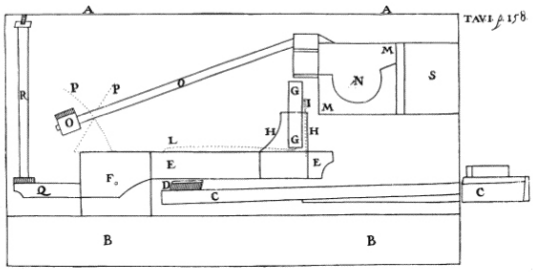


Figure 8 Bartolomeo Cristofori Piano, Hammer Mechanism 1911

Cristofori's basic intention was to overcome insufficiencies of earlier keyboard instruments such as the clavichord; these instruments were not successful at musical dynamics since they supplied a limited control over the sonic power and volume. Some innovations made the piano take over the place of the harpsichord and the clavichord such as hammer and cast iron framing. In fact, the piano was not an invention, because the piano did not offer something new and avant-garde in terms of acoustics and interface. Rather it was like a redesign of the clavichord - harpsichord combination. The first Cristofori pianos did not have a pedal system while its rivals the clavichord, cembalo and organ used to have; all these pre-piano keyboard instruments had pedals or knobs which influenced the volume, intensity and tone. However, the piano displaced all its rivals because with the hammer and lever system the performer could afford important control over sound and dynamics. In 1722 Cristofori applied hand operated "una corda" pedal which functioned the same as left pedal of today's pianos. This hand operated pedal, whose translation in English is one string, was placed on the side of the keyboard and evolved as soft pedal (or left pedal) in the modern piano: when activated the hammer hits only one string (instead of two) which produces a softer tone.

The piano could be argued to have been the most influential instrument in music history. Well known examples were composed by Beethoven; Chopin and Liszt took the piano to its limits for their days. If we consider the fact that it was used as a concert instrument and a tool that helped musician to compose, place of the piano could be understood more clearly. Besides, it is used as a tool in education and student training. Especially 19th century music was composed at the piano as this is a capable instrument in terms of a wide range of harmonic possibility. Shortly the

piano has been a dominant instrument to shape European Music since the second half of the 18th century.

The piano market and its manufacturing shows a more serious development than that of any other instrument according to Théberge (1993). In the last decades of the 18th century there was an important increase in the demand for pianos which required a reformation in manufacturing in order to satisfy the need. Loesser (1954) mentions Nanette Streicher as a piano manufacturer who accomplished important progress in the piano production process. According to Loesser this was enabled by a larger space and more workers in addition to "*a fairly rigorous division of labour, and a steady purchase of ready treated materials*" (Loesser, 1954, p.133) which remembers the modern factory model. Increased manufacturing required a better promotion; and in less than a century the piano could enter a large number of houses; to those from middle or upper class it became a sign of high culture. International fairs also played an important role in promoting piano such as the World Exhibition in London (1851), the Paris Exhibition (1867) and the Centennial Exposition in Philadelphia (1876). "*Awards and citations received at these numerous events could then be turned into important indicators of technical superiority in future ad campaigns*" (Roell, quoted in Théberge, 1993, p38).

The piano has an interface made of keys which are used to *play* the instrument, and in addition it has two to three pedals according to the brand and model. Unlike electric pianos, it does not have sound shaping facilities. In history several attempts can be found to make the piano a more capable instrument. Two important experiments are the Jankó Keyboard and the concave keyboard patented by different manufacturers in different countries. As will be clarified in detail in Chapter 3.1.1.2.,

these keyboards besides being successful in theory could not catch on and were eliminated in time. The roll piano by its nature has a resemblance to digital piano; in fact it could be argued that MIDI files and automatic piano rolls are interestingly similar. Both of them play pre-defined music and they do not offer any interpretation to the performer.

Figure 9 Steinway & Sons, New York, 1871

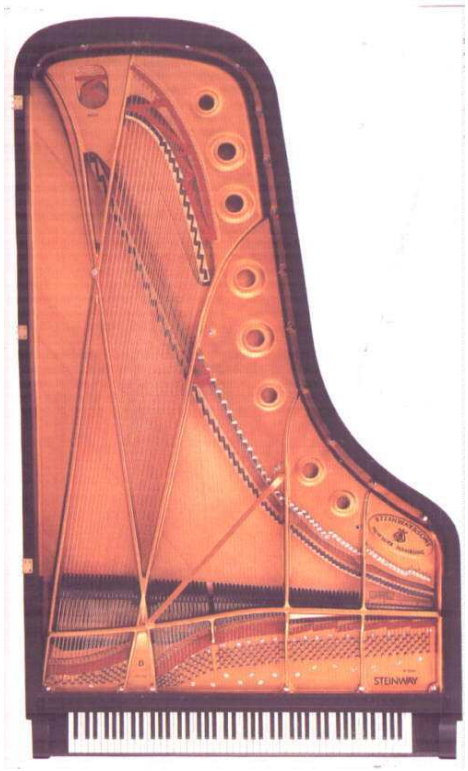


Figure 10 Modern Steinway & Sons grand piano Model D

2.2.2. Electric Keyboard Instruments

"*A new music came when the composer and performer joined with the engineer to use electronically produced sounds*" (Blacking, 1995, p.128). Although Blacking uses the word "electronic" he implies electrically, electronically and digitally produced sound. In fact, the first instruments which profited from the use of electricity were electric instruments. Besides similarity and relativity, electric and electronic instruments have pretty different working principles. "*This terminological confusion has its roots in the naming and describing instruments during the period between the two world wars when electronic technology was first developing*" (Sadie, 1984, p.658). It is not easy to make the electric-electronic division due to several reasons when keyboard instruments are concerned. Firstly, one version of the same instrument might be an electric instrument while another should be grouped under electronic category. In addition, all electronic instruments principally function with means of electricity. Therefore, the unprofessional doesn't hesitate to use these terms interchangeably. Technically speaking, electronic devices should be considered as the subset of electric devices, which "*incorporate thermionic valves or semiconductors*" (Sadie, 1984, p.657). Another terminological confusion can be found in electronic music. There is a tendency towards naming music performed by electric or electronic instruments as *Electronic Music* but in fact Electronic Music can be defined as a composing medium rather than a kind of performance, by musicologists whose well known composers are Edgard Varèse, Karlheinz Stockhausen and Pierre Schaffer. However it is clear that, in this research Electronic Music refers to music production which is composed on a recording medium like

magnetic band (tape) or hard disk. This kind of music is generally called Concrete Music, Organised Sound or Tape Music as it is composed concretely on the magnetic band by using *recorded sound*[4] from the environment instead of writing scores on paper virtually.

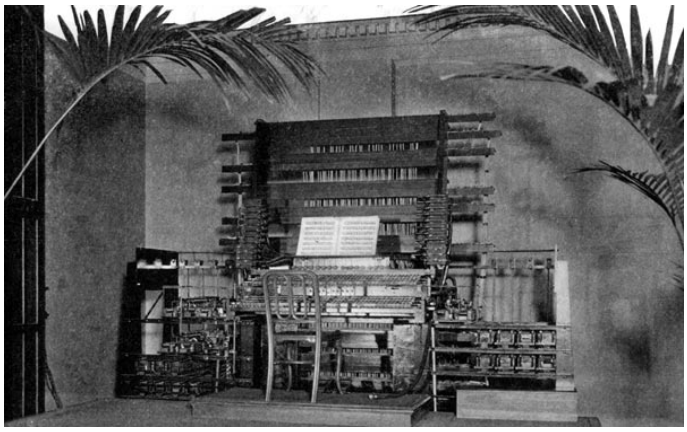


Figure 11Telharmonium, Thaddeus Cahill, 1897

The first application of electricity on instruments dates back to 1896 and it is pretty clear that electronic or digital keyboards, which are so common today, got the first inspiration from them. It was not for decades that instrument manufacturers recognized a great possibility in combining acoustic instruments with the possibilities of electricity. Acoustic instruments' capability could have been improved surprisingly which in turn would contribute to music and culture in both positive and negative ways. Although many electronic keyboard instruments could provide the musician with opportunity for musical experiment, they are sometimes played in a way which is far from being an art product. "*Today's electronic*

[4] In tape music, sound recorded from the environment is used as the body of work. Source for recorded sound could be anything from engines roaring to birds singing.

instruments, synthesisers that are growing in number, like the first electric instruments besides new possibilities they supplied, can be considered to have brought degeneration and fruitlessness to the timbre repertoire instead of richness in the form of poor imitations of conventional instruments such as the trumpet, violin, or piano" (Mimaroğlu, 1993, p.157).

2.2.2.1. Electric Piano

"*In the early 1930s instruments, which had the general appearance of a piano, but relied upon electro-acoustical methods of tone production and were heard through an amplifier and loudspeaker, began to appear on both sides of the Atlantic*" (Sadie, 1980, p.106). Two pioneers were Benjamin Miessner (Millburn and New Jersey) and W. Nernst (Berlin). Conventional acoustic piano was adapted to an electrical instrument. Its principle was not much different than acoustic piano; the sound source was similarly the strings but instead of amplifying the sound acoustically, the electric piano picks up almost non-audible sound by magnetic sensors and conveys it to electrical amplifiers. When the player depresses a key on the keyboard, the hammer hits the wire; its vibration is captured by pickups, converted into voltage variations, reinforced by the tone bar and amplified by means of electricity. Since vibrations of sound amplified by the tone bar, amplifiers and loudspeakers, no soundboard is necessary. Firstly normal air microphones were tried as vibration capturer but then they were found unsatisfactory. Since the sound is processed by the means of electricity, double and triple bass strings were unnecessary, too. Instead, bass pitches' frequencies were lowered electrically, which in turn cancelled the compulsory use of long strings and decreased the size of this instrument.

The Neo-Bechstein Flugel doesn't look different than traditional piano, except for its smaller soundboard. This electric piano has 88 keys on its single manual. Strings are grouped in five and a pickup serves five strings which equals 18 pickups totally. Thr Neo-Bechstein Flugel has two pedals like most acoustic pianos: left for soft timbre and right for suspended sounding by lifting the damper in order to sustain the vibration of strings. "*The introduction of an amplification system also made possible alterations in the timbre of sound by means of pickups positioned at different points along the strings or filtering or amplifying the harmonics*" (Sadie, 1984, p.655).

Figure 12 Neo-Bechstein Flugel

Rhodes electric piano made a revolutionary contribution to electronic piano manufacturing in 1940s. The first instrument Harold Rhodes created dates back to World Was II, 1942. He used aluminium tubes from wings of bomber aircraft B-17. In following decades his firm produced several models of electric piano (or piano like instruments) that inaugurated a new era of this instrument.

Figure 13 The Rhodes Pre-Piano 1946-48

Figure 14 The Fender Rhodes Celeste 1966-68

Figure 15 Rhodes electric piano MkIV 1983

From the 1942 Army Air Corps piano to the 1984 Rhodes MkV important improvements were realized by Rhodes. The 1964 model clearly reflects the design characteristics of those years: Modernism. It explicitly reveals influences of

modernist art and design with its metallic footing and graceful form. The 1964 Rhodes pre-piano had a sound shaping advantage but this feature had been developed in The 1959 Fender Rhodes piano bass. The 1964 Rhodes electric piano gained an enormous fame and reputation with 88 keys, 1 pedal, 3 sound shaping knobs and two buttons (volume, bass, treble and tremolo-controls). Buttons and knobs were on the left as usual. This instrument became very popular and used by different musicians or groups. Bill Evans, Ray Charles, Cannonball Adderley and Miles Davis or their group members who shaped the music deeply used the 1964 Rhodes electric piano making this instrument more and more famous in the 1970s. The 1980 Rhodes electric piano MkIII EK-10 can be seen as a turning point because this model introduced a built-in synthesizer. Although Rhodes left out built-in synthesizer in a later model, the 1980 MkIII would have given idea to work more and create Rhodes Chroma (synthesizer with keyboard), because the 1980 Rhodes caused an odd story: Its introduction turned out to be a irritating show, just after the television program started to be broadcasted it was quickly discovered that the EK-10's synthesizer component interfered with PAL-format TV in a very bad way: During a national broadcast demonstrating the new piano, it caused televisions to explode. As a result Rhodes decided not to use built-in synthesizers in Rhodes electric piano MkIV.

"*The keyboard-hammer-damper action was similar to that of the conventional piano but redesigned to accommodate the much lighter touch necessary for this instrument*" (Sadie, 1980, p.106). The impact of the hammer itself produces a little tone. Produced sound is picked up electromagnetically or electrostatically by means of air microphones, built in microphones or magnetic pick ups. In these types of instruments, amplification of the sound can be controlled by the left pedal:

Changing the degree of pedal alters the amplification. In conventional pianos, the left pedal stands for generating a soft timbre, however in electric pianos it can give a wide degree of alterations in sounding.

The utmost important thing in the design is to imitate the acoustic piano sound and characteristics; electric piano basically does not tend to create something new and unfamiliar. It aims to make a smaller and lighter (in weight) imitation of the conventional piano. The electric piano tries to imitate characteristics of the acoustic piano such as the sound of the hammer. In acoustic pianos when the hammer hits the string, beside the vibration of the string (which is called timbre) another sound is produced which is hardly audible: the hammer sound. Although it gives the impression that it is not a deserved sound, when electric piano was first introduced, musicians and the listener were willing to hear conventional characteristics of acoustic piano, including the sound of the hammer.

The piano is a very capable instrument and this has made it maintain its superiority in music education for centuries. However its size and weight cause problems and difficulties to transport and move the instrument. The piano forces the players and students to own one at the school and one at home. The electric piano is a product of an effort to make the grand piano a transportable instrument. Besides, most electric pianos are less expensive according to their same quality acoustic versions. This decrease in the price enables musicians to own it more easily. In addition, almost all electric pianos have the opportunity to modify or shape the sound. As a result they can imitate other instruments, as well, such as harpsichord or clavichord.

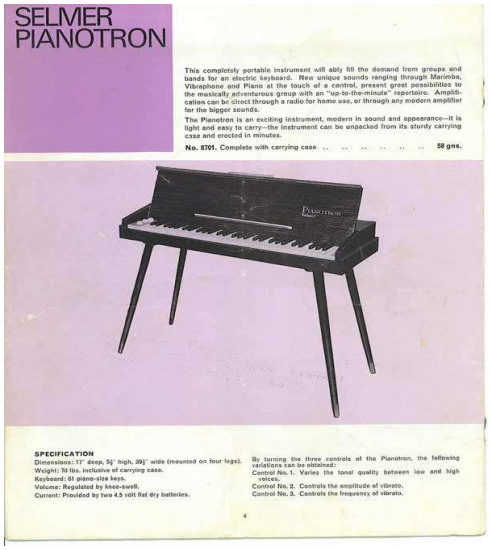
A few electric pianos were constructed that did not use a conventional piano mechanism in 1930s such as Variachord, Clavier of Lloyd Loar and Pianotron by

Selmer. In Variachord, strings are activated by electromagnets; in Clavier of Lloyd Loar and Pianotron instead of strings, plucked reeds are used as the sound source. "*Apart from few recent instruments, most modern electric pianos have also abandoned conventional piano action and with it the form of the grand piano, appearing as keyboards on legs, similar to many small electronic organs*" (Sadie, 1984, p.655).

Figure 16 Clavier of Lloyd Loar

Figure 17 Clavier of Lloyd Loar

Loar's reed action features felt-covered hammers (the white vertical strips above the centre) and a series of reeds that were tuned to pitch by adjusting their length and securing them to a steel bar (the grey flat surface).


SELMER
PIANOTRON

This completely portable instrument will ably fill the demand from groups and bands for an electric keyboard. New unique sounds ranging through Marimba, Vibraphone and Piano at the touch of a control, present great possibilities to the musically adventurous group with an "up-to-the-minute" repertoire. Amplification can be direct through a radio for home use, or through any modern amplifier for the bigger sounds.

The Pianotron is an exciting instrument, modern in sound and appearance—it is light and easy to carry—the instrument can be unpacked from its sturdy carrying case and erected in minutes.

No. 8701. Complete with carrying case .. .. **58 gns.**

SPECIFICATION

Dimensions: 17" deep, 5½" high, 39½" wide (mounted on four legs).
Weight: 70 lbs. inclusive of carrying case.
Keyboard: 61 piano-size keys.
Volume: Regulated by knee-swell.
Current: Provided by two 4.5 volt flat dry batteries.

By turning the three controls at the Pianotron, the following variations can be obtained:-
Control No. 1. Varies the tonal quality between low and high voices.
Control No. 2. Controls the amplitude of vibrato.
Control No. 3. Controls the frequency of vibrato.

Figure 18 Pianotron

2.2.2.2. Electric Organ

The electric organ is a keyboard instrument that can produce sound without using a pipe system and has common features with a church organ. These common features are the ability to sustain the tone, the ability to play cords and the ability to increase or decrease the sustained tone. Basically the first intention for almost all electric instruments was to mimic its acoustic predecessor; on the other hand, some aspects could be eliminated such as deficiencies in timbre quality. In addition, it would be of help simplifying the playability or adding new features. "*The first successful organs with electric action were the result of the collaboration of Albert Pechard and Charles Spackman, who obtained a significant patent in France in 1868*" (Sadie, 1984, p.657).

"*The term electric is used of two types of instruments: electroacoustic and electromechanical instruments*" (Sadie, 1984, p.657). The first group produces sound almost inaudible; sound is picked up by built-in microphones or magnetic sensors. If the sound is picked up by magnetic sensor, then it is referred to as electromagnetic subdivision. The second group creates no sound acoustically, but

it creates a regular fluctuation in an electrical circuit and this can be converted into audio signal. The famous Hammond organ should be classified under this category; its tonewheel is known as the basis of this electromechanical system and has been used in keyboards since 1890s. Whether it is electroacoustic or electromechanical, the electric organ does not produce any audible sound. Therefore it has to amplify produced sound through speakers. Amateur electric keyboards have onboard loudspeakers while hi-end professional instruments are designed with a separated speaker cabinet. Leslie speaker are widely known with the rotating part of the speaker which gives the characteristic sound to this instrument.

"*In many ways the most contentious of all electric and electronic instruments has been the electronic organ. Unlike most other electronic instruments which have established new areas of application and musical style, the electronic church organ directly rivals with the pipe organ, and to succeed must emulate the pipe organ's particular characteristics*" (Sadie, 1984, p.675). The first serious threat against the pipe organ was the Hammond electric organ. The Hammond Company didn't design their organs specifically for churches, but many small churches tended to buy one; it was very suitable for amateurs and home, as well. In fact, even the name of the instrument used to be problematic in many cases resulting in legal battles, because conventional organ producers didn't want those electronic organ producers to use the word *organ* and the Hammond Company had to struggle against the Federal Trade Commission in order to get the privilege to introduce itself as an organ. Laurens Hammond patented his innovation in 1934, in a short period of time it became a widespread instrument in the whole world "*and within 40 years electric organs had outnumbered acoustic ones as a result of their clear advantages in expense, size and portability*" (Sadie, 1980, p.107). In addition, Hammond has a reputation for

producing the first polyphonic instrument in 1950s on which the performer can play more than one note simultaneously.

Some performers, especially those who were strict about conventional instruments, decided not to play electric instruments, because they didn't derive satisfaction from them. This situation led the engineer to deal with issues of the pipe organ: he noticed that these imperfections in the timbre could be a source of satisfaction. For instance, pipe organs had some pitch problems in higher frequencies. In addition, in lower frequencies they had delay problems; since it takes time to fill wide and long pipes with air, the church organ needs some several micro seconds for sounding. Following this, through the sophisticated circuitry micro second delays were added to the sound.

Identity of the electric keyboard is interesting because like many electric keyboard instruments including the electric piano, organ and synthesisers, besides its advantages the electric organ has always received suspicion from many. "*At one extreme it has nearly always been related to the church organ, to be compared with it, usually unfavourably*" (Sadie, 1980, p.110). On the other hand, it has been introduced and observed as a *one man orchestra* rather associated with popular music. In addition, this is quite clear in its interface as its presets and stops usually get their names from conventional orchestral instruments.

2.2.3. Electronic Keyboard Instruments

2.2.3.1. Electronic Piano

Several manufactures attempted to produce the fully electronic piano from 1950s onward, although until the early 1970s none of them could succeed. Their working

principles were not much different from that of electronic organs. RMI electra piano is considered to be the first fully electronic piano which was followed by Armon, ARP, Elka, Korg, Roland and Yamaha. "*In addition to a choice of piano timbres (including acoustic and electric), many of these have stops such as harpsichord, clavichord and vibraphone*" (Sadie, 1984, p.678).

Figure 19 RMI Electra Piano

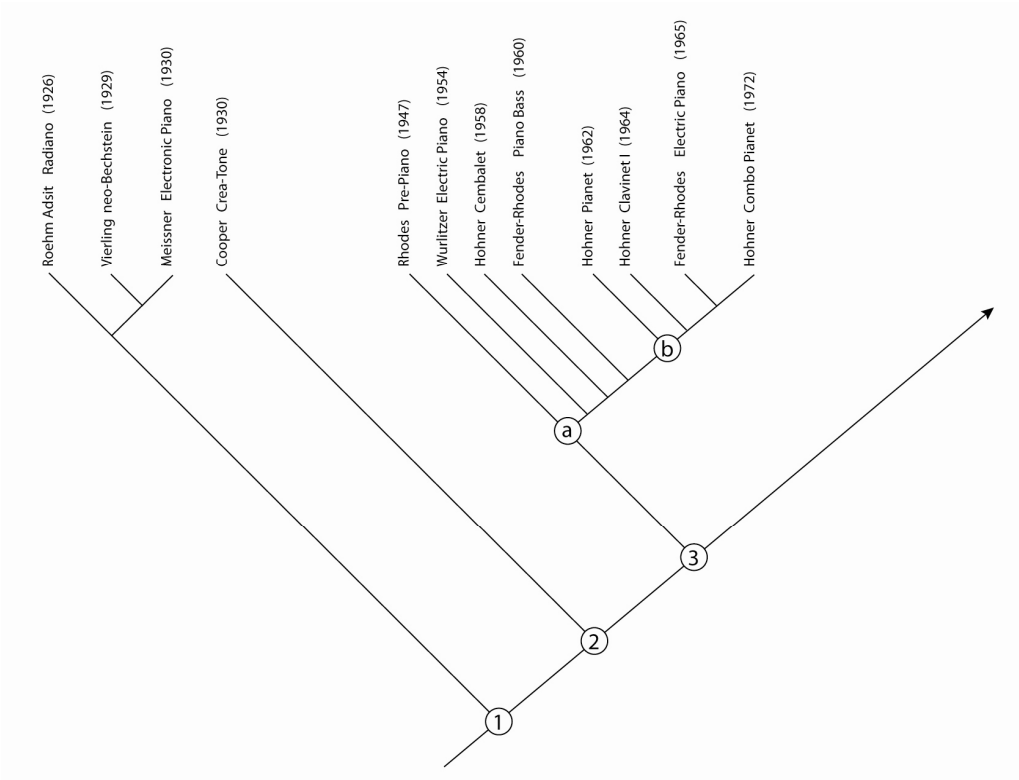


Figure 20 Evolution of electronic pianos (Holmes, 2008, p.243)

Key:

1. Magnetic Pick Up

2. Magnetically Vibrating Strings

3. Tone Bars and Metal Reeds

a. Vacuum tubes b. Solid state

2.2.3.2. Electronic Organ

"*The first fully electronic organ in the market was the American Allen organ, produced from 1939*" (Sadie, 1984, p.675). In 1971 introduction of the Digital computer organ was again realized by Allen. It pioneered the application of latest technology which in turn enabled the faithful organ sound with its tone cards and card reader.

Figure 21 Allen electronic organ

Figure 22 Allen digital organ

Electronic keyboard instruments incorporate electronic oscillators in order to produce and modify sound. Their mechanism does not produce any audible sound, because unlike electric keyboards, they do not include parts such as tone wheels or strings. In more technical terms, electronic devices are a subset of electric devices that incorporate thermionic valves or semiconductors.

Although the Hammond organ contributed to experimental electronic music only in a modest way, it influenced some popular music groups such as The Doors. Ray Manzarek, organist of the group, was able to use a small and mobile organ thanks to those technological developments. He used several electronic organs such as the Vox Continental and the Gibson G101. 1960s psychedelic rock groups used to involve an electronic organ. Vox Continental was designed for touring musicians and its aim was to replace heavy tonewheel organ such as Hammond. Vox Continental was used in many 1960s hit singles and it was-well known with its bright sound.

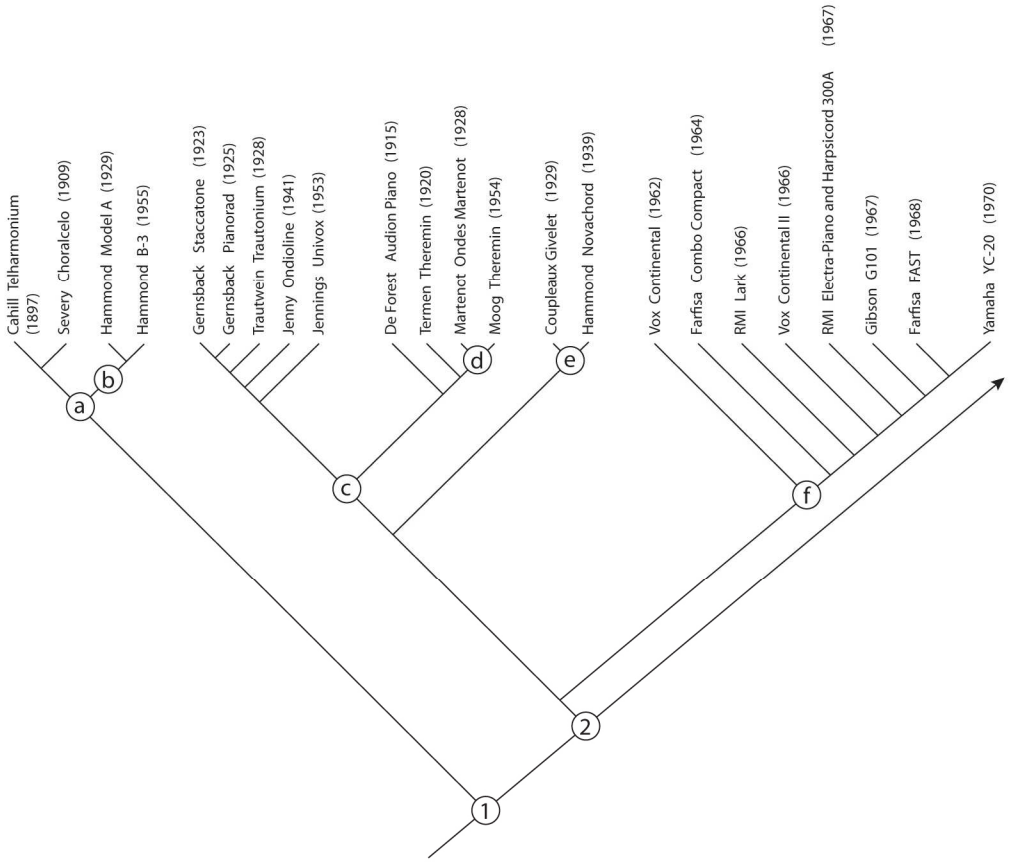


Figure 23 Evolution of electronic organ (Holmes, 2008, p.240)

Key:

1. Electro-Mechanical Instruments

a. Direct current b. Vacuum tube

2. Electronic Tone Generation

c. Monophonic (vacuum tubes) d. Monophonic (solid-state) e. polyphonic (vacuum tubes) f. d. Polyphonic (solid-state)

2.2.3.3. Electronic Keyboard

The term electronic keyboard is commonly used as a generic name for all electric or electronic pianos and organs in many books and encyclopedias. Therefore, it is difficult to address the name correctly even for the expert. However, in this thesis

electronic keyboard addresses the instrument which has a single manual, designed for popular music and generally has a 61 or 76-note keyboard. This instrument is different from the electronic piano which has a 88-note keyboard or the multi manual electronic organ.

Japanese companies like Yamaha and Casio started manufacturing very small and smart instruments especially for amateur and home use, "*which quickly came to account for more than half the total sales of electronic instruments annually*" (Sadie, 1984, p.677).

Figure 24 Casio Tone VL-5 (1982)

The primary aim of the earliest electronic organ was to rival with the pipe organ but after World War 2 different functions of the electronic organ became distinct and manufacturers aimed at different target groups such as light music artists and amateurs for home use. Electronic organs manufactured for concert can be divided into two: for classical music and for light music. The second group of instruments includes unusual stops and sound effects. The most famous ones were Allen, Wurlitzer, Baldwin, Gulbransen, Conn and Farfisa.

Figure 25 Farfisa

On the other hand, home entertainment organs were capable of doing more things and owned a wide range of automated functions in comparison to professional organs. Since their primary target was defined as the hobbyist user by manufacturers, those instruments used to have automated accompaniment facilities. The performer could benefit from electronic accompaniment that enables a *polished performance* without necessities of advanced skills developed only by hard work. Accompaniment could be in terms of rhythm (1960s), bass partition, chordal accompaniment (1970s) memory and replay (1970s), storing and recalling tones (1980s). "*The Hammond Company was the first to detect the market potential of such instruments and for a long term was the leading manufacturer of home organs*" (Sadie, 1984, p.676). Electronic home organs are usually monophonic and have one or two manuals. The spinet arrangement (position of manuals) was first introduced by the Hammond in 1949, their manuals were generally shorter than that of professional instruments. Hammond used a lower-pitched manual at the bottom and the higher pitched manual on top. Hammond in 1950s introduced the chord organ. That organ had "*a keyboard with buttons or occasionally keys (usually on the left) each of which provides a chord; it enables the player to produce an accompaniment*

to melody played on the manual without having to finger complete chords" (Sadie, 1984, p.677). In the 1960s Hammond domination was challenged by other manufacturers such as Lowrey and Thomas organs. In following years many manufacturers entered the market such as Bontempi, Casio, Cavendish and Crumar.

Figure 26 Lowrey organ

Figure 27 Thomas organ

"*Solo performances on electronic organs, especially the Hammond, have been common in jazz, swing and related music*" (Sadie, 1984, p.677). In the 1960s few musicians could afford to buy a small organ; those were especially Hammond, Farfisa and Vox. Although those instruments are not considered to be small today,

now, they used to be, for that period because the sophisticated circuitry considerably changed the concept of portability since 1980s. As a result, musicians were able to carry their own instruments to concert halls and journeys. The Animals' record "*the House of the Rising Sun*" in which Alan Price plays a Vox Continental and the Pink Floyd song "*Set the Controls for the Heart of the Sun*" in which Rick Wright plays a Farfisa are two of most well known examples.

Figure 28 Vox Continental

Figure 29 Farfisa

Electronic circuitry improved rapidly resulting in less space requirement for enough versatility and sound quality. "*The concept of portability has changed considerably over the years: the original Hammond organ, weighing around 80 kg. was*

considered portable; in the 1950s small dance band or "combo" organs weighed around 35 kg. and could be fitted into the boot of a car; today a small organ can weigh as little as 2,5 kg." (Sadie, 1984, p.677).

2.2.4. Digital Instruments

Digital keyboard instruments render and modify sound through *ones and zeros* and their infinite combinations, although electronic keyboards create their timbre through generation and control of electrical voltage. In digital instruments, quantification process is done on discrete steps (unlike quantification process of electronic keyboards that occurs through continuous scale of voltages), therefore they are said to have been more accurate than electric-electronic instruments. Besides, their maintenance could be claimed to be easy and inexpensive relatively. *"…Once initial designs have been incorporated into hardware and software form, they can be mass produced at lower prices than analogue equipment*" (Théberge, 1993, p.72).

Digital keyboard instruments offer great precision, control and flexibility over the sound. Only a touchscreen can do what many buttons and knobs did before. Unlike electric-electronic instruments are divided into groups according to their principles (electromagnetic, electroacoustic… etc.), digital instrument has a less complex structure. "*Most digital synthesis techniques are based very strongly on mathematics*" (Russ, 1996, p.223). Since they don't have to include some parts that are necessary in electronic keyboards, manufacturers can offer smaller instruments. In addition, accuracy, repeatability and consistency are other advantages of digital keyboards. Sounding principles of the digital piano, organ and keyboard are almost the same; therefore images are displayed without text under following subtitles.

Figure 30 Yamaha YPG 535 digital piano

Figure 31 Hammond XE-200 digital organ

Figure 32 Yamaha Motif XS

CHAPTER 3

3. Interface Design Considerations in Musical Keyboards

Music and technology have gone together for the last 20.000 years. Building a drum is an act of technology.

Schmidth, 2000, p.36

"*Technology has always been inseparable from the development of music. But in the 20th century a rapid acceleration took place: a new "machine music" came into existence, electronic musical instruments developed and composers often turned into sound researchers*" (Braun, Ed. Braun, 2002, p.9). Similarly, it can be argued that when Bartolomeo Cristofori designed the first piano, that instrument was a representation of the level of technology of 18th century. Also the first known organ, *Hydraulis*, (Hindley, Ed. Braun, 2002, p.36) in which air that produces the sound is pushed by water from a natural source, is a proof of the technology standard of 3rd century BC.

Technology, or specifically electricity has had a great impact on evolution of music; and this led to fevered debates in literature. "*Textbooks on twentieth century music delineate Futurism as the "first clear manifestation" of "a major and enduring concern" for the relationship between new music and modern technology*" (Bijsterveld, Ed. Braun, 2002, p.123). With the leadership of Theodore Adorno, Walter Benjamin, John Cage, Karlheinz Stockhausen and others, there is a serious amount of theories and critiques on this subject. Also researchers and academics including Hans-Joachim Braun, Trevor Pinch, Frank Trocco, Thom Holmes, Aden Evens and many others write on music and technology.

However, there is almost no reference to interface of instruments and music machines, although it is of great importance in terms of capability and productivity of the electronic instrument. A well designed interface can help to improve interaction between the player and instrument; on the other hand poor design can result in errors and fails especially during the course of live performance.

Parallel to the technological developments in the 20th century, music instruments had swift improvements and influential overnight design decisions since the invention of the electricity. Through decades, important improvements occurred in instrument production technology. Especially, improvements in electronic keyboard interfaces in late 20th century gave powerful tools to the musician. Capability of mimicking other instruments enabled the keyboard to sound like other instruments from violin to guitar, automated accompaniment enabled even a novice musician to sound like a professional. In today's market, top keyboard manufacturers like Roland and Korg are competing with each other to build *the most capable* keyboard ever (or in other words music production stations). With the possibilities of touch screens and softkeys, these brands have seriously improved capabilities of this instrument.

3.1. Ergonomics in Keyboard Instruments

Keyboard is a product of a very long evolutionary period and has influences from string instruments such as Dulcimer. All keyboard instruments have some common points with each other; their keyboard ergonomics are more or less the same. This is mainly because of the traditional data accumulation and level of technology of their time; in the era they first appeared, pluck, hammer and lever systems used to have some difficulties to produce, as they require very precise key action and withdraw mechanisms. The production was excessively dictated and directed by the nature

of the material and strings. It may be logical to claim that their straight form was a simple and basic background for strings, keys and their connections, in their time. In almost all keyboard instruments in history, keys were placed on a linear surface with naturals 12.5 to 15 cm. in length and 2.4 cm. in face size; and accidentals approximately 5 cm. shorter in length and narrower than naturals in contrast colour. Traditionally, keyboards have had white colour for naturals and dark for accidentals, "*whereas German and Australian makers used the opposite, wood stained black naturals and white (usually ivory) for accidentals*" until the beginning of the nineteenth century (Good, Ed. Palmieri, 2003, p.203).

One may argue that almost all musical instruments do not represent any sign that they are "designed" for people in terms of their ergonomics. For instance the violin; its playing posture is really challenging and the performer cannot see the whole keyboard. In addition, it does not permit the bow to touch three strings simultaneously, which limits the harmonic capabilities of this instrument. However, the reason for that is acoustic requirements and nature of the materials, which results in a brighter and louder sound. As Emanuel Winternitz argues in his book *Musical Instruments of the Western World* (1966), one cannot change any measure or angle in any instrument without affecting the balance of the whole. Moreover, he mentions the thickness of the walls and curvature of the body as parts that give the characteristics of an instrument. If we consider the fact that keyboards have very complicated pluck mechanisms, with the level of technology available in its time, the designer had to work in a very confined level of imagination. In other words, the keyboard designer did not have the chance to manipulate his instrument according to the human body. However, as the technology improved, new alternatives have always been proposed in order to have more sophisticated ergonomics or a better

timbre. "*Progress, that is actually improvement, exists only in the realm of technology, where better solutions for certain mechanical problems are found through the inventions of practical devices, that solve mechanical problems better than had been done before*" (Winternitz, 1966, p.21).

Figure 33 Roland Fantom G7 Touchscreen and soft keys

In this figure, touchscreen and soft keys of a Roland keyboard are presented. Although there are many objections against the use of touch screen, it has become the most important part of the interface as every detail can be displayed and manipulated through it. However, touch screen is often blamed for being imprecise and slow for live performances.

3.1.1. Evolution in the Form

Electric organs and pianos are deeply influenced by the universal layout of mechanical keyboard instruments. When Bartolomeo Cristofori designed the first piano, he had ideas highly influenced by the clavichord and harpsichord. Instead of plucking the strings, he came up with the idea of beating the string with hammers. "*The present form and the function of the piano is a result of a very long and complicated evolution. Taking into consideration the actual acoustical*

characteristics of the instrument, it seems that the greater number of the components that have to do with the generation, amplification, and radiation of the sound are seen in the light of dynamics and quality" (Poucke, Ed. Palmieri, 2003, p.10).

To an extent, it is quite logical that electric instruments resemble the characteristics of their acoustic ancestors. However, it might be claimed that they should not mimic their predecessors any more. Electric instruments can be shaped and designed without many constrains of materials and timbre requirements; they should be designed for people in mind. In the history of keyboard instruments the *straight keyboard* is not the only keyboard, there are alternative keyboard systems, but very few. They are products of the demand to a more ergonomic keyboard layout. They are the Concave Keyboard and the Jankó Keyboard (designer Paul von Jankó).

3.1.1.1. Concave Keyboard

In history, several attempts to change the straight layout of the keys can be found. They stem from the basic idea that "*the arms and hands could move more naturally over a concave keyboard*" (Good, Ed. Palmieri, 2003, p.204). Although these concave keyboards never found wide interest, they can be claimed to have been more ergonomic in comparison to straight keyboards as they respond to the natural shape of human body. Besides, different producers through time came up with similar solutions. The first example is thought to date back to 1824; in those years, Johann Georg Staufer and Max Haidinger in Vienna applied the concave idea to their pianos. "*Similar ideas can be found in the work of Wolfel in Paris in the middle of the nineteenth century, and in an 1881 German patent by Gustav Neuhaus*" (Good, Ed. Palmieri, 2003, p.204). In 1907, Ferdinand Clutsam patented the same

idea in Germany.

Figure 34 Concave Keyboard

3.1.1.1.1. Jankó Keyboard

"If I were to begin my career anew it would be on this keyboard."

Arthur Rubinstein (1887-1982)

Paul von Jankó developed an invention done by William Lunn (Lunn used to use Arthur Wallbridge name) in 1843. "*Lunn used two rows of keys in whole tones, the lower row from C-sharp, the upper from C. An earlier "chromatic keyboard" (with only one manual) had been presented in 1791 at the Berlin Academy by Johann Rohleder, with "naturals" and "accidentals" alternating, the whole-tone scale from C as the "naturals," the whole-tone scale from C-sharp as the "accidentals*" (Good, Ed. Palmieri, 2003, p.205). Jankó developed this model and introduced it on a piano in 1882, therefore it is known as Jankó keyboard in the literature. His main argument was that human hand can hardly stretch more than 9 keys on the piano. He redesigned and proposed a keyboard, which had two interlocking manuals, and each key lever had three touch points. "*The purpose of the keyboard was threefold: (1) to*

simplify fingering, (2) to extend the player's reach, (3) to fit the hand more comfortably" (Good, Ed. Palmieri, 2003, p.190). The Jankó Keyboard was very advantageous in pieces whose melody requires depressing keys over a wide register because he could manage to shorten an octave on the keyboard to a 6-key width.

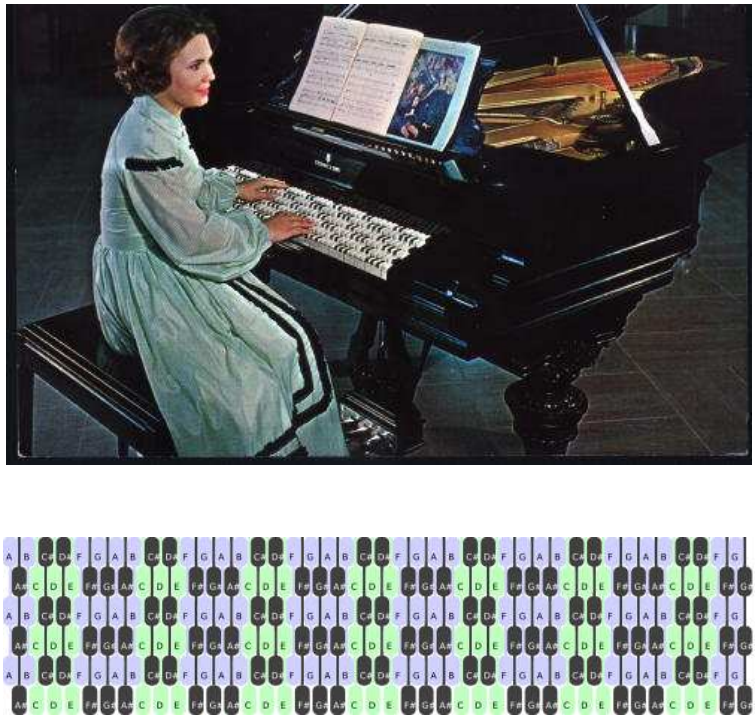


Figure 35 Jankó Keyboard and key system

"This invention will have replaced the present piano keyboard in fifty years' time."

Franz Liszt (1811-1866)

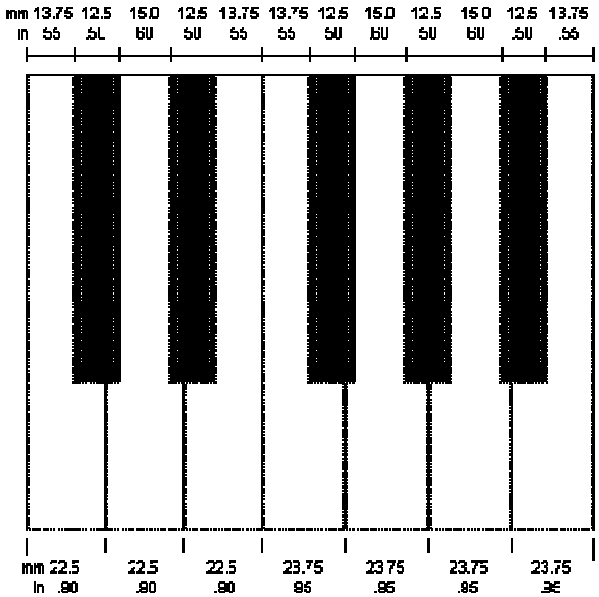
It was a really imaginative and clever alternative to the standard keyboard but contrary to Liszt's prediction, this instrument did not catch on and disappeared within less than half a century. The main reason was that virtuosos did not want to relearn another system of keys after mastering an ordinary piano keyboard. In

addition, it was more expensive to manufacture in those years as it used to have 264 keys unlike 88-key universal keyboard.

3.1.2. Dimensions

From clavichord keyboard to digital keyboards a great progress has been achieved; especially roll-up digital organs (for amateurs or children especially) are incomparable in terms of size. However, key dimensions have not changed a lot. Traditionally keys for accidentals are about 5 cm shorter than naturals and in contrast colour. This is mostly because manufacturers prefer to build digital instruments which are similar to their acoustic predecessors in terms of dimensions.

However, manufacturers do not avoid dividing or combining manuals; different church organs may have multi-manual keyboards in varying numbers. Similarly, some experimental pianos have existed that incorporates different keyboards, which are located at different heights. "*From 1922 to 1923 Emanuel Moor produced two-manual pianos of his own design, with one set of strings, the upper manual playing an octave above the lower*" for instance (Good, Ed. Palmieri, 2003, p.205).



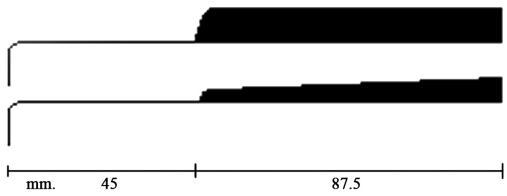
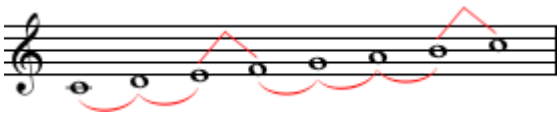


Figure 36 Traditional key dimensions

3.1.2.1. Naturals

In each octave on the keyboard, there are 7 natural keys which are white and whose width varies between 22.5 and 23.75 mm. Their length can be between 125 and 150 mm. They are wider and longer than accidentals but it doesn't mean that they are pressed more often; this contrast in colour and shape aims to increase visual perception and roots from the major scale (2 whole 1 half 3 whole 1 half).



3.1.2.2. Accidentals

In each octave, there are 5 accidentals in black on the keyboard. They are shorter and narrower; their length can be between 85 and 100 mm. And their width is normally 10 mm. less than naturals. Besides, they are placed away from the player that would cause difficulty in reach if they were not clearly raised from the level of the naturals.

3.1.2.3. Differences in Electronic Keyboards

Besides using similar key dimensions and ergonomics, electronic keyboards may have slightly different keys in terms of shape. Firstly, their keys are not exactly

horizontal; they are sloped with a small angle and it aims to fit the natural posture of hand in a better way. In addition, accidentals in electronic keyboards have a radius on top.

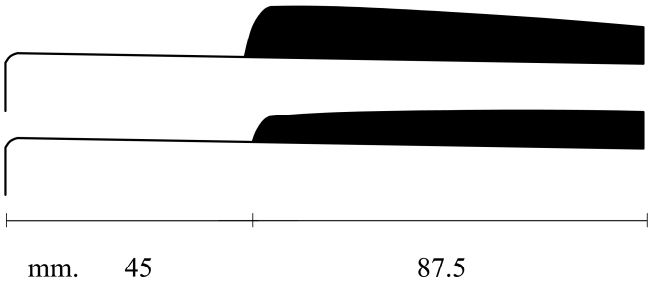


Figure 37 Keyboard keys

3.1.2.4. Instrument Size

Whereas almost all modern piano instruments are standard with an 88-key layout (except for 92/97-key Bösendorfers), there are plenty of electronic keyboards of different size, height and shape in the market. Therefore, generalisations should be avoided in terms of size, though 61 and 76-key layouts are two most common examples, and the total length of the keyboard generally does not exceed 140 centimetres in order to improve transportability. Electric pianos generally have the same 88-key layout with acoustic pianos, and pipe organs usually have 61 keys on each manual. There is a variant of pedalboards from 12 to 32 notes on pipe and electric organs.

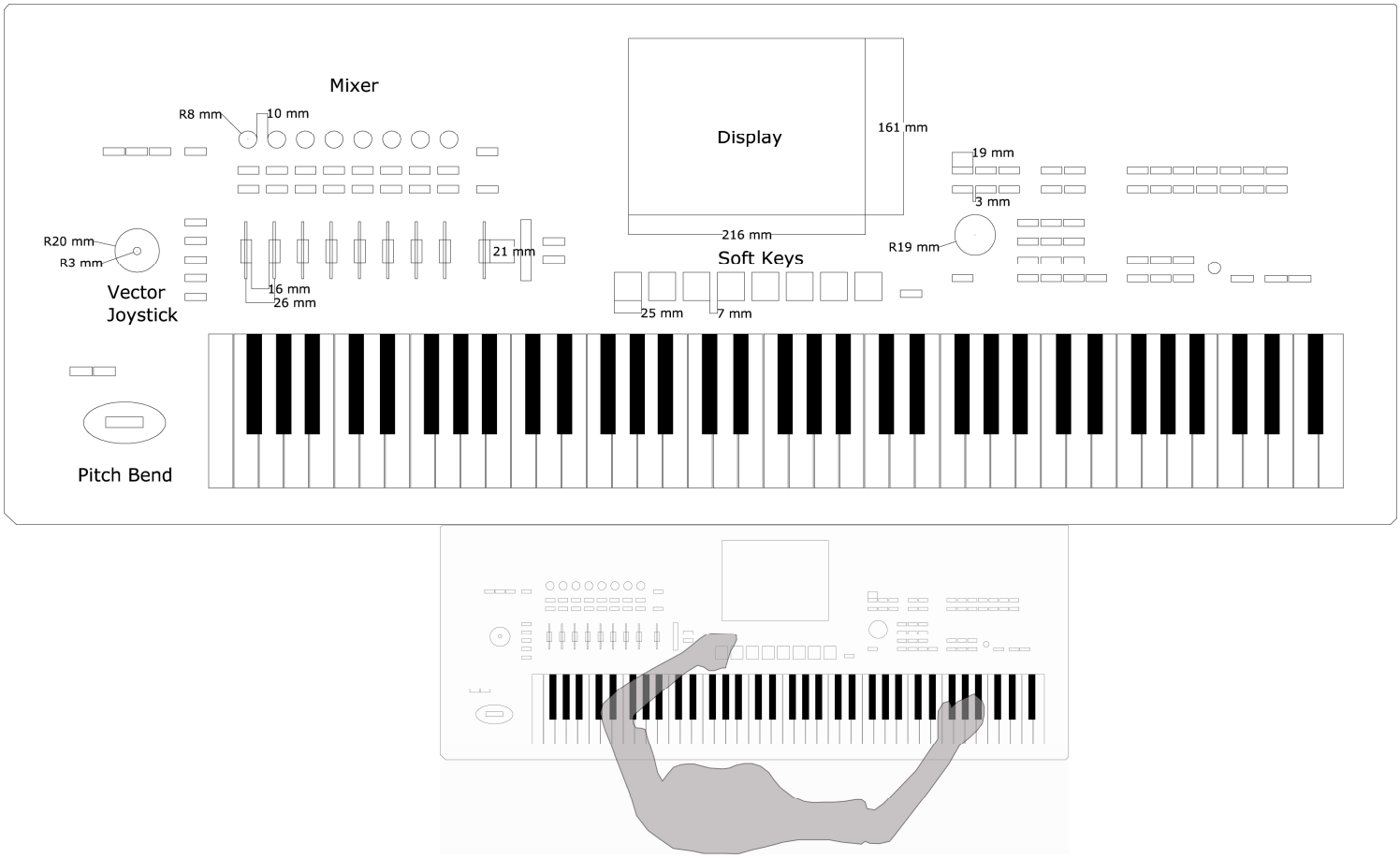


Figure 38 Interface dimensions of Korg Oasys

3.1.2.5. Sitting Position and Height of the Manual

The height of a person can vary considerably. In addition, the player can either sit or play standing up; and even if s/he plays sitting on a surface, the height of the surface might be different. These are reasons why it is difficult to define the height of the instrument. However, a player can adjust his instrument to a suitable level by using stand adjustments.

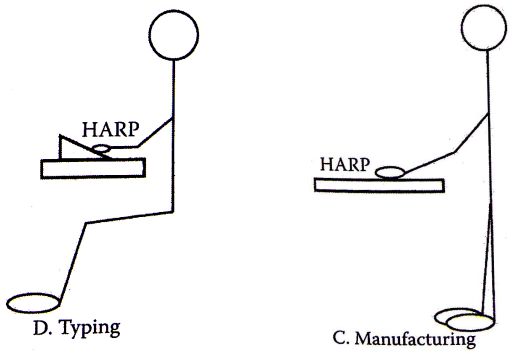


Figure 39 Reference points of hands for different purposes

Martin Halender argues that reference points of our body may vary according to the type of anthropometric design. HARP (Hand Reference Point) can be advocated for jobs that are executed by hands. "*For heavy manual jobs, the hands should preferably be about 20 cm. below elbow height, but for precision tasks with supported underarms, the hands should be about 5 cm above elbow height*" (Halender, 2006, p.156). Pianists try to position their arms parallel to the keyboard and this is possible if their elbow and hand height is the same as the height of the manual.

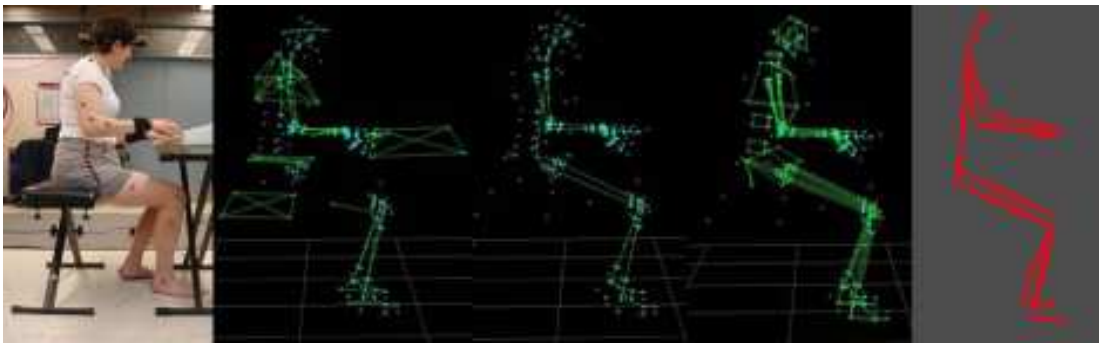


Figure 40 Constructed Skeleton with Its Hierarchy (University of Ottawa)

One of the basic rules of playing the piano is that the performer adjusts his or her seat so that the elbows come to the same height as the manual and the part between the elbow and the hand can reach the keys parallel to the manual. As can be seen in the figure above, the arms should be in parallel position with the manual in proper piano playing posture. Unlike the piano, harpsichord or organ players, keyboard players generally perform standing up which means their hands are not parallel to the manual. In this position, the performer should adjust the stand height or angle. Derek Sherinian[5] comes up with an extraordinary solution; he plays his instrument in a different set up.

It is obvious that the player will be bound to play keyboards of different heights on a multi-manual instrument, which, in terms of ergonomics, may lead to difficulties in reach and accuracy. Considering multi-manuals, height adjustment seems to be impossible as manuals have different heights. In other words, multi-keyboard instruments may cause ergonomic problems for the performer.

[5] Renowned rock keyboardist. His style will be elucidated in Chapter 3.6.3.1.

3.1.3. Hand Movements

On a keyboard the reach limit of a normal hand is the 9th key, and stretching more can be hazardous. This length can be insufficient when reaching sound controls on the electric keyboard is considered. Therefore, many sound shaping facilities on the interface cannot be controlled by the same hand which plays the melody.

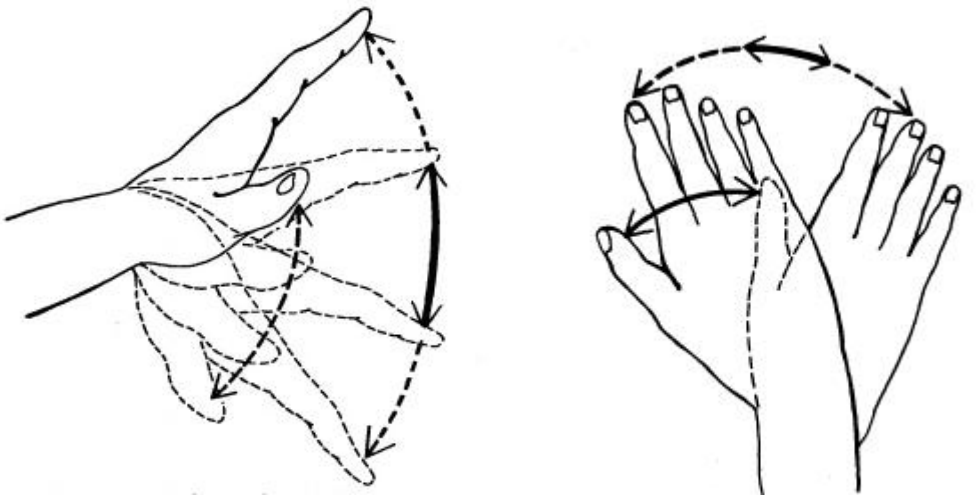


Figure 41 Vertical and horizontal hand span of hand

Like all parts of the body, finger movement has an arc shape. Therefore, all controls should be designed for the "arc-shaped" nature of our body. Example below is a very experimental Korg (the most innovative manufacturer in keyboard market in terms of design) keyboard: Korg 700S. It has front mounted controls in order for easy access. On the other hand, due to poor design this instrument could not catch on because vertical surface on which the controls are placed is out of sight of the performer. Besides, the interface doesn't give any clue as to how it should be modified and controlled. Nevertheless, although this product is awkward in many aspects, it is one of the very few examples of human factors applications on musical keyboards.

Figure 42 Front mounted controls on Korg 700S

3.1.4. Flexibility

Flexibility is generally seem as relevant to use and adaptability. If a product is said to be “flexible”, then its design should provide a chance to determine the method of use and should be adaptable to the users’ approach. A good example might be the Korg Radias.

Figure 43 Korg Radias and flexibility

The Korg Radias is a professional rackmount 49-key keyboard and synthesizer. It is really flexible because its control panel can be adjusted from left to right. Besides, the angle of the panel can be changed. This instrument gives a very flexible use to players of different height, and it can be adjusted for left-handed and right-handed users. Because its control panel can be adjusted, this instrument can be used together with other keyboards very easily in varying setups.

3.1.5. Usability

"*Usability is based on individual interpretations*" (Steinfeld and Danford, 1999, p.19) and therefore it is thought to be very subjective since the level and quality of observation can vary greatly for each individual. Especially if we are testing usability for a non-professional tool (lets say a mobile phone), it means our job is even harder. "*Usability is a measure of the effectiveness, efficiency and satisfaction with which specified users can achieve specified goals in a particular environment*" (Iwarsson and Stahl; 2003). As the sentence explains, it is difficult to test the level of usability of an interface or a product; because level of usability can be determined by

the conditions of the environment, too.

Testing the usability of a professional object can be less complex, because professional tools require an education and there are tangible criteria as to what should be tested in that design and where should be started, and the test should include a number of professionals.

For the music keyboard placement of buttons with an order, clarity of functions, symbols and definitions of controls, colour, contrast and readability of screen make this instrument more or less usable, because "*what is difficult to see is difficult to think of*" (Halender, 2006, p.96)

Buttons, knobs and dials should be coded by some features; their order can be expressed by Location, Colour, Shape, Size and Labelling (Halender, 2006). In many keyboards colour coding and grouping have been used since 1940s. This makes these controls easy to find to the player. However, there is still a big complexity in many recent keyboards; their interface is surprisingly complex and needs to be simplified. As can be seen in the figure below, the interface does not reveal its order, because almost all buttons and dials look the same. In addition, there is no grouping or colour coding. Moreover, there is no reference to human body; "*fingers, like the hand, arm, and the rest of the human anatomy, always move in a curve line*" (Sandor; 1981, p.23) and eventually player will use his/her hands in an arc-shaped movement. Also in this example, the spacing between controls is too small to supply a reliable touch, which may result in failure in the live performance.

Ensemble clavier et rack

Figure 44 Front panel of Korg Radias

"*Coding by the location is the most powerful principle*" (Halender, 2006, p.104) and location criteria can standardise easily through time. If not standard, it is very common to place the pitch bend on the left-hand side for instance; and this gives the player a sort of "universality" sense on keyboards. Coding by colour is a widely used principle on keyboards, keys are coloured according to their purpose forming clusters and groups. "*One potential problem with colour coding is that it only works in a well-illuminated environment*" (Halender, 2006, p.104); however, most keyboards of today use LED light as a source of colour. Coding by size can be a distinguishing factor between different controls but interfaces coded by shape (these two are close) can have much merit. Shape can give clues about the function in both abstract and concrete ways. According to Woodson and Conover (1964), an operator

can distinguish up to twelve different shape-coded control knobs. In the figure below, a button in piano shape as a part of an electric piano interface is seen whose function is to activate the grand piano sound.

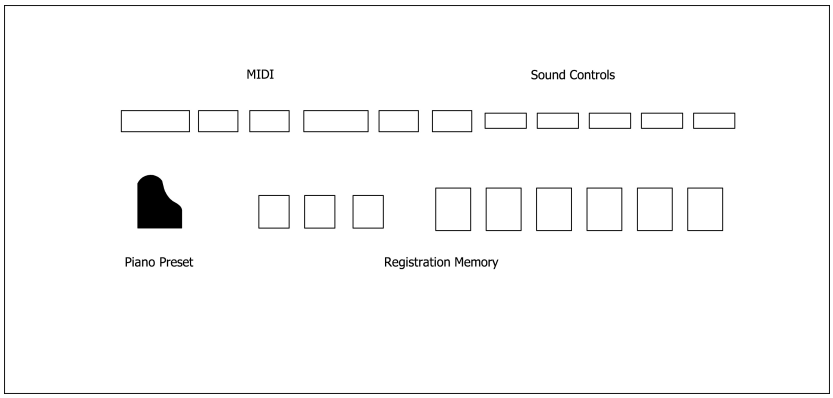


Figure 45 Piano preset on Yamaha Clavinova interface

3.2. Interface Elements Related to Keyboard Design

> *In September 1978, a project was proposed: to design and build a high-quality all-digital keyboard synthesiser for the commercial market… The proposal was motivated by the successful prototyping of a digital circuit that simulated 32 oscillators… With a working example in hand, it seemed everyone involved that the hard part was over… It was estimated that this process might take a few months. Two and one-half years and nearly one million dollars later, the resultant product is available for sale. In retrospect, the tremendous number of technological design and production difficulties encountered make the original estimates seem appallingly naïve (Kaplan, Ed. Roads, 1989, p.611).*

Instrument design, including acoustic, electric, electronic and digital, has always been done in order to gain a better or louder timbre, dynamics and functions. Although instrument designers and manufacturers have worked in collaboration with the musician in history, the end product rarely appears as a widely accepted perfect tool for making music; rather, it continues to evolve and improve. For instance the guitar nearly 3900 years after its first existence in Çatal Höyük (approximately 2000 B.C.) was redesigned by Antonio de Torres Jurado in 19th century and this modern guitar is still subject to changes by different producers according to needs. For

instance Sergio and Odair Assad use guitars made by Thomas Humphrey, named the Millennium, in their Baroque recordings as this guitar has a raised fret board that makes the higher notes clear of the body of the guitar. It allows the player to play higher notes more comfortably. "*The guitar is an instrument that is still developing, with a lot of good results*" (Assad, 1993). Théberge argues that an instrument can not be completed in design and manufacturing process: "*It is only made "complete" – often in a variety of different ways and in different musical contexts – through its use*" (Théberge, 1993, p.70). And then this *invention* is turned into an *innovation* only by the hands of the musician.

Musical performance includes two main inputs: instrument and performer. This interaction is enabled by controls of the instrument, which have a variant of type, size and quality. Since there is no constructional limitation and acoustic requirement, unlike almost all musical instruments, electronic keyboard interface and controls are shaped "*by the flexibility of the synthesis technique and its physical implementations*" (Russ, 1996, p.330) and the main goal is to increase the utilisation of the resources of the instrument. If the layout is more natural and intuitive, limitations on the performer seem to decrease. Because electronic keyboards are not universal unlike many instruments, and there are completely different types and sizes in the market, the performer should spend some time to orientate controls on them.

3.2.1. Front Panel Functions and Placements

Pipe organs have had controllers such as rotary knobs and dials for centuries; however, these controls became seriously important on electric keyboards after 1940s. Since the first Hammond organ, Model A, the front panel has always been important, however after 1970s, it became loaded with sliders, knobs, tablets and a

screen. It still goes on to develop and improve; and "*has moved away from hardware to solutions which increasingly depend almost entirely on software*" (Russ, 1996, p.353).

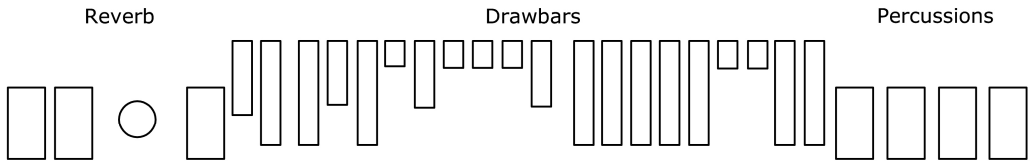


Figure 46 1950s Controls in a row style front panel

In those years' front panels, all tablets and buttons controlled only one parameter, which required using many of them.

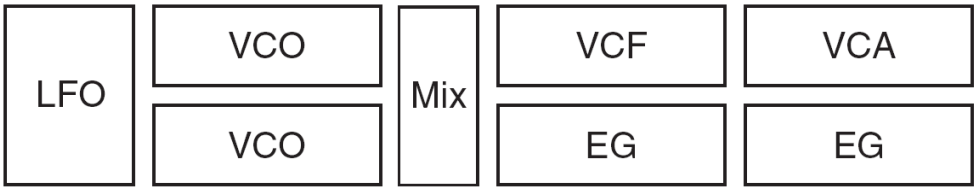


Figure 47 1970s form=function front panel

In the 1970s, parallel to the highly improved capability of the keyboard, the front panel became very complicated. "The layout reflected the structure of synthesis method" (Russ, 1996, p.353).

Figure 48 1980s minimalistic front panel

In 1983 the Yamaha DX7, which is known as the first commercially successful synthesiser, came up with a minimalistic arrangement: Yamaha introduced the left-right hand approach. In this instrument, single slider control was used in association with parameter selection buttons. These buttons had different meanings with respect to mode controlled by a single slider; player first selects the parameter with the right hand and then adjusts the value with the left hand. Although it enabled the panel to become minimal, it required much concentration.

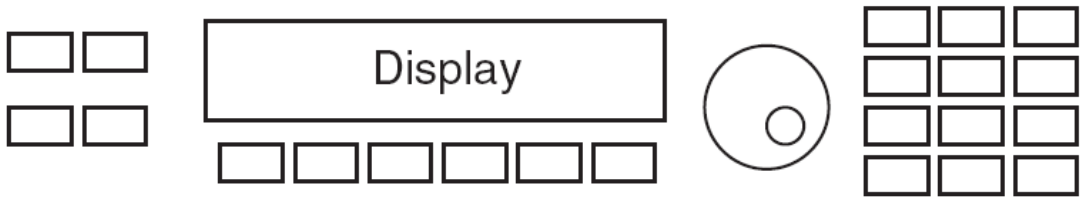


Figure 49 Early 1990s softkey driven front panel

In 1990s, single slider was joined by rotary knobs and increment-decrement buttons. In addition, soft keys were added and the screen tended to increase in size. As the display progresses to be dominant, less controls were required and "*front panel space was then available for additional performance controllers: track-balls and joysticks are two examples of methods used to permit rapid real-time control of parameters from the front panel of a synthesizer*" (Russ, 1996, p.352).

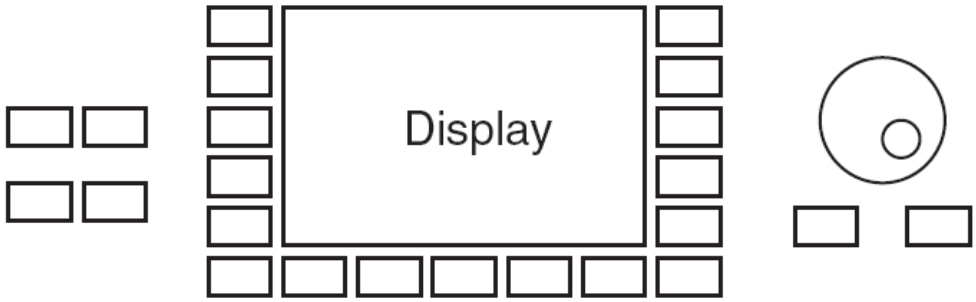


Figure 50 Mid-1990 the display is everything front panel

In the mid-1990s, touch screens were first introduced and through the second half of 90s, more soft keys were added and the screen started to be the focal point of the panel. After these years when the big LCD screen became widely available, the importance shifted from button-knob unity to using the display as the control. Rows of softkeys near the display gave an important flexibility, as the buttons could be assigned different functions.

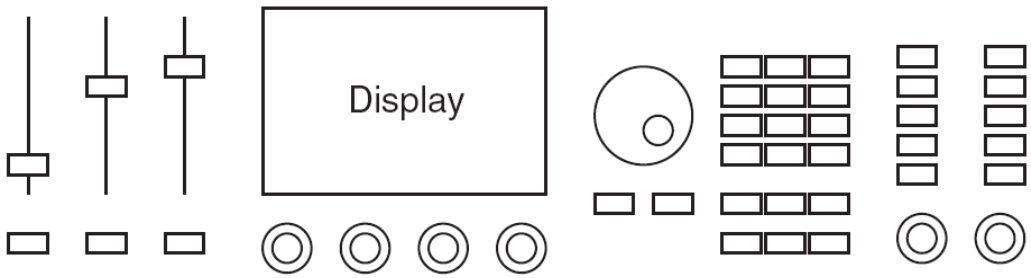


Figure 51 2000s softknob and touchscreen with dedicated function areas

The 2000s saw three trends (Russ, 2004):

The first trend was a return to minimalism in order to manufacture less expensive instruments. Second was a mixture of display-based softkeys and softknobs for mid-range instruments, often organised into functional groupings. And the third trend was using touchscreen in high-end instruments; manufacturers tend to join them

with assigned controls for specific functions. The first colour touchscreen was used in the 2000s and it was estimated that it would move down to less expensive and less professional products, however it seems as the decade has progressed to the 2010s, this foresight has not proved to be true.

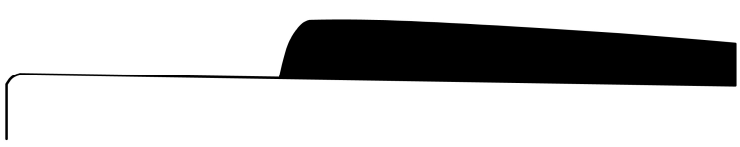
3.2.2. Control Types

Electronic keyboards have a wide range of controls and different brands and models may use different type of controls to accomplish the same task. On the other hand, they can be summarised as follows:

3.2.2.1. Keys

Basically, electronic keyboards have two types of keys: organ type and piano type. Organ type keys are generally used in mid-range products while piano type keys are used in high-end instruments.

Organ type keyboards have light keys made of plastic with a hollow inside enabling a lighter action. This type has black keys that are sloped with a curve from the front face to the end face. The key action is very light and fast in comparison to piano type and, after being released, the key returns to first position with the help of a spring.



piano type keys are generally made of wood and are covered by plastic. They are heavier, and although they do not have lever and hammer mechanisms, they have

a slower action. This mimicking of the grand piano is made possible with the help of some weights, therefore piano type keyboards are known as “weighted”. In addition, they have flat top surfaces.

Figure 52 Key geometry

3.2.2.2. Knob

In very early synthesisers and electronic keyboards, rotary control knobs were very commonly used for many continuous adjustments such as volume, pitch bend, equaliser, modulation and many more. “*But knobs were not very satisfactory for live performance use*” (Russ, 1996, p.342) and some alternatives were tried.

3.2.2.2.1. Wheel

Wheels are a sub-type of rotary knobs, pushing the disk clockwise or counter-clockwise adjusts the designated function. Their diameter can vary between 40 and 80 mm. and normally one third of the wheel sticks out of the interface and is visible generally with a small and suitable surface to be touched by finger.

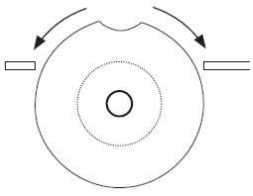


Figure 53 Wheel

3.2.2.2.2. Lever

Levers are very close to the wheels technically; they are like *a part* of wheel. Their length is normally between 5 and 6 cm. "*The rotational movement is normally less than a wheel: a maximum of 90 degrees and a minimum of about 45 degrees*" (Russ, 1996, p.343).

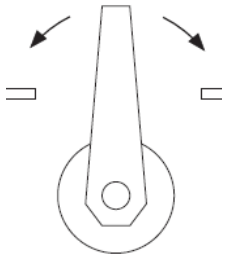


Figure 54 Lever

3.2.2.2.3. Joystick

Joysticks can move either through four directions (up, down, left, right) or 360° continuously. They can be very efficient and some other functions can be added: They can be clicked or rotated which makes them a very important part of the interface. Today many interfaces (from cameras to game stations) benefit from their possibilities.

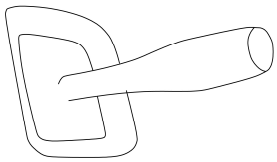


Figure 55 Joystick

3.2.2.3. Bistable Push Buttons

These buttons can be called buttons or dials, but on a Hammond organ they are tablets. Though their name can vary, their function is very basic though: "*control with two stable states which changes the state at every operation*" (Baumann and Thomas, 2001, p.135). The position of a button between two states should be clearly apparent to avoid failure.

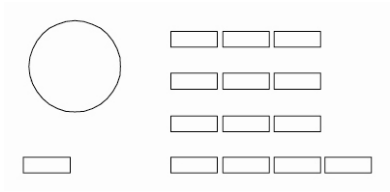


Figure 56 Buttons and tablets

3.2.2.4. Soft Keys

Soft key is an association between the soft label and hard key, which is used with screens and "*function of one shot key doesn't exist physically*" (Baumann and Thomas, 2001, p.145). They are software-controlled keys and they are not part of the hardware. Their function varies according to the situation and their variable function is indicated on the screen.

Figure 57 Soft keys

3.2.2.5. Touch Screen

The touchscreen can be summarised as a synthesis of control and display; and "*it offers a maximum of flexibility in limited space*" (Baumann and Thomas, 2001, p.151). However, due to being imprecise and slow, many keyboardists are often in opposition to the advantage they have supplied. Touch screens are meaningful with the software, and the purposes of controls are highly flexible. They supply efficient control over the instrument but generally are not regarded as precise as hard keys.

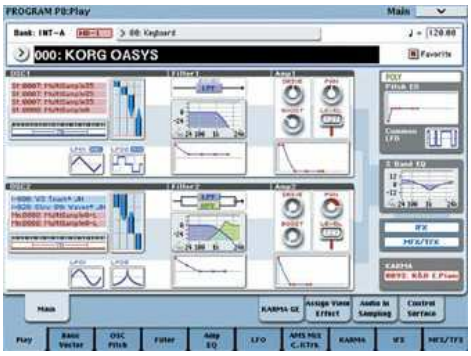


Figure 58 Touch screen

3.2.2.6. Slider

Sliders are designed for analogue (infinitely variable) adjustment and their function is very close to rotary knobs. They suit horizontal or slightly inclined surfaces, well, and used mostly as equaliser continuous sliders and volume-intensity adjustment controls. Their direction is generally located parallel to the user's line of sight, because "*pushing sideways or upward is less powerful and less precise*" (Baumann and Thomas, 2001, p.140).

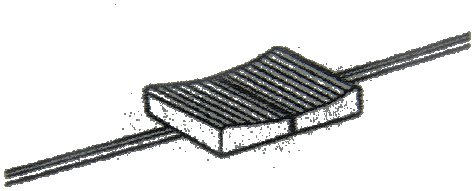


Figure 59 Slider

3.2.2.7. Foot Controller

Foot controllers are generally rotary controls depresses by the player's feet. They can either be continuous controllers or have only two values. They are used for many purposes from volume controllers to sustain pedals.

3.2.2.7.1. Foot switch

They can be in the form of pedals, where a lever system is used or they can be just push buttons. "*Foot switches normally have two values only, although there are some rare multi-valued variants used to control sustain on pianos*" (Russ, 1996, p.345).

Figure 60 Foot switch

3.2.2.7.2. Pedal

Traditionally piano, harpsichord and pipe organ feature feet-operated manuals and pedals. For the piano it can be two or three pedals which are used for nuance possibilities such as sustain and deepness. Organs feature foot pedals for playing purposes, many organs and electric organs, bass notes are assigned to pedalboards; these pedalboards can be 12 to 32-note keyboards.

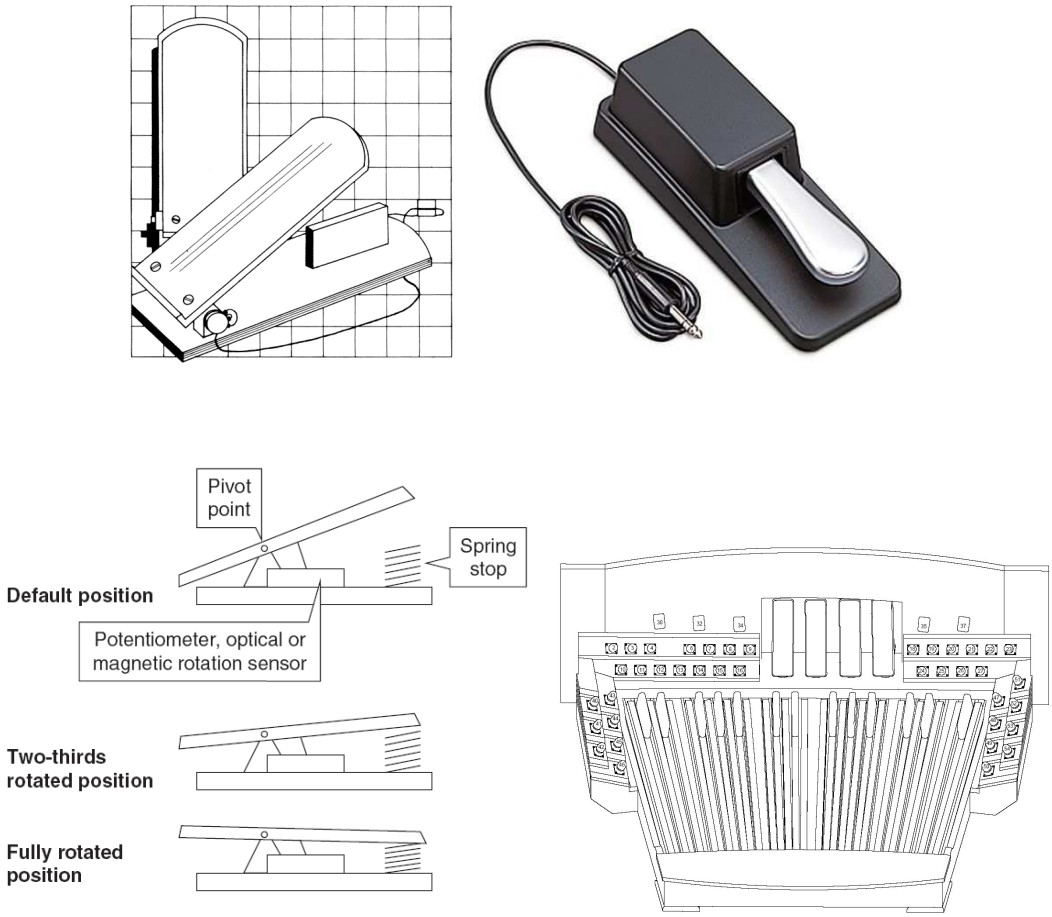


Figure 61 Pedals and pedalboards

3.3. Visual Elements, Perception and Beauty

The criteria by which people judge visual qualities of the product are generally unclear. However, it is obvious that our personality affects our visual-aesthetic taste and, therefore our purchase decisions and judgement of beauty. On the other hand, judging visual and aesthetic qualities may include other several points when professional products, like music instruments, are concerned.

Aesthetics and beauty of a keyboard for the musician are not simply defined by its colour and finish; it is attributed historic, social and abstract meanings, which cannot be achieved by design. Our visual system conveys the meaning of product appearance to the brain and this leads to experience and sensory perception, which

means our personal experience and knowledge is of great importance about which appeals to our brain as of beauty. Barry states that "*perception is our chief means of knowing and understanding the world; images are the mental pictures produced with this understanding*" (Barry, 1997, p.70).

3.3.1. Form, Beauty and Aesthetics

Visual elements are part of the design and they generate the product's total appearance. "*They are fundamentally related to each other and cannot be easily separated during visual experience*" (Wong, 1993). These elements are lines, shapes, form and colour.

A line represents the shortest path between two points, which implies motion, and suggests direction or orientation. "*The direction and orientation of a line can also imply certain feelings. Horizontal lines imply tranquillity and rest, whereas vertical lines imply power and strength. Oblique lines imply movement, action and change*" (Berdan, 2004). Shapes are the result of closed lines and space is defined by both lines and forms. "*Form is three-dimensional equivalent of shape, which also can be referred as mass*" (Lauer and Pentak, 2005), and the form with colour and finish details give the end product.

Beauty is believed to be a matter of aesthetics and it reveals aesthetically pleasing feelings about anything. A common anonymous phrase attributed to the concept of beauty is "*beauty is in the eye of the beholder*".

Tractinsky et al. (2000) seem to underpin this idea; what is beautiful is usable suggests that perceptions of usability influence perceptions of beauty. Therefore, he adds, "*what is beautiful is usable"*. According to this idea, if we find something

usable, we might find it also beautiful. In addition, Overbeeke, et al (2002, p.11), proposes that, "*beauty is sometimes a nice interaction more than a visual aspect of a product*". They complain that, aesthetics in product design, appears to be restricted to making products beautiful in appearance, and the ease of use strategies do not appear in the process. As a result, we have products, which look good at first sight but then, frustrate us after we start to interact with the product. "*Again, we think that the emphasis should shift from a beautiful appearance to beautiful interaction, in which beautiful appearance is a part*" (Overbeeke et al, in Jordan Ed, 2002, p. 11). On the other hand, there are some experimental results suggest that people may be more satisfied with a beautiful product that performs less-efficiently than a more usable but less appealing product (Zhou, Fu, 2007).

Understanding of beauty in Renaissance was not much different from beauty in architecture or handcraft and "*it has always been the concern of the craftsmen who built them, ever since the earliest phase of civilisation*" (Winternitz, 1966, p.5), and the utmost goal for instruments was *to be pleasing to the eye and the ear alike*. These instruments may appeal overloaded with ornaments to the contemporary observer. Likewise, instruments of 21st century would have looked strange to the Romantic musician.

Aesthetics is derived from the Greek word aesthesis, which refers to sensory perception. The objects that provoke aesthetic emotion might vary for each individual. We all have a variety of responses to the same subject. "*All systems of aesthetics must be based on personal experience – that is to say they must be subjective*" (Bell, 1997). Aesthetics is variously defined (in Feagin & Maynard, 1997) as beauty in appearance (Lavie & Tractinsky, 2004), visual appeal (Lindgaard

& Dudek, 2003), an experience (Ramachandran & Blakeslee, 1998), an attitude (Cupchik, 1993), a property of objects (Porteous, 1996), a response or a judgment (Hassenzahl, 2004a; 2004b), and a process (Langer, 1967).

Evaluating visual aspects in keyboards is different from evaluating other design products. Understanding of beauty in the shape and colour can be dependent on different factors. A Hammond XH-200 can be unappealing for most people, but it is a legend in digital instruments and the keyboardist observes this instrument with his experiences and feelings. The fact that famous musicians are using it contributes to the instrument's appeal.

The Hammond B3 might be seen as the most famous electric keyboard of all times, although it is not clear what makes it that famous and popular. Maybe its smooth interaction and flexibility, or its legendary sound helped to create this fame. However it is clear that important figures who played this keyboard in concert halls and recordings are the most important sources of its success.

3.3.2. Pleasure

Pleasure is "a feeling, satisfaction or joy; sensuous as an object of life" (Oxford Dictionary, 2001). Electric, electronic and digital instrument manufacturers are concerned about producing instruments that give the same satisfaction with their acoustic counterparts. In order to achieve this effect, they sometimes apply physical characteristics of acoustic instruments to electronic instruments synthetically, such as hammer sound in pianos: the electric piano tries to imitate characteristics of the acoustic piano such as sound of the hammer, because this sound of hammer gives pleasure to the player. In acoustic pianos when the hammer hits the string, beside the

vibration of the string another sound is produced which is hardly audible: the hammer sound. Although it gives the impression that it is not a deserved sound, when the electric piano was first introduced, musicians and the audience were willing to hear conventional characteristics of acoustic piano, including the sound of the hammer.

3.4. Evolution of Interface Design in Keyboard Instruments

The Hammond Company has been producing electric-electronic organs for more than seven decades and it proved to be successful in producing innovative instruments and interfaces since the early years. Therefore, tracing Hammond history could be appropriate in order to grasp the main trends in the evolution of keyboard interface. This section is tended to elaborate on the evolution in the Hammond interface.

3.4.1. Hammond A

The Hammond Company was first granted a patent for its tonewheel organ in 1934. This patent officially enabled Hammond to produce its first electric organ (model A) one year after. The organ was introduced to the public at the Arts Expositions in Radio City's RCA building on April 15th, 1935. From the serial number 2501 onwards, the company made some changes which would last to B3. Those changes were to deepen the cabinet and those instruments (after 2501) were designated AB model.

The first model of the Hammond had two manuals (the Swell and the Great manuals) each of which had 61 keys with a 25-note pedal keyboard. There were two sets of 9-knob harmonic drawbars for each manual. In addition, two drawbars are employed for the foot pedals to control the 8' and 16' organ tones. 18 preset keys used to enable the player to switch instantly to the instrumental or other voice desired without setting the harmonic drawbars. Also this instrument had one expression pedal controlling the Swell, Great and Pedal keyboards, and there was one adjustable tremulant for all three. All of these were contained in a console or cabinet whose dimensions were 75 centimetres wide, 91 centimetres high and 60 centimetres deep. In this respect, the Hammond slogan *church organ in a packing box* was a reasonably proper description.

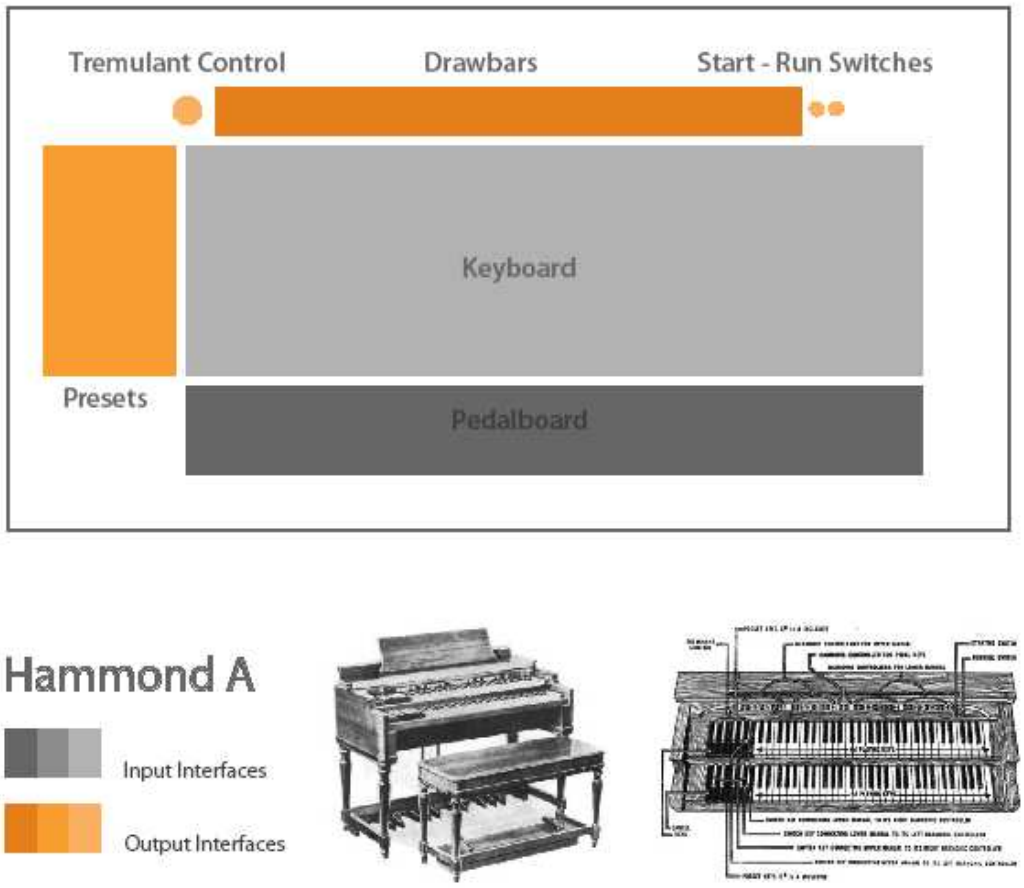


Figure 62 the Hammond A Interface

On the left hand side of each keyboard there were preset keys in a reverse colour system: naturals are black and sharps are white. Those preset keys are used for basically shaping the sound of the instrument and are eminently primitive. When a preset key is depressed it stays down and when the second one is depressed, the first one pops up. Only one preset key should be depressed at one time on the same manual. The key at the extreme left is the “cancel” button and it is used when two preset keys are depressed at the same time mistakenly. Because these mistakes sometimes caused fails and gaps in the performance of the musician in latter Hammonds some precautions were taken. Before playing the organ one preset key has to be depressed and the tone of the organ changes from one quality to another

when different preset keys are depressed while playing. Some of later model Hammond organs (Model E) used preset pistons instead of drawbars.

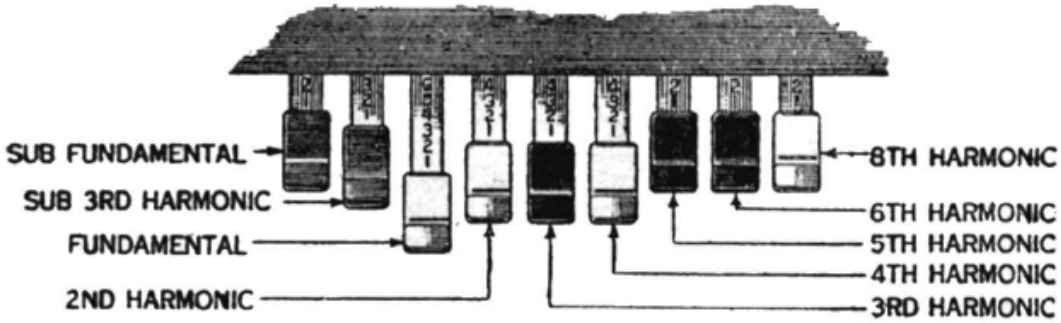


Figure 63 Harmonic Controller

The Harmonic Controller is the device that enables the player to mix the fundamental and any of all different harmonics in various proportions. Totally there are nine drawbars and the third from the left is designated the Fundamental. "*The four principal families of organ tones are Flute, Diapason, String and Reed*" (1930s Hammond Catalogue, p. 7).

3.4.2. Hammond AB

From the serial number 2501 onwards, the Hammond Company produced Model A organs under the name of AB in 1935. There were little differences between those models. The cabinet was deeper in order to allow room for the Chorus Generator. "*This imparts a new and extraordinary richness and beauty, instantly noticeable even to the untrained ear*" (1930s Hammond Catalogue, p. 9). The chorus control switch is placed at the right so that the organist can be capable of turning on or off this switch while playing the instrument. The chorus generator made possible a wide amount of ensemble qualities. The familiar Voix Celeste and Unda Maris are two of

many useful organ stops which utilize the same principle involved in the Hammond organ chorus effect.

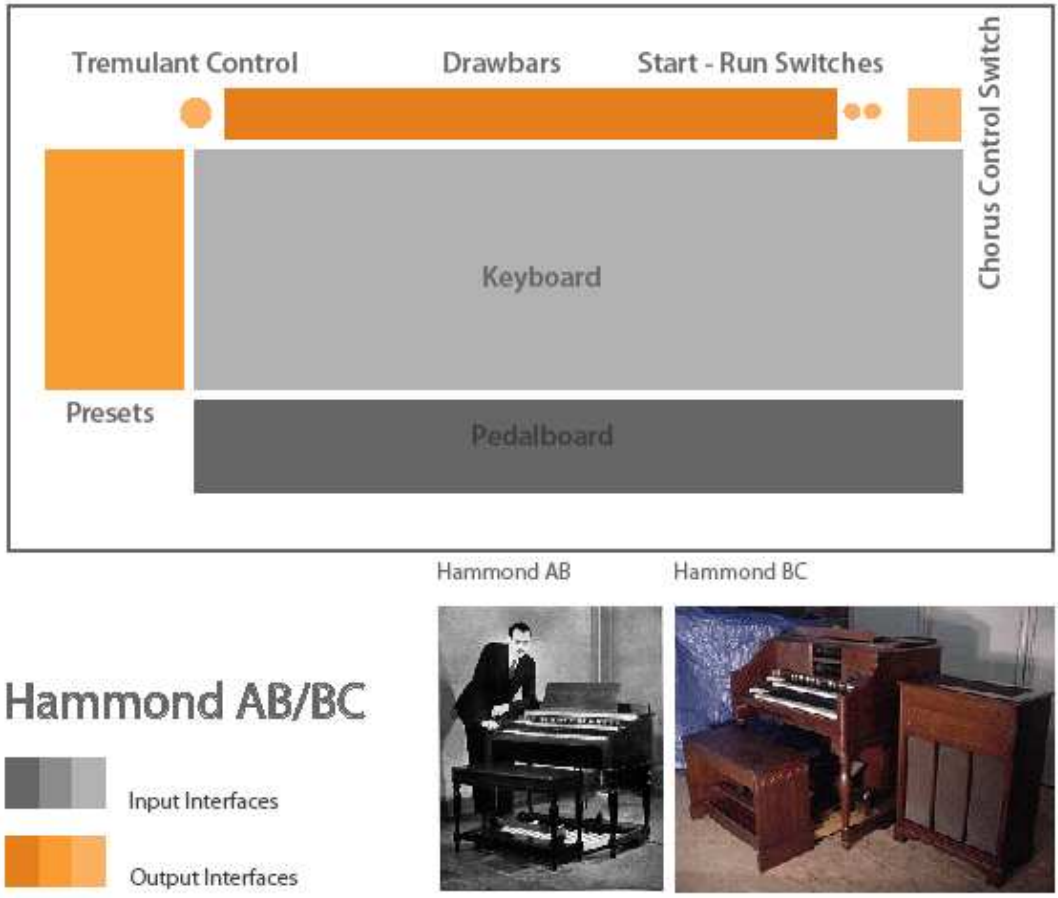


Figure 64 the Hammond AB/BC Interface

3.4.3. Hammond BC

In December 1936 Model BC was released; it was the same as Model AB but BC had an extra bank of tone-wheels for the Chorus Generator in addition to the regular tone-wheels. "*Hitherto, it has been customary to limit such an effect to one or two tonalities. In the Hammond organ, the chorus effect may be on any or all tone qualities. When the full organ is used, an added richness and fullness of tone will be*

instantly observed: an effect of tone emanating from many sources" (1930s Hammond Catalogue, p. 10).

Figure 65 Ethel Smith in a TV Concert

In the first years of production, Ethel Smith was the face of Hammond advertisements. She played this instrument in concerts and clubs and she made several records. Although there are many stories about her first relation with this instrument, Smith quotes that she first saw a Hammond organ in the Hammond Store in Los Angeles. "*I first saw it sitting in a corner in Los Angeles studio. I had never seen anything like it before*" (Hammond Times, Volume 31, Number 3, 1969). Smith, in the first years of her career, performed a kind of music which was deeply influenced by Classical European Music. After she was invited to New York, which resulted in a 26-week engagement to play a Hammond organ in Copacabana Club in Rio de Janeiro, she was attracted by a more popular kind of music. With the possibilities provided by the Hammond organ, she was giving recitals without accompaniment.

Figure 66 Hammond Model BC

3.4.4. Hammond Novachord

In 1939, Hammond introduced its Novachord. It was not an organ, though it can be considered as being "*the predecessor of all the electronic organs and the forerunner of today's synthesizer*" (The Hammond History). "*Novachord was an instrument conceived largely in Lourens Hammond's mind as an organ that would produce all the sounds of orchestra from notes generated by radio vacuum tubes*" (Fifty Years of Musical Excellence, p. 8).

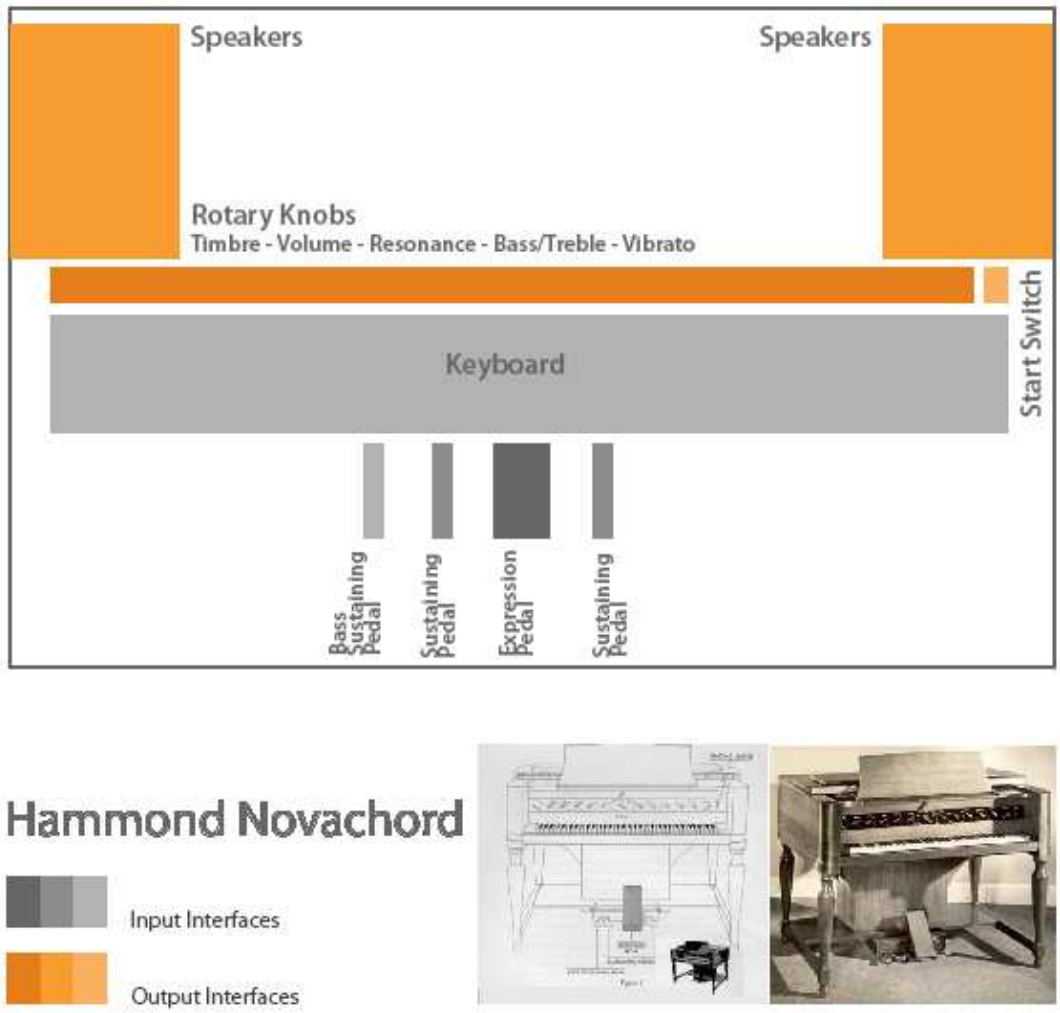


Figure 67 the Hammond Novachord Interface

The Novachord was introduced in the New York World's Fair by Collins Driggs on the keyboard. In appearance, it seems to resemble the piano and the aim was to provide what the musical world had wanted with its capability to produce music with amazing resemblance to a dance band. However, the listener of the 1940s evidently preferred to see the "band" instead of this instrument and as a result Novachord "*never caught on*" (Fifty Years of Musical Excellence, p. 8). This instrument was the first purely electronic organ, the first synthesizer and the predecessor to all the

Hammond and other vacuum tube and transistor sound generating organs; however it was discontinued at the outbreak of World War II.

Novachord came sooner than the world was ready for this kind of an instrument; it was far ahead of its time. It employed 169 vacuum tubes and its circuitry ideas were adapted from the first computer of the world, the ENIAC. Upon its introduction, Novachord received a strong resistance from music communities. It was neither experimental nor traditional; that is the reason why it was honoured by no one. Production ceased in 1942, July, because in addition to lack of interest from musicians and organists, it became very difficult to get the required materials due to the World War II.

3.4.5. Hammond Concert Model E

"*Hammond Concert Model E is the first Hammond organ with a 32 note pedal keyboard*" (The Hammond History). This pedal keyboard was concave and radiating which allowed easier and more accurate foot action on the pedalboard. Also two expression pedals, two separate tremulants for both manuals (Swell and Great manuals) and Preset Pistons instead of Preset Keys were features of this model Hammond organ.

3.4.6. Hammond Concert Model RT

Concert Model RT, introduced in 1949, incorporated a unique solo system in its pedal keyboard with separated volume control. "*The vibrato was available on both home and church models from 1946 on, and in 1949, was improved so that it could be used on both manuals simultaneously or on either manual separately*" (Fifty Years of Musical Excellence, p. 10). In addition to its 32-note A.G.O. pedalboard,

Model RT owned a unique pedal solo system which incorporated the synthesizing system of the Solovox and Novachord.

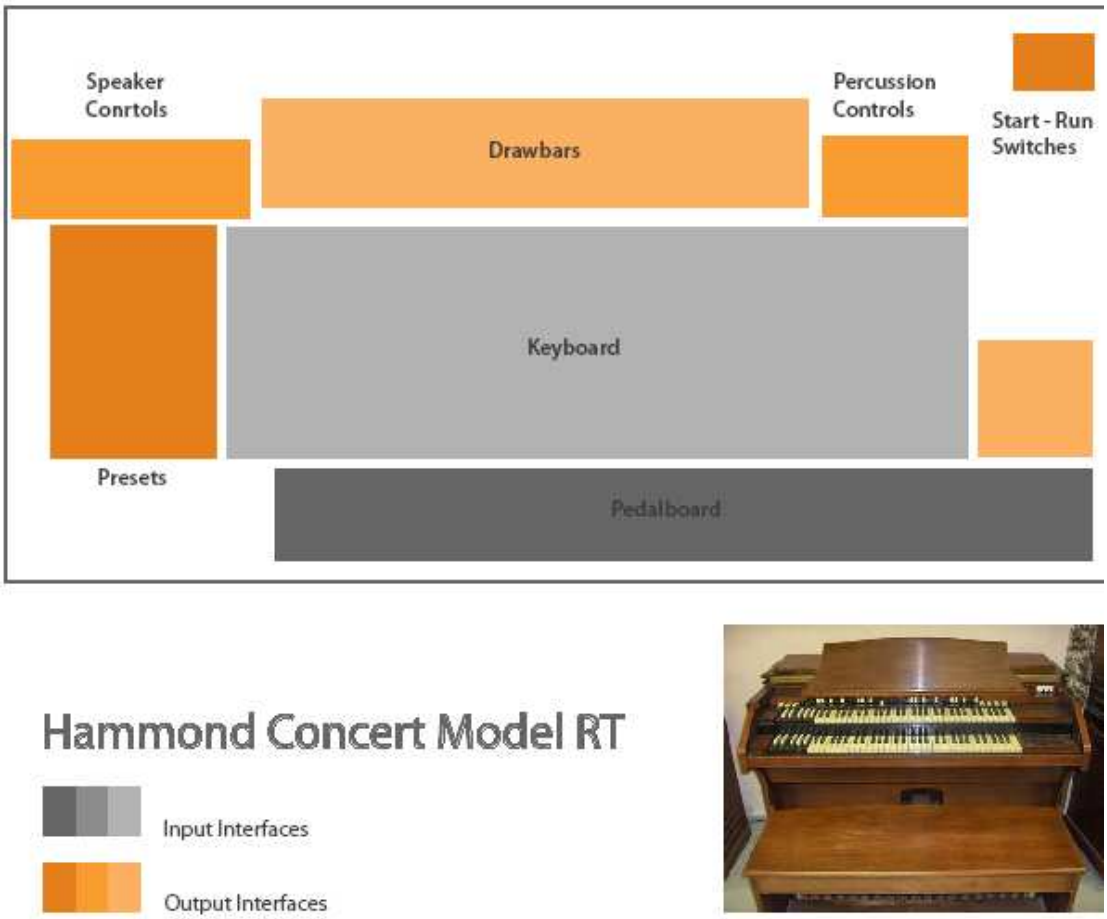


Figure 68 the Hammond Concert Model RT Interface

3.4.7. Hammond Spinet Organ

The Hammond Company was the first organ manufacturer which realized the great opportunity of homes and amateurs as potential users and buyers. They invented and designed the Spinet Model M in 1949; this model was specially designed for homes, hence was smaller in size. "*Its size -slightly smaller than the first Hammond Model A- was perfectly dimensioned for a modern living room or game room. And there*

was no need for additional space for amplifying and speaker equipment" (Fifty Years of Musical Excellence, p. 11).

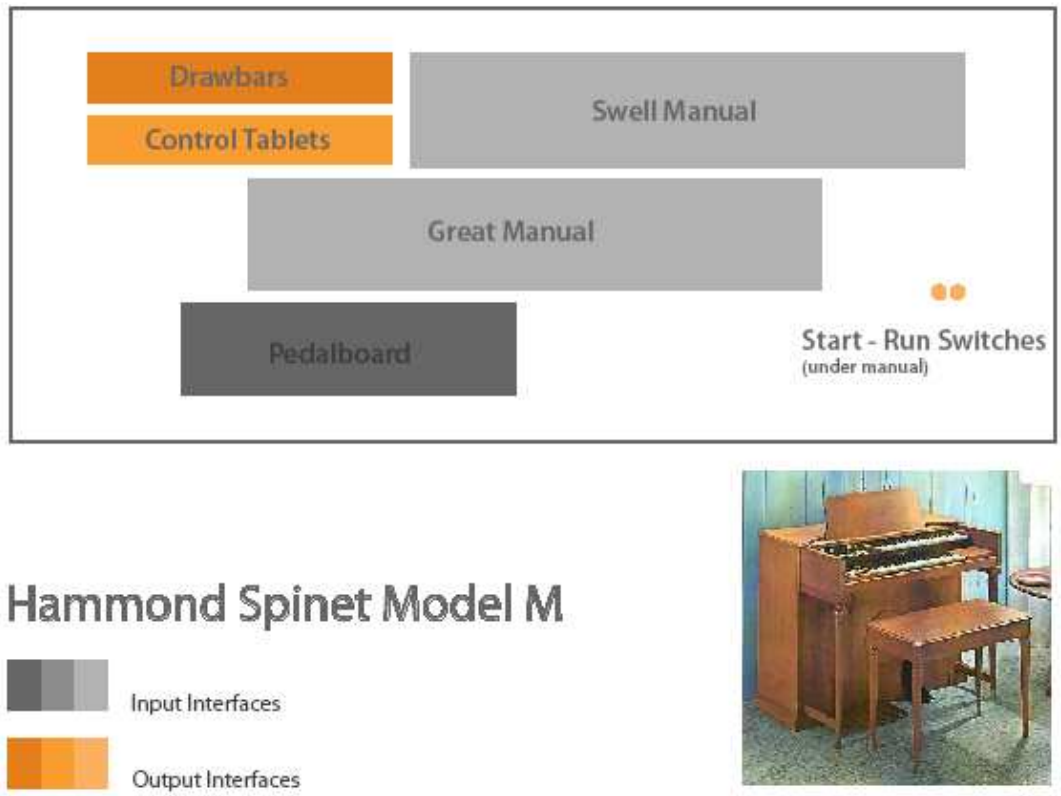


Figure 69 the Hammond Spinet Model M Interface

Hammond Spinet M had 44 keys on each of its two manuals and a 12-note pedalboard.

3.4.8. Hammond Chord Organ

The Hammond Chord organ is an important step for its claim to design smaller and smarter instruments. Model S was introduced in 1950; it has a 37-key single three-octave keyboard. Besides, it had a panel of 96 buttons that is used to produce selected chords when a key is depressed with left hand finger. Model S also had two

pedals which are used to select the root note or the fifth note of any chord played. As a result, Hammond Chord organ became very popular among music-loving amateurs with its user friendly interface and easy to operate functions. Even more, one could learn to play this Hammond within several minutes by non-musicians in simple fashion. "*Playing the Hammond Chord organ became as easy as reading an ordinary road map or, for many map-puzzled motorists, far easier*" (Fifty Years of Musical Excellence, p. 12).

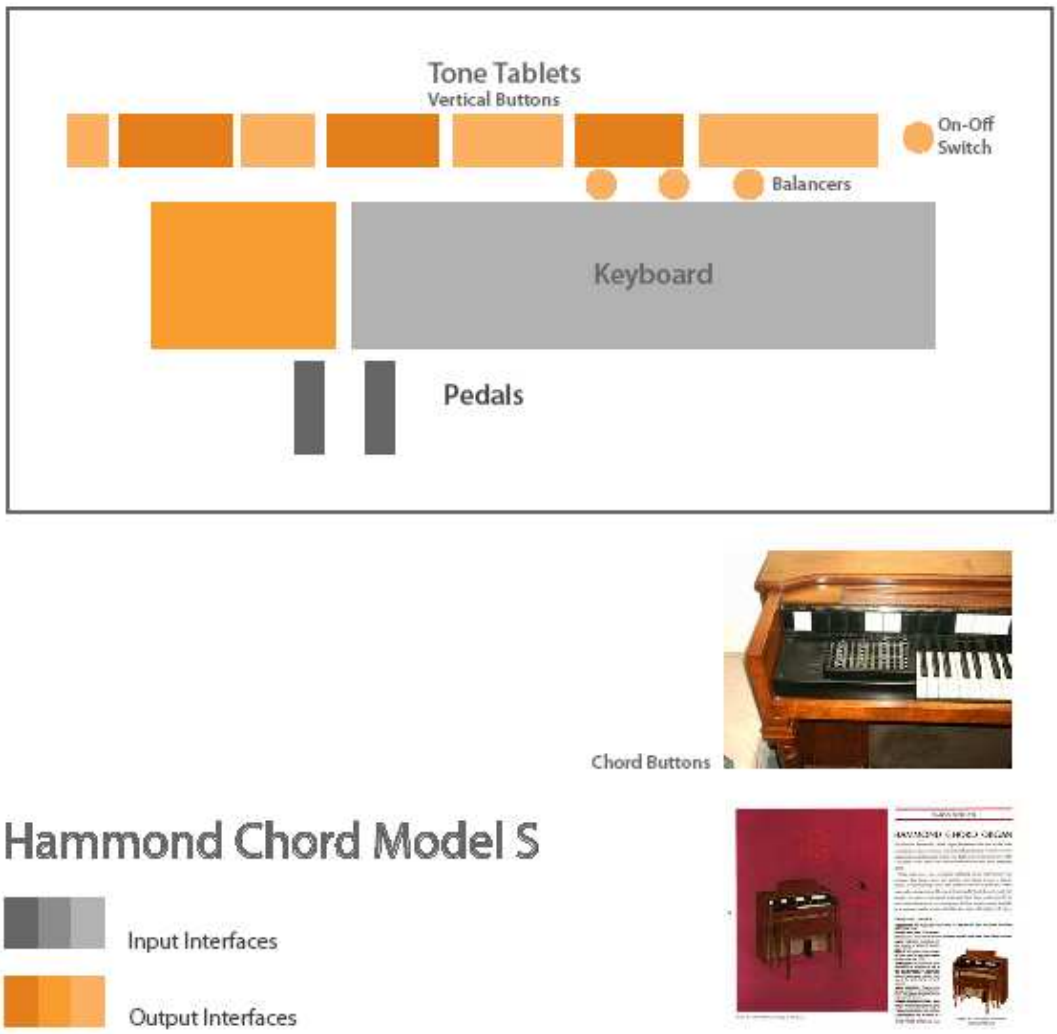


Figure 70 the Hammond Chord Model S Interface

3.4.9. Hammond B3

The Hammond legend B3 was introduced in 1955. It was the same as Model B2 except for Hammond Percussion, first used in B3, C3, RT3 and M3. The Hammond B3 still keeps its reputation as being the largest selling console model organ in the market. Within a short period Hammond percussion became famous, especially in the jazz style. "*The emphasis of the second and third harmonics with control of the volume and decay, enabled organist –professional and novice alike– to create a*

multitude of new sounds" (Fifty Years of Musical Excellence, p. 13).

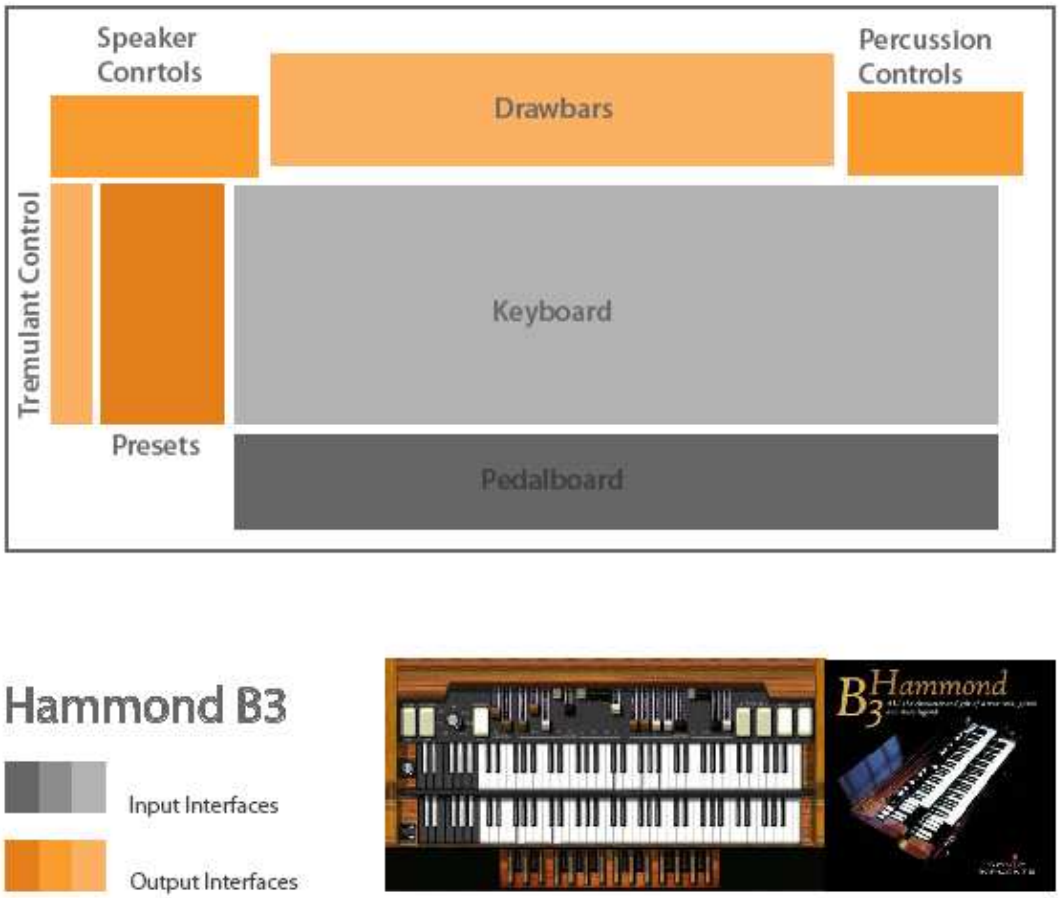


Figure 71 the Hammond B3 Interface

3.4.10. Hammond A-100

A-100 was the first self-contained console organ which was introduced in 1959. "*To many, this was the first time that they could have most of the features of the B3 without the need for external amplifier and speaker equipment*" (Fifty Years of Musical Excellence, p. 13).

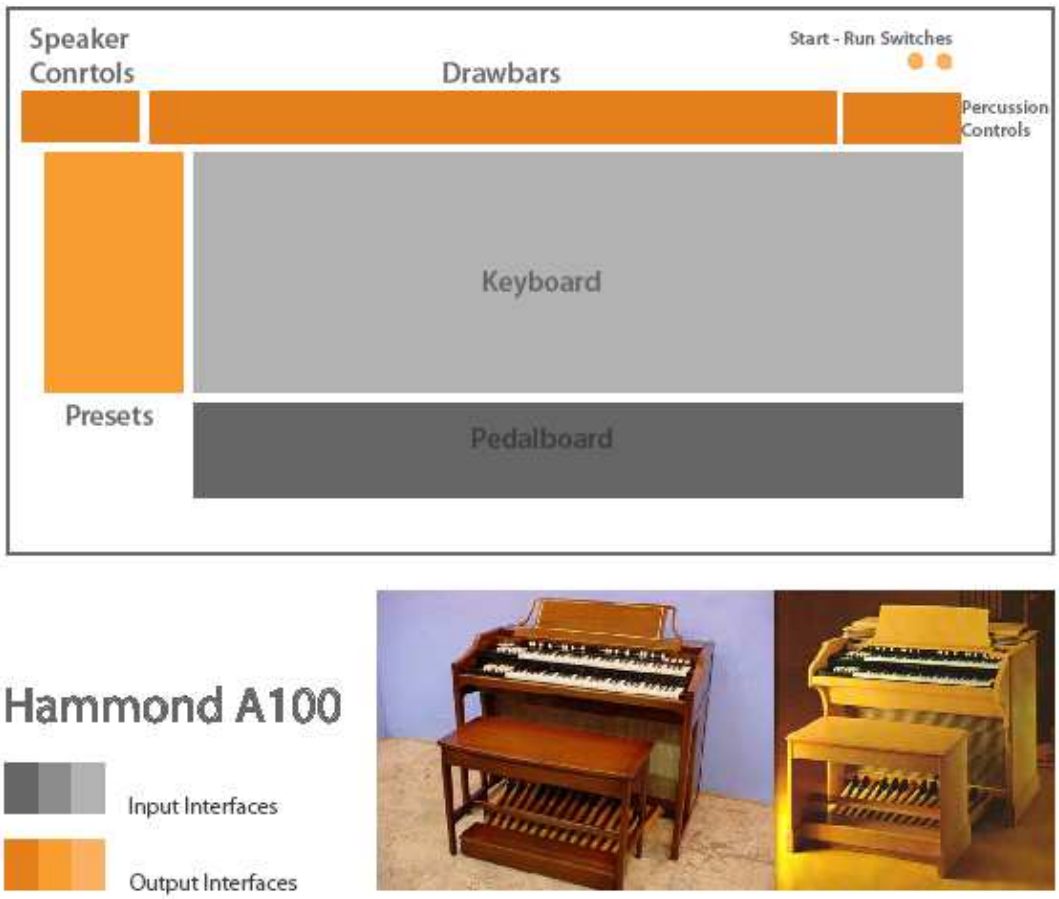


Figure 72 the Hammond A100 Interface

3.4.11. Hammond X-66

X-66 was the *first pedestal design* of Hammond for many organ players. Hammond created a radical new look in the prototype of its "new star" in 1965; but the production would start in 1967. "*This radical new look was an overnight sensation*" (Fifty Years of Musical Excellence, p. 15) and years after designers and engineers of X-66 would consider it as a brave and novel attempt. Also the Hammond X-66 had the first composite tone generator in the industry with tabs and tonebars.

This model featured a new system for sounding; it utilized tone wheels to produce

bright wave voices as well as pure drawbar pitches. In addition, it had a 200 watt tone cabinet and an elaborate vibrato system which gives the X-66 its unique sound.

In this model some new and fresh ideas were applied for the first time. In terms of design, Hammond X-66 is a distinctive organ and some new ideas were applied first such as colour coding. On the Hammond X-66 preset buttons are placed, as usual in most Hammonds, on the right hand side but sound shaping buttons such as orchestral manual voice tabs and accompaniment manual voice tabs have colour information. As a result, they can easily draw attention and can be perceived easily. However, it seems that colours don't represent an order in their layout. Buttons devoted to orchestral manual voice tabs are placed on the left hand side and upper part of the input keys and they can function Diapason, Viola D'orch, Trumpet, English Post Horn and Kinuro. Those instruments are assigned in colours starting from white, then yellow, red and green respectively; which has the impression that there is not a clear colour order.

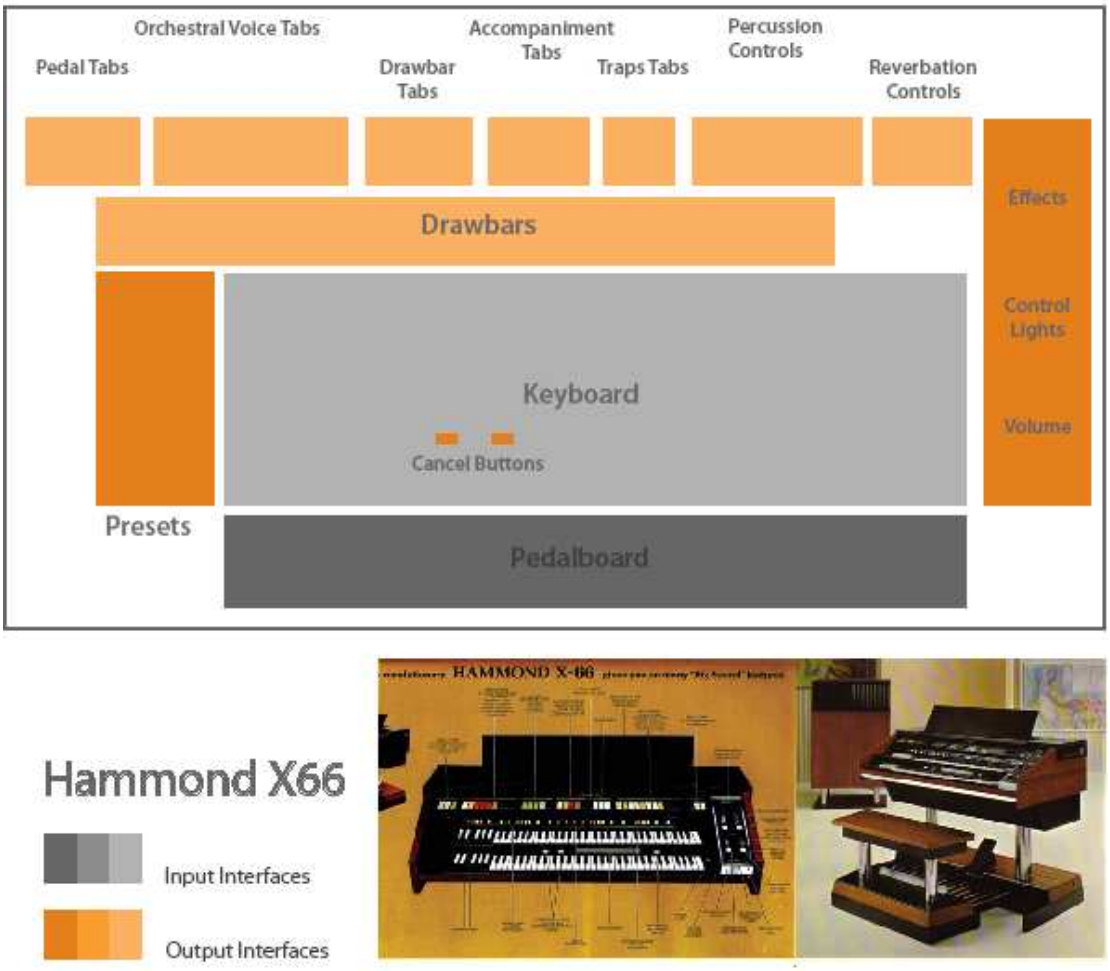


Figure 73 the Hammond X66 Interface

CHAPTER 4

4. Keyboard Design and Musical Identity

Through thousand years of music history the most fearless experiments and breakthroughs took place in the 20th century. In composition, atonal music and polyrhythm gathered important acclaim. Besides, form of sonata was distorted and new forms were tried. In addition to this, new musical instruments, generally dependent on electricity, were designed and developed. "*In short, the 20th century opened up new horizons for musical expression, supplied with new mediums and tools; and from this point it has been the most productive era of music history*" (Mimaroğlu, 1993, p.120). Similarly in the 20th century the varieties in musical identity are more explicit than any century in music history. This chapter tends to understand the relationship between keyboard instrument design and music approach of the performer.

4.1. An Ergonomic Application: Technical Perfection and Design

In the design research process of this thesis a supplementary part was carried out in which concave keyboards' ergonomics, possibilities and advantages-disadvantages were investigated, resulting in an arc-shape design proposal. The primary goal was to improve virtuosity and decrease the strain and difficulty in reach by design. Although measuring the virtuosity sounds ambiguous, in this project virtuosity is proposed to be measured by number of keys played in a limited amount of time Also another aim for virtuosity is eliminating failures.

In the process, natural movement of hands and arms were measured and in the design process human body was given the utmost privilege. All parts of the

designed keyboard were meant to increase the ability and stability of the performer. Each part was designed to fit the nature of human body. Its basic shape (concavity) roots from the basic arc of our arms; if a keyboard player shakes their arms horizontally to both sides (left and right) his or her arms tend to move in an arc shape. This principle was used in order to increase the speed and reach.

Basically its interface was designed under three categories: Control while playing (left hand side) houses sound selection and style selection buttons. Deep control (right hand side) houses vibrato settings, percussion settings, speaker and microphone settings. Instant access (front mounted panel) was designed for momentary access and it aims at rendering an easily accessible interaction. During the performance, player may need fast alterations on the sound. The most important is the pitch bend; many keyboardists use it right during the performance for microtones and some sound effects. Besides, the keyboardist might need to modify the volume and bass-treble controls. However, this should be really instantly so that the performance does not have to stop. In addition, players generally play on a base background which is recorded to a medium like MD or CD. Consequently, he has to rewind or fast forward in order to select the desired track. The vertical surface between the keys and player is thought to be a very accessible place for instant controls, because the thumb can reach this surface even when the performer is playing the keyboard. Midi controls, volume and pitch bend-modulation buttons and knobs were placed on this vertical surface. In addition, two touch pads on both sides can control the LCD screen which gives an important flexibility to the performer.

Figure 74 Ergonomic musical keyboard for Professionals

According to the data acquired in this research, besides being independent of height of the person, the radius of the arms when s/he moves their arms tends to be closer to 73 cm. as a mean value. This can be seen in more detail in the figure.

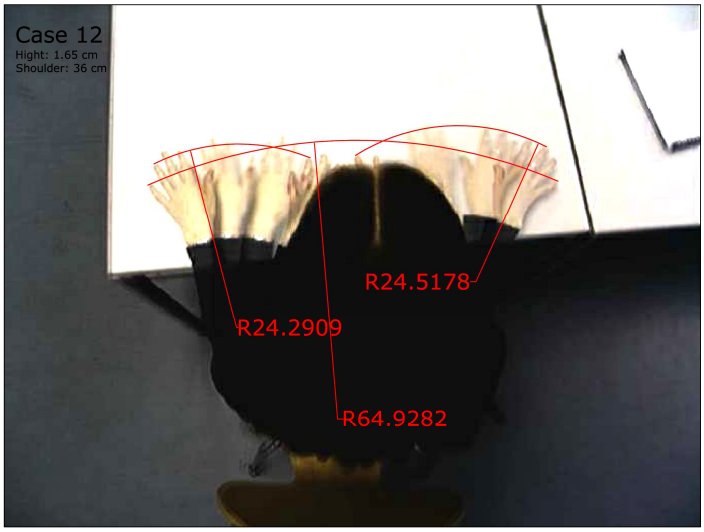


Figure 75 Radius of Arms

Participants were selected from different genders, physical attributes, ages and nationalities. In 14 cases, height and shoulder lengths of the person were recorded. Movement of the arms was captured from the top. Different positions were placed and then these compilations were scaled in CAD software. As a result, it became possible to measure the length of the radius of arc. In the graph, details of these 14 cases are shown.

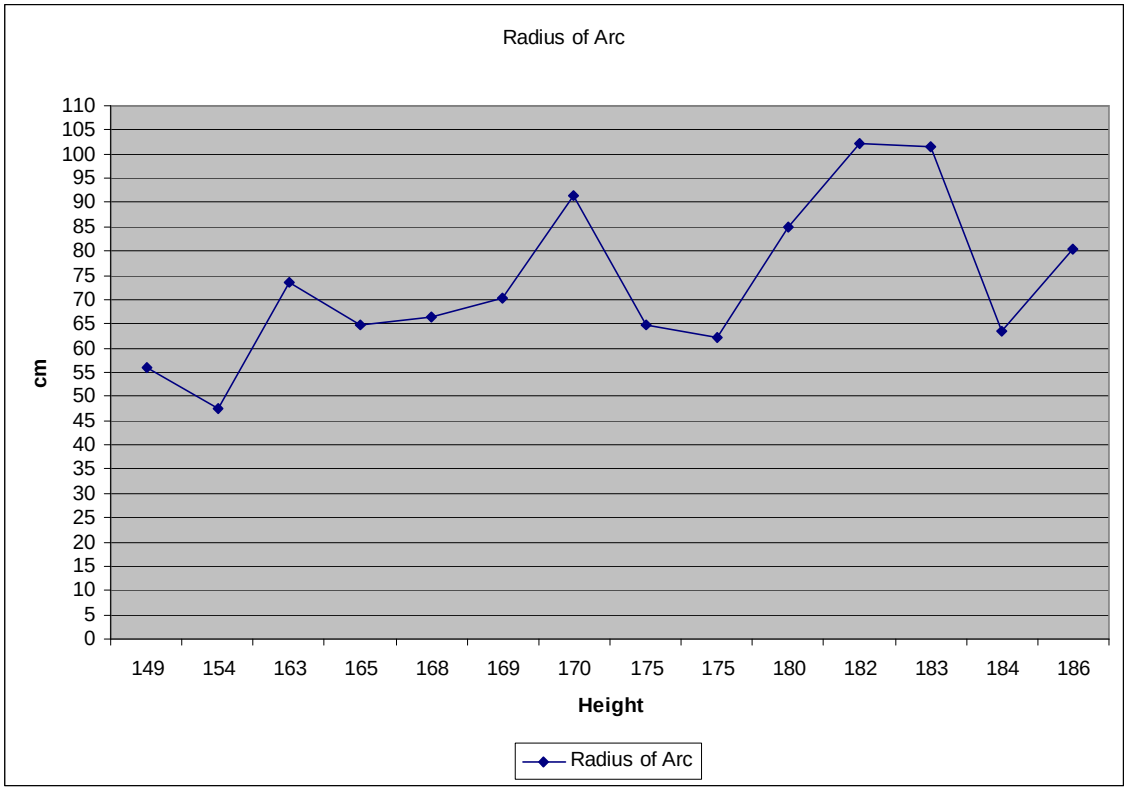


Figure 76 Measurement of Radius with 14 cases

As can be seen in the graph, although there is a tendency to increase in the length of the radius with respect to height, there are some exceptions that keep us from generalisations.

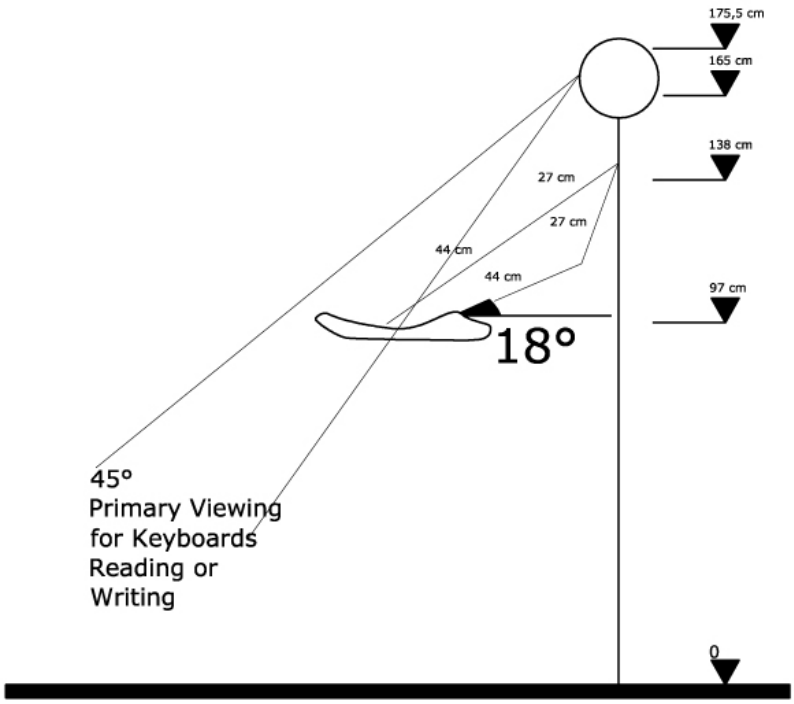


Figure 77 Slope of the Inclined Keys

In the design process 99 percentile were intended to satisfy. According to the placement of stand (97 cm high from the floor), keyboard and a normal distance from the instruments, 18 degree of horizontal angle between the sloped keys and horizontal line seems to fit the arms and hands of a 175,5-cm long performer.

4.1.1. Outcome of the Project

As it is stated in the product image, this keyboard is designed for professionals as the curvy form and inclined keys require a professional training to master. Product of this project was tested by keyboard educator Laurence Alexander; he agreed with the left-right separation and proposed to place controls in the middle so that if the player needs to access with the other hand (than the assigned one) s/he can do without much difficulty. Another interview was done with Dr. Kia Ng in Leeds University;

he, as a musician, encouraged the form, as well.

Design process was important to understand the needs and necessities of the performer for a smooth interaction. According to the findings of the project, left-right separation is extremely important but has never been applied properly. It helps the performer orientate on the interface easily. In addition, although thumb performs a very important function on many instruments, it is apparently ignored when the electronic keyboards are concerned.

Form and interface of the keyboard are important on the music style it is used for. In this example the name "Dynx" is coming from the word dynamics and its name reveals the intended musical style. This instrument is designed for popular music in which velocity and rhythm are thought to be more important than polyphony which requires multi manuals.

4.2. Transition from Art Performance to Designed Experience

Edgard Varèse points out that music scene in the 20th century was structured by the musician accompanied by an electrician. "*What we want is an instrument that will give us continuous sound at any pitch. The composer and electrician will have to labour together to get it… Speed and synthesis are characteristics of our own epoch*" (Interview for the Christian Science Monitor, 1922).

On the contrary to the keyboardist *idea* of former centuries, the modern keyboard player had the advantage to *talk to* the audience through an instrument, which had been designed by an engineer, starting from the 1940s. An instrument, which was used as a tool to approach the listener by the musician, became a product of a manufacturing process that includes performance enhancement procedures, error

cancellation studies and Research & Development efforts on ergonomics. Having been the end product of comprehensive research activity, the result was satisfactory enough: an instrument as capable as an orchestra at times though is not sentimental enough. It can be argued that one of the many objectives of electric instruments was to enable high sonority which resulted in larger concert halls and a higher number of audience attendance. When electric instruments were in their infancy, namely from 1900s to 1950s, music had already left the houses of aristocrats and started heading for squares and concert halls excessively. "*Electronic keyboard instruments were subject to similar modifications, in some instances being developed into comprehensive synthesizers in their own right, offering a number of performance facilities. This trend has led to a considerable blurring of the boundary between what would normally be considered an instrument and a fully equipped studio system*" (Manning, 1993, p. 204).

The possibilities of electronic instruments capabilities have inaugurated an era in which the identity of musician and instrument started to differ from that in the 19th century. For instance, electronic circuitry especially digital technology after 1980s enabled the performer to modify music even during the course of the performance such as increasing the speed, adding different partitions on an existing theme and using samples. This ability of the digital keyboard made it possible to take over an orchestra in some respects. Although it may have disadvantages in terms of touch, feeling and sentimentalism, a hi-end digital keyboard can quite successfully imitate an orchestra. One might argue that the keyboard instrument, which was a part of the orchestra in the past, has been evolving in a way in which it possibly is becoming *the orchestra* itself.

Record history can be an objective indication of the change in musical identity of the 20th century. As one of the greatest record companies, EMI's first release was the works of sopranos Adelina Patti, Nellie Melba and Emma Calve and tenor Enrico Caruso who were widely considered to have been great musicians of their time. The first great star of the recording medium, Enrico Caruso (Théberge, 1993, p.255), started his first recording session on April 11th, 1902 which took two hours (EMI). Deutsche Gramophone released 240 Caruso records in his lifetime. In the 1930s, radio and sound films served as an important medium to convey these artists' sounds to the masses. These records brought him fame and money that inspired many other artists to take part in the record industry resulting in a developing market.

EMI continued record production with many artists in the 1910s; the attention was mostly on European Classical Music. Columbia, in the 1920s, made recordings with some of the top conductors of the day, including Sir Thomas Beecham, Sir Henry Wood, Bruno Walter, Igor Stravinsky and Gustav Holst while the Gramophone Company's leading artist was Sir Edward Elgar. In the 1930s and 40s, Classical Music sustained its existence in the record industry as the most popular music style. However, after the 1950s, one can observe an attitude towards individualisation among musicians with different and unusual dressing and hair styles. In contrast with the musician profile of the past, the *modern* musician was different from the *others* with their costume, attitude and preferred vocabulary. It can be argued that this individualisation was even inspired and encouraged by the individual nature of the keyboard, as it can be defined as one man band among other instruments. There have always been star keyboard players like Rick Wakeman who are well known with their extraordinary stage costumes. Howard Becker describes popular musicians and new life styles they developed which often make them quite different from

the rest. He mentions that society regards the popular musician as deviant, which in turn leads the musician to establishing deeper isolation from social norms in their lifestyle and become *outsiders* (Becker, 1963, p.79).

Keyboard music has been exposed to technological shifts and influence since the first appearance of electric keyboards in 1930s. Due to technological, social and spatial changes in the production and consumption of keyboard music, art performance could be argued to have turned into a *designed experience* today with presence of complicated and smart digital synthesisers and keyboards. In the 1950s, record companies started putting pressure on the music industry through the promotion of blues and rock music, in addition to creating new sound recording techniques. In other words, sound engineer and producer together were creating a new understanding of sonic beauty and aesthetics.

Transition from mechanical to digital keyboards re-shaped the identity and structure of music which in turn led to an *industrialisation* in music. Here the word "industrialisation" implies an increase in production and consumption of music, and does not mean that the musician turned to be a professional who too often buys and sells instruments and accessories but industrialisation does mean the musician aligned his activity to somewhere in the centre of consumerist culture.

Shift from the first electro-acoustic keyboards to computer controlled digital keyboards occurred gradually and this transition has been reflected on their interfaces. In this process, dependent on the evolution of interface, performer-instrument interaction was exposed to serious influences. There is an unclear chronological order in this shift between significantly different interaction styles; the

shift in the interaction levels can be grouped under three categories:

4.2.1. Keyboard as a conventional instrument

In the 1930s, it was the Hammond which introduced the first electric organ that incorporates a tonewheel to produce sound from electricity and almost the next forty years the Hammond organ had been a pioneer in electro-acoustic musical keyboard industry until the late 1970s when the market saw a shift towards digital keyboards and synthesisers. Hammond became extremely successful during the first half of the 20th century because this instrument did neither disregard its acoustic ancestors like the church organ nor was it an engineering experiment: Laurens Hammond's idea, which inherited a lot from electric clocks, was to use electricity as a source to get a signal by additive synthesis and he used the tonewheel and the frequency of electricity with a drawbar facility which works like *stops* on church organ and alters the timbre. "*Part of this success was no doubt due to the fact that Hammond's ambitions were relatively conservative*" (Théberge, 1993, p.63). This brilliant innovation provoked church organ producers and caused some problems between them and the Hammond Company since this electro-acoustic instrument was really smart, inexpensive and capable of shifting between different tones compared to the church organ: it was advocated that the Hammond should not have been introduced as an *organ*, because, it wasn't believed to be so by pipe organ producers. This particular example can give a clue about how the producer of this instrument was willing to resemble its acoustic rivals.

Resembling acoustic instruments like the piano, organ and clavichord would involve some sound effects enabled by the means of electricity. For instance, the hammer sound of the conventional piano can be generated electronically: when the key on

the acoustic piano keyboard is depressed, a hammer hits the string resulting in both vibration on the wire and a hardly audible sound caused by the strike. The hammer sound is imitated electronically on electronic and digital pianos in order to compete with the acoustic beauty of the piano sound. Likewise, characteristic sound of the pipe organ is imitated similarly: especially on low frequency notes the pipe organ generates sound with a quarter-second delay since the pipe has to be filled with air and it takes time when long and wide pipes (namely bass notes) are concerned.

Although first electric instruments such as the Dynamophone and the Theremin promoted a kind of music which was regarded to be sophisticated and avant-garde for their period, the first electric organs and the pianos in the 1930s were played in the way conventional instruments used to be played. While a sizeable group of avant-garde composers and performers gave their works in a highly sophisticated field of keyboard music, many others preferred conventional tools and techniques in composing and performance. The second group used electric instruments for their colour and benefitted from their smaller size. This group includes Milt Hert, Jimmy Smith and famous keyboardist Jon Lord. Ethel Smith is an important figure who played the Hammond organ as a former pianist; besides she was a celebrity and worked for the Hammond Company to promote this instrument.

4.2.1.1. Ethel Smith

Ethel Smith (1910-1996), a former pianist, was the promotional artist of Hammond organ and also in charge of introducing that brand to the public. There are some different narratives as to how Smith met the electric organ the first time but she refers that she adapted to this instrument easily. Ethel Smith played the Hammond organ in pop style. She used the Hammond interface to get sound effects she

needed; in her music, Smith uses vibrato often. Her most famous LP is a keyboard arrangement of popular theme, Tico Tico (LP released in 1945, Tico-Tico no Fubá, Brazilian chorus music, composed in 1917 by Zequinha Abreu). In this performance Smith achieves instantaneous shifts between different timbres using Hammond presets which were not available on pianos and church organs, therefore could be regarded as a new feature enabled by the means of electricity and offered by Hammond interface. In the musical Bathing Beauty (1944) Smith's performance on this new instrument was filmed and broadcasted. As a film star in addition to being a musician, she made an important contribution to the promotion of the Hammond organ in the 1950s.

4.2.2. Keyboard as a tool to widen limits of creativity

As Ferrucio Busoni predicted in the early 20th century by talking about freedom as the destiny of music, technology has been removing limits of instruments since the time when electricity was first applied on musical instruments. Acoustic instruments have many limitations caused by the material and technology in their era: for instance some instruments can not produce sound loud enough to be played in concert halls. Electricity enabled the instrument sound to be much louder than ever before resulting in a higher number of audience. Much more development and improvement has been tried; presumably the keyboard is the one that makes the most of that effort, because the keyboard is at the same time an interface used in synthesizers that combines musician and synthesis process, therefore has an importance as a control device with record and rhythm sections.

4.2.2.1. Vangelis

Being a part of the synthesis process enabled the keyboard to create a new sound, timbre and effect worlds. In order to create these colourful worlds, Vangelis (Evangelos Odysseas Papathanassiou, 1943 born) uses a wide range of electro-acoustic or digital keyboard instruments. A decrease in the number of instruments he has used through his career can be understood from his concerts and records; Vangelis used to own more keyboards and synthesisers than he does now and this is probably due to the enhanced efficiency and capacity of the keyboard today. The following table shows the instruments of Rick Wakeman and Vangelis through their career. As can be seen in the table, some manufacturers have dominated the keyboard market through particular intervals. For instance, the Hammond dominance can be seen in the 1970s. Also the Moog was widely preferred between 1972 and 1979. However, when it comes to the late 1990s and 2000s, the Korg is apparently the leader in the digital keyboard market.

Figure 78 Vangelis in his studio, 1973

Timeline 1971 1972 1973 1975 1978 1979 Timeline

The Dragon | Aphrodite'S Child | L'Apocalypse Des Animaux | La Fête Sauvage | Beaubourg | Opera Sauvage

Vangelis


Hohner Clavinet D6


Hammond L-100


Fender Rhode Piano


Elka Rhapsody 610


ARP Pro-Soloist


Roland SH-1000


Korg 800 DV


Yamaha CS-80


Roland SH-3A


Selmer Clavioline

Fender Rhodes

Hammond

Rick Wakeman


Hammond C3 RMI Electric Piano


Mini MOOG Mellotron 400-D


Polymoog


Fender Rhodes

Close to the Edge (YES Album) Journey to the Centre of the Earth Rhapsodies

1972 1974 1979 1979

Moog

Korg

Timeline 1981 1985 1994 1997 2003 2004 Timeline

1981 The Friends of Mr. Cairo | Invisible Connections | Blade Runner | Oceanic | Odyssey | Alexander

Vangelis


Hammond B3


Roland System 100


Korg T3


Korg M1


Korg SV1


Kurzveil K2600

Korg

Rick Wakeman


Hohner Clavinet


Gem Promega 3


Korg Triton Pro


Korg Karma


Gem Promega 3


Korg PA1X Pro Elite


Roland XV88

Cost of Living 1995 The Seven Wonders Of The World Visions Retro

1983 1995 2000 2006

Keyboard instruments used by Vangelis and Rick Wakeman

In the picture (Figure 78) from 1973 Vangelis can be seen with an ARP ProSoloist, the Hammond L100, the Hohner Clavinet and a Roland Space Echo box.

ARP ProSoloist is an instrument, which had *after touch* that allows the player to force down the note of the keyboard in order to add resonance, volume and brilliance. Also ProSoloist allows him to compose and play very fast passages fluently, as its key touch is very comfortable and dynamic. The keyboard solo on his piece La Fete Sauvage was played on a ProSoloist and this instrument's keys provided him with a dynamic medium for that rapid solo.

Yamaha CS-80 is often referred to as the *king of the synthesisers* as it could be said that it is Vangelis who made this instrument worldwide famous in the late 70s. CS-80 is a five-octave, 61-key synthesiser keyboard that has semi-weighted keys, similar to those of acoustic pianos which respond to velocity and aftertouch. Tone selectors are placed just in the geometric middle of the entire instrument and at the back it has synthesis buttons and analogue sidebars. This instrument has a very unique sound and its polyphonic aftertouch made this instrument's tone unique and distinctive. However, having no patch storage feature, which means that the musician has to remember slider positions in order to recall the same sound again, was a problem for the performer. "*Where the CS-80 really shines is in its controller implementation. The aftertouch can control pitchbend, modulation with dedicated*

rate control, VCA volume and VCF sweep" (Brad Coates, Sythmuseum). In that instrument Yamaha preferred to use a pitch ribbon instead of mode wheels and the ribbon has a constantly evolving centre point; this system uses the first touch as the starting point for pitchbends, which allows sharp and flat pitchbends according to the direction of the slide.

In 1977 Vangelis first used the legendary Yamaha CS-80 in his album Spiral. In this album the main instrument was the ARP ProSoloist but then, between 1977 and 1986 Vangelis composed and recorded the body of his work on his Yamaha CS-80. This keyboard's personal timbre was important for the identity of Vangelis' music. He used the brass preset of this instrument often; also he used other presets such as Guitar 1 and Guitar 2 on L'enfant (from album Opera Sauvage, 1979) and the electric piano preset on Mayflower (from *The Friends of Mr. Cairo* with Jon Anderson, 1981). The album by Vangelis, Chariots of Fire released in 1981, is also widely known for its natural sounds.

A very important innovation was the Pitch Ribbon, which was first developed on Yamaha CS-50, CS-70 and then CS-80. "*The ribbon itself was nothing new, but the method Yamaha employed that allowed the "zero-point" to be wherever the ribbon was touched initially was an instant hit*" (Scott Rider, Maintaining the Yamaha CS-80). In his music, Vangelis uses an incredible amount of sound effects and always tries different timbres. For that purpose, felt covered pitch ribbon plays a vital role; this tool enables him to modify this instrument with a great freedom and ease of use. As can be noticed in his performance *Curious Electric*, in *Short Stories* (released in 1980) Pitch Ribbon gives flexibility and great possibilities to the player for sound process, synthesis and effect controls. In the album Friends of Mr. Cairo (1981)

Vangelis changed his Hammond L-100 with a B3 and used this instrument for its strings sound. In the 1990s his gear used to include Korgs more than ever before. His work for Blade Runner (1994), Oceanic (1997), Odyssey (2003) and Alexander (2004) were mainly composed and played on Korg instruments.

4.2.2.2. Rick Wakeman

Another important figure in the history of music that uses the Yamaha CS-80 is Rick Wakeman who is regarded as one of the best rock keyboardists. His album Journey to the Centre of the World (1974), which is based on the novel of Jules Verne and recorded on 18th of January in 1974, comprises an important number of sound effects used for expressionist purposes in his music. Wakeman is a noted player of the Moog and the Hammond organ and on his album "Journey to the Centre of the World", he uses the Moog as main instrument with Hammond organ; Moog enables Wakeman to create and develop his characteristic sound.

The Moog, by principle, is an instrument that allows very different and unique synthesis techniques depending on the creativity and imagination of the musician. Rick Wakeman makes the most of this instrument to help develop his trademark sound and timbre. In the Yes album "Close to the Edge", released in 1972, Rick Wakeman plays the keyboards; the first track on the LP, The Solid Time of Change, starts with *concrete* sounds recorded beforehand in nature. Following this introduction, Wakeman's keyboard part is quite virtuosic and worth to listen to; he preferred a timbre which sounds like liquid pouring down on a surface from a height. His performance grabs the attention due to its resemblance to liquid sound; fluid and fluent. And, this performance is enabled by the wide colour range of the Moog

synthesiser.

Besides accompanying groups like Yes and Strawbs, Rick Wakeman has released more than fifty solo albums. His first solo album “Piano Vibrations” dates back to 1971. The musical life of Rick Wakeman can be analysed under three main categories. In the first era of his musical life Wakeman deals with progressive rock style. Also this period is the era when he works as a group member of rock band, Yes. One of the most important solo records of this era, *The Six Wives of Henry VIII* (1973), is full of spicy sound of Moog. Especially in Catherine Parr, Rick Wakeman gives important clues about his trademark sound on the Moog synthesiser that will be more famous in subsequent years.

On *The Six Wives of Henry VIII* Wakeman plays basically six keyboards and synthesisers. These are the custom built Hammond C-3 organ, RMI electric piano and harpsichord, Mini Moog synthesizer, Mellotron 400-D (Brass/Strings/Flutes), Mellotron 400-D (Vocals/Sound Effects/Vibes) and the Steinway 9’ grand piano. In addition to these instruments, he incorporates frequency a counter and a custom mixer.

Figure 80 Rick Wakeman in Studio

1 and 3 Mini Moog Synthesizer

Moog is an indispensable keyboard instrument for Rick Wakeman as he achieves his trademark sound on that instrument. Rick Wakeman has always changed and updated his equipments and instruments, but he has never abandoned the Moog.

2 and 4 Mellotron 400-D (Vocals/Sound Effects/Vibes) and Mellotron 400-D (Brass/Strings/Flutes)

5 RMI electric piano and harpsichord had a very distinct sound in comparison to Rhodes and Wurlitzer.

6 Hammond C-3 organ

7 Steinway 9' grand piano

Rick Wakeman especially in his later works gave weight to acoustic instruments and acoustic sounds. Second era of Rick Wakeman starts in the 1980s and in this style he would head for a more popular sound instead of progressive rock. On his album *Silent Nights* (1985) he sometimes uses keyboard instruments in the style of guitar; his keyboard sounds like an electric guitar. The general sound of the album is narrower and less experimental.

In the 1980s, a tendency towards acoustic sound in Rick Wakeman music is quite apparent. Between 1983 and 1993 he released four albums in which he played only acoustic piano and used acoustic sounds: *Sea Airs* (1989), *Night Airs* (1990), *The Classical Connection* (1991) and *Heritage Suite* (1993) are these acoustic albums. He gives weight to musical substance and essence more than virtuosity in these albums. "*On The Classical Connection Rick Wakeman shows himself to be a virtuoso of the classical piano*" (Wakeman, 1991).

After the 1990s, his music includes examples from ambient music; *The Seven Wonders of the World* (1995) can be a good example to Wakeman's third creative period. Rick Wakeman's equipment in 2000s can be listed as Roland RD700 piano, Korg 01W ProX, Mini Moog, Gem Promega3, Korg Karma, Korg BX3 single manual organ, Korg Prophecy, Korg Triton Pro, Korg Trinity Pro and Roland XV88. When the shift in his gear from 1970s to 2000s is considered, we can estimate the reason behind the change in his musical style.

Wakeman's current equipment can give an idea for this shift to his more synthetic and *designed* music. His equipment after 2000s includes Korg PA1X Pro Elite, Roland XV88, Korg Triton Pro and Korg Karma. These keyboards enable the player

to accomplish great modifications on sound and music even live.

It can be claimed that sometimes in each period Rick Wakeman used to make music that does not fit his musical approach in that particular time. For instance *No Expense Spared* (1993) is like a return to 1970s' progressive rock. Also *Cirque Surreal* (1995) calls his earlier album *Rhapsodies* to the listener's mind.

4.2.3. Keyboard as an interface between music and musician

The transition from electric to digital keyboards has many outcomes on the production, consumption and performance of music. Successful interface and *beautiful* interaction might have effects on the evolution of music. Examples starting from the mid-1990s have shown that the keyboard is a designed product and there is enough evidence to advocate that music performed on these keyboards is becoming akin to what is called *designed experience*. Digital keyboards have the potential to enable an independently designed user interface, which in turn maximizes the capabilities of the instrument in a limited space. Big manufacturers in the market like Korg and Roland have realised the importance to improve musical virtuosity and technical perfection by design.

Interaction design aims at a smooth and beautiful communication between the subject and the object. When it comes to instruments, this motto becomes even more important, because playing a musical instrument is a challenge and musical keyboards are full of functions, which take time to master on. The capability of this instrument has both negative and positive aspects; an interface might become complicated and difficult to use especially during the course of the live performance.

4.2.3.1. Derek Sherinian

Dream Theater's sound is thought to be quite synthetic by many; this band's main target is the accomplishment of virtuosity and technical perfection by each member of the group. Their first album *When Dream and Day Unite* was released in 1989. Starting from the first album the band has always been careful on the *design* of their music, which means they carefully select their notes and each detail like many other groups and musicians. Keyboard solos can be investigated in three periods since the group has worked with three keyboardists: chronologically Kevin Moore, Derek Sherinian and Jordan Rudess. These keyboardists have different musical approaches and it caused a differentiation in the sound of the band.

Kevin Moore is well-known for his melancholy and preferred a less synthetic sound, while Derek Sherinian shows his virtuosity on the keyboard instrument. He tries to make the most of the instrument; therefore he established an extraordinary interaction with the keyboard. He plays the keyboard on an inclined surface in order to make his instrument parallel to his hands for a better and faster movement. There is important potential for the designer: technical perfection and virtuosity could be accomplished or supported by design. *A Change of Seasons* (1995) is a live album of the band. Derek Sherinian's improvisation on *Funeral for a Friend* in this album reflects his virtuosity, and in addition, sounds like it was designed before.

CHAPTER 5

5. Conclusion: Design and Representation of Music in the Industrialised Era

Electric instruments are a departure from nineteenth century tradition. Because they depend on physical discoveries of this century, they are often considered the most characteristic instruments of our time.

Sachs, 1940, p.447

The primary stimulation that directed humankind through the development of tools, which we call instruments today, is universal in character according to Sachs (1940). "*They include motor impulses – the desire to express emotion through physical movement, ritual functions – the desire to invest sound with symbolic meaning or magical powers, and later melodic impulses – the use of instruments to imitate repetitive patterns in speech and song*" (Sach in Théberge, 1993, p.27). Music, like other fields of art, is a representation of the real world and the musician is deeply influenced by the structure of his or her era. Influence of the nature and its beauty is often clearly apparent on romantic musician of 19th century; likewise, modern urban lifestyle, in other words living together with the technology in a strong relationship could be argued to have some strong influence on 20th century music. The use of machinery in music as source of sound and inspiration was a part of a bigger fascination for mechanised urban life.

As a part of his era and world, the composer has always given clues about what s/he observes and feels. For instance, music of Vivaldi comprises explicit reference to the nature; his violin concerto *the Four Seasons* depicts human-environment relationship and the way nature dictates on life of the man. Besides, his music is referred as

impressionist and sounds very worldly. "*With the development of industrialisation an increasing number of composers no longer considered it as appropriate to obtain their thematic inspirations from a pre-industrial era*" (Braun, Ed. Braun, 2002, p.107). The 20th century was the time of factories, machines and the railways and many artists and composers were inspired by themes from them. Composers like George Antheil, Arthur Honegger, Edgard Varèse and Karlheinz Stockhausen wrote music which has reference to machines, factories, noise and transport engines. In notable amount of electronic music, instruments were used in the way they imitate machinery and hoots. Pierre Schaffer, know as one of the pioneers of *Musique Concrète*, uses pre-recorded sounds captured at a depot for the *Gare des Batignolles* in Paris as body of work in his first composition *Etudes aux chemins de fer*. These recordings included steam engines of locomotives, whistling of trains and wagons moving on the rails.

Reflections of technology (especially electric) on music goes back to early 20th century when *music machines* and *noise* concept were new and of interest to many people living especially in cities. It was a few years before Stravinsky's polyrhythm and atonal music of Schoenberg; composer George Antheil used train, car and airplane engines as the major theme in his works. Those years, 1920s, was an era of rival between the humankind and the nature; therefore power, speed and greatness concepts were of great importance and interest. Machinery and technology, spacecrafts, trains, cars and planes, in other words tools and objects that humankind was not much familiar with were found astonishingly interesting by both the composer and the audience. Arthur Honegger found music ideas and themes in transport vehicles and used them as source of inspiration to compose a less-sophisticated type of music for the general audience. These works, which are still

regarded as being popular to a degree (Braun, Ed. Braun, 2002), give the feeling of energy and power to the listener since being associated with the railway engines.

In early 20th century music, *noise* was raised to the state of an art (Schafer, 1977). "*Recording engineers assumed increasing importance and the rise of studio aesthetics had a significant impact on the expectations of listeners in the concert hall*" (Braun, Ed. Braun, 2002, p.9). In the light of Braun it would be reasonable to claim that musical aesthetics were getting akin to a technology-ridden activity in the 20th century. If we consider that studio recording includes an important amount of post-production, editing and mastering efforts, therefore albums realised in the studio environment can not possibly be reproduced live, we should agree with Theodor Adorno who argues that "*technology has gradually penetrated to the hearth of the work of art itself*" (Adorno quoted in Braun, 2002, p.9). Geoffrey Hindley (Ed. Braun, 2002) mentions about the technological effect of transition from lyre to keyboard and claims that when the mechanical keyboard replaced the bardic lyre in Western polyphonic art music, this promoted an important shift in human mentality.

Arthur Honegger composed a piece for symphonic orchestra in 1923 named by him as Pacific 231. By using this particular name Honegger renders sign of his respect and gratefulness to one of the fastest American locomotives of its time. In Pacific 231 Honegger picks some ideas from transport such as energy and dynamics and turns them into concepts of musical language. Honegger insisted that it was not a program music; instead the composer believes that he translated his impressions into a musical structure (Ringger, 1986). Likewise, Edgard Varèse used technology as an inspirational source in his music: his notable work *Poème Électronique* conveys the sound of factories and machines to recording medium. Modern man, who is targeted

by these contemporary composers, is willing to hear the sound of technology as it is really of interest to him. In addition, music of contemporary composers comprises *silence* as a musical idea, which would have been used as an utmost important component by John Cage. His work for keyboard 4'33'' (1952) gives explicit clue about his respect to the silence as a theme in music. In 4'33'' the keyboard player opens the fallboard of the keyboard and waits for four minutes and thirty three seconds. This can be classified as being experimental and the audience hears nothing as music but pure silence of attendees.

Jazz and blues musicians picked themes from technology and transport, as well. Duke Ellington's Daybreak Express (1933) stands as a very important piece of music inspired by trains; in parallel to Pacific 231, rhythm speeds up gradually. At the end, the train decelerates and stops with an inharmonious wheeze (Schuller, 1989). In 1977, Kraftwerk with their piece Trans Europe Express reflected a similar fascination of transport themes (Bussy, 1997).

In the second half, the curiosity of early 20th century did not lessen. Due to improving technology and a market advocating the consumerist musical culture, electric-electronic musical instrument design and production shifted from curiosity based engineering experiments of the first half of the century (Dynamophone, Theremin, Ondes Martenot) to efficient and reliable concert instruments (electric guitar, electric piano and organ) "*what must truly be regarded as the most characteristic instruments of our time*" (Théberge, 1993, p.48).

Technology inspired music of our century might be evident to the *technologic heart* of contemporary music. Helicopter String Quartet of Karlheinz Stockhausen (1992) can elaborate on this inspiration. When Stockhausen was asked to compose a

quartet for *Salzburger Festpiele*, firstly he didn't accept as he considered this form to belong to 18th century music. But then he composed a string quartet for four helicopters, four sound technicians, four columns of speakers and some other electronic devices. Helicopter String Quartet was performed by musicians each of whom was in different helicopters playing their parts while the vehicle was moving on the air. This performance based music gets its very core element from technology; in this example, technology should be regarded as both the source of inspiration and the means of realisation.

Keyboard and synthesiser were a part of the wider culture; they were an integral part of the liberating culture of the 60s and the early 70s. "*The synthesiser, and the sound it produced, was a part of the counter-culture, the sixties thing, and the psychedelic revolution*" (Pinch & Trocco, Ed. Braun, 2002, p.78). Living together with technology was relatively new especially for a majority of people. Idea of liberation and freedom used to be understood in connection with power, energy and technology. An example can be John Coltrane's *Song of the Underground Railroad* (1961); the word *underground* in title has a double meaning of transport and an escape from the slavery (Coltrane, 1961). 1967 is a milestone in keyboard history, in that year Robert Moog built his first successful instrument. In such a world he produced that instrument and affected numerous composers, millions of people and he sort of changed the style and way of music being produced in his time. "*The launch of modern electronic music is generally dated from Bob Moog's paper on 'Voltage-controlled modules for electronic music', given at the Audio Engineering Society of America in 1964 and quickly followed by his patenting of designs for a voltage-controlled oscillator (VCO), a voltage-controlled amplifier (VCA) and a voltage-controlled filter (VCF*)" (Jenkins, 2007, p.49). The Moog was first used

by radio stations as an effect instrument; musician who put the Moog in music world is Wendy Carlos. Her impact was sudden: following Robert Moog's speech at an International Electronic Music Conference in United States two sample pieces were played at the hall. Moog refers that moment as creating an unpredicted amazement at attendees; he says that everybody found that music shocking because Moog had never been used as an instrument and hearing that it can serve as a musical instrument was astonishing. Two pieces of Bach were played with precision and clear tones of the modular synthesiser which is almost impossible on conventional keyboard instruments.

Those years music was regarded as a happening; rather than being mere listening, it used to render a life; being in the concert meant participating in music. John Cage concerts would be good examples which were more than just music, but they were art happenings. These concerts were held in very exclusive places; no photography, no recording and filming. Music was consumed as a pure instance of art. Experiencing music was a way of mind expansion and so was the use of keyboard and synthesiser for most keyboardists. "*There is no doubt that the spacy sounds that synthesiser could produce perfectly matched people's exploration into inner-space*" (Pinch & Trocco, Ed. Braun, 2002, p.79). Groups like Yes and ELP picked themes from their environmental explorations and placed them in the body of music by the possibilities of keyboard and synthesisers. In other words, the keyboard enabled the musician to explore and experience different spaces in their music. As a keyboard instrument, meaning of the synthesiser rooted in the technology, and this meaning developed in the way the instrument had been used to be performed before and then again this meaning altered music which is played on the keyboard according to the changes in the technology. After Japanese companies like Yamaha entered the

market, keyboard became so popular such that "*every pop star had to have a keyboard*" (Pinch & Trocco, Ed. Braun, 2002, p.80).

5.1. Keyboard Music in the Digital Age

Since the first decades of 20th century, keyboard instrument design and manufacturing have witnessed radical changes and paradigm shifts. In this period evolution period of keyboard instruments occurred in a different way from how it used to happen to acoustic piano or organ prior to first use of electricity and voltage control. Several major factors catalyzed those changes one of which is the mood of production. Conventional tendency for producing musical instruments is subject to changes; most of the instruments were not produced by craftsmen named as *luthier* in the last seventy years roughly. Instrument production has become an issue of design and engineering that enable an increase in the amount of production. By the advantages of improving technology, keyboard design and engineering saw technological turning points such as transition from modular analogue synthesisers to digital; or shift from *form equals to function interface* to softkey and softknob driven touchscreen centred interface of 2000s, which in turn would lead to enhancing consumption levels and rapid obsolescence. What seems interesting and different from other musical instruments is the way the keyboard has evolved; electricity has been applied to many instruments such as guitar, drum and strings but none of them adopted different sections like rhythm and harmonic accompaniment. It could be wise to explain this as a mimetic point; image of the keyboard has been a meme from the Baroque Music as in that era the conductor plays the organ and conducts the orchestra from his instrument. This meme plays a role to acknowledge the keyboard as a tool to have control over music. In addition, the pipe organ used to

have a control console which houses many buttons and serves as a control facility on the whole instrument. These controls include stops that is used to change the registration, in other words to alter the timbre. To sum up, the keyboard inherited a lot from its acoustic ancestors, evolved very fast unlike other instruments and became an instrument which is not only used as an instrument but also as a control device on the stage.

Enormous progress in the 20th century meant an incredible consumption due to rapid technological obsolescence as well as designing more capable instruments. Due to wide production and consumption of *industrial instruments* and an apparent aligning to the technology in the attitude of the musician, industrialisation in the production and consumption of music became apparent after 1960s in the light of today. Several reasons can possibly be suggested for this transformation: for example electronic instruments are basically more accessible in comparison to acoustic instruments concerning their prices. There are several reasons for their lower prices such as their material, new possibilities of mass production and technological improvements. An important factor which defines the price is mode of production: electronic keyboards are industrial goods produced in hundreds of thousands, on the other hand, conventional keyboard instruments, although they stand at the centre in European Classical music, were produced in a "made to order" nature due to the high cost of instrument and the small size of the manufacturer. Before 1740s, an average workshop with a craftsman and maybe his assistants could produce no more than 17 to 19 keyboards per year. "*It is unlikely that, before the middle of the eighteenth century, there was enough demand for harpsichords and clavichords in any one German region to occupy a craftsman exclusively with the making of them. Usually these instruments were a side line of organ builders or of cabinet makers. It was*

after 1740 that the demand grew to a point where building them could become an independent trade" (Loesser, 1954, p.16).

In the 1960s, inventors and entrepreneurs (generally working in collaboration with musicians) contributed excessively to the development of synthesiser and keyboard design and technology; these inventors, like Le Caine, often used to work in small "*make-shift laboratories*" (Théberge, 1993). For the Moog case, Robert Moog was firstly an inventor and entrepreneur who then became the president. There is enough evidence to claim that these former entrepreneurs often turned into "*innovation suppliers*" (Baba, 1989) working for giants in the market; for instance "*the creative team behind Sequential Circuits has been absorbed by Korg and became the centre of their US based R&D efforts*" (Théberge, 1993, p.95). In these decades electronic keyboard selling figures reached up to hundreds of thousand and it started to compete even with the piano in the non-professional market (Majeski, 1990). According to AMC and MIAC statistics in North America the number of acoustic pianos sold started to fall after the late 1970s while at the same period there was a growth in electronic and digital piano sales. What lies beneath the manner of the professional musician who prefers to move towards to the technology and its possibilities is not simply discounts on prices or technological progress made during the 1960s; it was a move in the musician's behaviour and essence towards a practice blended with a consumer practice which turned the professional musician into a *consumer of the technology*. The shift in the behaviour of the musician and evolution of electronic musical keyboards were synchronous movements contributed by technological improvements, market and its promotions, and industrial organisation. The term professional musicians as consumers of technology "*does not simply mean that musicians have become consumers of electronic musical instruments and*

recording devices as consumer objects; but rather, they have, in various ways, aligned their musical practises with a kind of behaviour which is akin to a type of consumer practice- a type of practice that is altogether different from earlier relationships between musician and their instruments as a means of production" (Théberge, 1993, p.9).

Technological improvements in microprocessor technology in the 1970s can be argued to be important factors that caused a "*technological discontinuity*" (Tushman and Anderson, 1986) in electronic keyboards. Although microprocessor technology was used in many different instruments, the most influential outcomes of it were realised by digital keyboard and synthesiser manufacturers, which in turn enabled serious discount on keyboard and synthesiser prices. This would be referred to as *democratisation of synthesiser technology* by Robert Moog later in 1985. In addition, electronic instrument manufacturers were not late to consider the great demand from amateur users. Hammond was first among keyboard instrument producers which realized that demand. This brand instruments have automated accompaniment facilities like bass sound or harmonics, which are played by the instrument itself automatically based on the depressed key on the keyboard. The electronic keyboard market did not have predecessors, therefore marketing was essential. Journals and periodicals became important in the 1960s and kept as primary medium to expand that consumption culture until the 1990s.

One of those periodicals, Hammond Times, serviced as a media to introduce new Hammond organ models and establish a social network between players. In addition, the journal had an educational mission; in each issue exercises, some simple music transcriptions and tips for musicians were included. On the other hand, the most

important mission of Hammond Times was to promote Hammond organ to amateurs as consumer electronics. "*The easy-play idea became an increasingly important part of ad campaigns for the industry during the 1960s*" (Théberge, 1993, p.48). This promotion was organised very well and proved to be very influential. Interestingly it could be argued that the same attitude, which stresses easy-play features as a promotion of the keyboard, caused resistance from educational and professional market. It was seen as a part of cheap popular culture, easy and practical way of learning music which could never compete with serious conventional music study.

Among the instruments innovated or designed during the first half of the 20th century the Hammond organ might be the most successful, enduring and important as it grabbed important attention and acclaim when it was first introduced, and kept on being a pioneer in electronic keyboard industry until 1970s with successful innovations. One of the most important factors behind this success is that Hammond organ was not experimental in the way this instrument used to supply an interaction between itself and the musician; the convention was relatively traditional unlike other electroacoustic or electromechanical instruments of its time such as Theremin and Dynamophone. The primary aim was to develop an instrument that can be adopted by the modern musician; inexpensive, lighter in weight and smart for basic church use. Hammond methodically used to establish resemblance between the piano and church organ. However, the Hammond organ has never received the respect it deserves; as an example that gives the idea of disregard can be Schrader's Introduction to Electro-acoustic Music (1982). In this book he mentioned about Laurens Hammond and his invention in only a single page-long passage; although according to him this instrument was "*one of the most commercially successful electro-acoustic instruments*" (Schrader, 1982, p.68). The reason for that

disregard could be found in the very sentence of him: "*Although it has been widely used in popular music, the Hammond organ has been all but ignored by composers of art music*" (Schrader, 1982, p.68).

When it comes to the 1990s and 2000s, prices decreased even more and many features that only high-end keyboards had featured before (in late 80s and early 90s) became standard such as touch screen, softkeys and softknobs. Touchscreen and softknob oriented keyboards of 2000s proved to be the most efficient keyboard instruments of the history as of today. Also MIDI sequencing and editing is made possible with the help of touchscreen on the keyboard besides the computer interface.

In short, from the early 20th century electronic keyboard instrument has caused strong influence on the production, performance and consumption of music. In addition, keyboard has influenced other musical instruments, recording technology and the music market, as well. This influence will be elucidated under four subtitles below.

5.1.1. Transformation of Space and Place Concepts

Spatial transformation could be argued to have been occurring in two ways one of which is the ease of integration of parts in electronic system including speakers, power amplifiers and rhythm section: electronic keyboard could be integrated to the whole system easily, which makes it a favoured instrument for large halls. Especially the synthesiser could enable control over all other instruments and the whole sound can be modified by keyboard instrument's interface. Sophisticated interface design of contemporary synthesisers can supply serious ease of use that in turn contributes

to the transformation in space and place. What concerns me most here is the second way in which the keyboard has turned to be the most important instrument of home studios after 1980s. Studios in general or home studios in particular, have an importance not only as a place of performance or practice but also as a mode of production and have served as important factors that shaped especially popular music since 1980s.

Expansion of recording industry, increase in music reproduction and domestic music player systems, sound amplification and powerful concert sound systems have led to serious reformation in space and place. Home entertainment industry, including studios, home Hi-Fi systems, record manufacturers and retailers has helped transform home to a place for entertainment, as well as microprocessor development. MIDI with floppy disk and then mini disc and compact disc have made home an environment of music production. Such new technologies enabled the musician to work in their home studio after the 1960s in a relaxed environment. According to Paul Théberge home studios owned by increasing number of popular musicians changed the sound concept; "…w*ith everyone having at their disposal (for a price) the same powerful technologies of production, there has arisen the subtle yet persistent feeling that everyone is beginning to sound the same*" (Théberge, 1993, p.8). Advantages of sound studio put it in the heart of twentieth century music and gradually since the first examples of magnetic tape music starting in the early 20th century by Pierre Schaeffer and Edgard Varèse, home studio concept has evolved and expanded; when it comes to the 1960s, as will be discussed in more detail later, works of Vangelis and alike proved home studio to be the centre of musical language for especially keyboardists.

Although in 1960s, setting a proper professional studio used to cost too much and only star musicians, Vangelis for instance, could afford to have one, after 1980s home studios became affordable for many amateur musicians. Especially in 1980s, multitrack tape recorders became inexpensive tools for sound recording and found enough even by the professional musician at least for demo recording. However, home studios have never been regarded as places of record production for commercial releases, since they generally didn't have high quality equipment such as microphones, mixing console and the acoustics of recording booth itself. Multitrack tape recording in home studios provided the musician with overdubbing and channel recording in which new channels could be added later, all these channels, assigned to different instruments or instrument groups, could be combined or equalised electronically, which is known as *mixdown session*.

"*But the multitrack tape recorder was not simply a new device for recording or layering of sound or even for the composition of music: it was part of a larger social technology*" (Fredericson quoted in Théberge, 1993, p.289). Sound studios, including home and professional commercial studios (but especially home studios), as a mode of music production, turned into places which are influential in internationalisation of musical styles. They played an important role in restructuring the production of popular music. According to Brian Eno (quoted in Théberge, 1993), musicians came to the studio with only a skeleton of the piece instead of finished conception and with studio facilities they tried to add some sound and then remove some parts. What they get by mixing this compilation was their music and this process should be regarded as the encounter of scores since it defines the actual structure of the piece.

Home studio is regarded as a favoured place for music production since it is private domestic space; working in private conditions regardless of time and money paid hourly for the professional studio makes it desirable for the musician. For many, it is "*the ideal site of musical inspiration and stage*" (Théberge, 1993, p.290) instead of professional studios or concert halls. In parallel to the expansion of home studio, more and more musicians were willing to turn a part of their homes into studios, which in turn transformed the domestic space into a working environment. As a result, home as domestic and private space turned into a place for music production and this mobilisation was encouraged via magazines and other means of media. When we consider that some of these musicians let their home studios to small bands and other musicians, one might argue that private domestic space turned into public space in those years. Another point which should be clarified is that electronic and digital keyboards have mounted outputs for headphones. Playing the keyboard with headphones while composing or practising music enables the player to perform in an *audio bubble* regardless of time and space. Especially home studio is a place in which musician can work in an absolute privacy with headphones at any time in the day. Electric keyboard is the first instrument which could sound through headphones and provided the musician with good profit such as playing or practising this instrument in privacy. Also it might be helpful for education purposes: as can be seen in the picture below, in a class environment students can perform without disturbing others and might communicate with the teacher through the microphones and headphones.

Figure 81 Hammond Brochure, 1946

Electronic and digital keyboards, besides multitrack tape recorders, were main instruments of the studio until 1980s. However, MIDI has turned keyboard into the main instrument; because as explained before, MIDI for many, has taken over the recording, which in turn radically decreased the need for any kind of sound recording device, including multitrack tape recorders. Home studios were often owned by musicians who work for TV commercials and in need for sound effects and different timbres. As a result, the digital keyboard has become indispensible for home studios. In addition, home studios often serve as demo recording facilities and many groups can only afford a keyboardist to play the background; in other words many groups hire a keyboardist to play all strings and rhythm instruments that helps make the digital keyboard main instrument of the home studio.

First commercial recording studios, Columbia and RCA Victor, date back to the end of 19th century (1888 and 1901 respectively). In the first decade of the 20th century their record catalogues (cylindrical disks produced with lateral or vertical techniques in those years) included numerous artists and orchestras and after 1930s record industry became a large market with other labels entering in and increasing number

of home entertainment devices. From 1960s onward, home studios became pretty popular, firstly in star musicians' homes, not only as recording facilities, but also as places, which then started shaping musical life. In subsequent years, home studios became more popular since the equipment price tended to fall due to developing technology. Another reason, a more important one, is that music production and consumption was shifting from concert or performance based to so called *record based* music. LP and tape recordings started to be regarded as the basic means of listening to music and definition of the musicianship approached to taking part in record sessions. Vangelis established his famous 450 square meter Nemo studio in London in 1974. Even though it is not a home studio technically, Vangelis used that studio privately, which means he didn't let it to other musicians and composed many important works in there such as Spirals, Opera Sauvage, Chariots of Fire and the Bounty which are referred to be some of the most important works of him. That studio became the place where he works, practises, composes, records and edits; instead of finishing a piece on paper, he rather shaped the piece by adding new partitions and layers to previously recorded sounds.

Technology opened the way for the professional musician to give concerts in large concert halls and places such as stadiums and city squares. Traditionally concerts with the audience attendance of thousands people have always been held since the time of Ancient theatres through the history. Auditorio Nacional in Mexico City (1952), one of the largest concert halls, has an audience capacity of 9.565 seats. Top concert halls list includes Vienna Musikverein, Austria (built in 1870, number of seats: 1.744), Boston Symphony Hall, USA (built in 1900, number of seats: 2.565), Sydney Opera House, Australia (built in 1973, number of seats: 2.579), Wiener Konzerthaus, Austria (built in 1913, number of seats: 1.840), Royal Albert Hall,

England (built in 1841, number of seats: 5.544) and Carnegie Hall, USA (built in 1891, number of seats: 2.804). These concert halls have been places for concerts and music gatherings, and in addition they have defined the way music is consumed by the audience for centuries. However, means of electricity and electronic instruments enabled the musician in the 20th century to give concerts in incomparably large spaces. For instance Heavy Metal Day at the 1983 US Festival, according to the record, attracted one of the highest number of attendance with estimated 375,000 people. Soon, it became a matter of monetary value for instrument manufacturers to get a louder sound from the instrument, increasing precision and playability as these enabled giving concerts in larger halls to more audience that makes more economic profit, which in turn transformed the manner in which music is produced and consumed into a highly profitable economic value.

In subsequent years, manufacturers also realised the importance of horizontal integration of synthesiser for a better communication between different keyboards and it was important for live concerts, as well. "*The degree of instrument compatibility required by the MIDI specification has created the basis for a horizontal integration of the synthesiser market*" (Loy, 1985, p.20). Musical Instrument Digital Interface was both software and hardware specification mainly aimed at horizontal integration of commercial digital keyboards, and proved to be essential and important for concerts and live performances.

5.1.2. Democratisation of the Synthesiser Technology

Robert Moog (1985) referred to the 60s and the 70s as a period of democratisation in the electronic keyboard industry. Undoubtedly there is some background underpinned by development of microprocessor technology, extensive use of

computer hardware and software that have led to so called *democratisation of technology*. The most important thing to consider might be the microprocessor technology as it enabled the manufacturer to build more powerful systems at lower costs. Also microprocessor started to be used as source of timbre and tone generator in addition to being audio control mechanism. Simultaneously in those years internal and external memory storage hardware, such as floppy disk, started to be used expansively and in turn "*synthesiser could function not only as instruments for the production of sounds but also for their reproduction as well*" (Théberge, 1993, p.122).

Intention of the keyboard manufacturers to lower the prices is basically was dependent on some interrelated trends. Firstly, fall in the price of microprocessor technology enabled the manufacturers to produce more powerful and faster keyboard instruments at lower costs. Secondly, MIDI technology supplied the amateur musician with great tools and capabilities, which in turn grabbed the attention of numerous musicians. These trends broadened the market of electronic and digital keyboard by more and more amateur and professional musicians using keyboards. Digital keyboard can be advocated to have reached its peak in this period; they were those years when the Yamaha DX7 was hit among musicians. This keyboard became popular with many amateur keyboardists because it was inexpensive and easy to program. In addition, it used to have well prepared default factory sounds. Introduction of MIDI technology was a large step through broadening of keyboard instrument because it introduced many helpful features; firstly it enabled music exchange easily by cartridge or floppy diskette. Also, since it was digital record of scores rather than sound recording, MIDI enabled the amateur musician to use pre

recorded music and to add something on it.

5.1.3. Rationalisation of Mode of Production

The phrase *mode of production* may imply stages of composing, performance, recording and mechanical reproduction of copies of the compilation. However here in this section it is intended to elucidate on the development of a proper notation system, alternatives to it by means of digital keyboard technology and outcomes with reference to Weber and rationalism. It should be clear that touchscreen, softknob and softkey features in the keyboard interface are quite serious attempts towards an accomplishment of rationalisation in keyboard music. It is wise to argue that MIDI technology has found its most productive environment by the use of touchscreen and softkey coordination.

As mentioned in Chapter 2, the first use of notation to record today's twelve-tone chromatic system on staff dates back to Guido D'Arezzo (991-1033). Before D'Arezzo, who was a monk of the Benediction order, some other quite primitive conventions had been used in order to write music on paper such as Neumatic Notation and Tablatures. Although they were primitive in practice and quite far away from the ability to represent many musical ideas such as dynamics, sense or some ornamentation, today we know hymns and carols from Medieval Era via these notation techniques; and Tablatures are still in use by especially popular music performers.

In especially Baroque Music, ornamentation was of great importance and by tradition it was improvised by the performer instead of having been written by the composer which gives a great flexibility and freedom to the performer. It was not

until the 17th century when a proper notation system, which indicates every detail such as nuances and even flat/sharps, was used. The first composer who marked flats and sharps was Johann Sebastian Bach. Before him, scores used to convey data only about rhythm, melody and harmony. Famous keyboard composers of Baroque Music; Rameau and Couperin in France, Scarlatti in Italy, Handel in Germany composed music without giving every detail and encouraging the performer through improvisation.

After the 17th century notational writing as a way of musical organisation gained enhanced importance which in turn caused opposition from the Romantic musician since musical organisation meant a dictation for the Romantic virtuoso whose motto could be summarised well by Jan Jacques Rousseau "*I am not made like any one I have been acquainted with, perhaps like no one in existence; if not better, I at least claim originality*" (1861, p.5).

Notation system, both staff notation and primitive systems such as tablatures, are thought to be abstract means of musical organisation. Scores serves as a piece of paper on which musical idea is recorded; and the musician interprets this skeleton with their skills and sense of beauty. In contemporary digital keyboards, notation system by default seems to have been changed by the extensive use of MIDI, which unlike conventional notation on paper, could be argued to be a concrete and rational way of recording a piece of music on a chip-like medium. Keyboardist sequences in an environment (this environment does not have to be the studio), later s/he can manipulate rhythm and melody, add effects and harmony. The data can be copied to other keyboards, which can be argued to be akin to that of player piano rolls. Both rolls and MIDI files are objective means of data recording since the musician doesn't

have opportunity for interpretation: s/he becomes someone who plays what *was* predetermined before for him or her.

Max Weber argues that in keyboard instrument design rational approach became an experimental method especially from the 16th century onward (Weber, 1958). Therefore, according to Weber instrument design in the West have had a tendency towards rationalisation after Renaissance. In parallel, one might argue that MIDI and breakdown of staff notation can be observed as an approach through rationalisation. This similarity between notation and MIDI, digital keyboard and orchestra might be widened through similarities between them. Score or sheet music is an abstract *record* of music that is played by an orchestra (which is a group of highly trained musicians managed by a conductor, therefore under supervision of him or her) or an individual performer. MIDI file, as discussed before, conveys data of melody, rhythm, harmony, dynamics and can imitate an orchestra. In this context, keyboard player becomes the conductor, keyboard takes the place of the orchestra and scores is displaced by MIDI. While the sheet music is abstract and open to interpretation, MIDI is numeric, therefore concrete and rational. And in order to imitate the orchestra, MIDI files can be modified slightly: for example timing of a note can be altered by a few microseconds or some pitches can be increased or decreased by microtones, generally not more than 1/9th. This process is called as *humanising the data* and Art Neville argues that after this *intentional damage* it becomes impossible to determine if it is live recording or not (quoted in Théberge, 1993). It should be noted that, here human is referred as being imprecise and random, in contrast with *rational* digital keyboard. What concerns me most here is the fact that use of MIDI technology in keyboards greatly accelerated after touchscreen based interface of keyboards marketed after 1990s. Although former instruments allowed MIDI

use, contemporary digital keyboards have incomparable advantage over electronic keyboards.

5.1.4. Sound as Commodity

> *When I buy a sampler, I think in terms of libraries, rather than capabilities*.
>
> Michael Josephs, (Keyboard Magazine, 1989)

For acoustic instruments, sound quality is the utmost important characteristic of a particular instrument for which performer often makes either the decision to buy the instrument or the selection, out of several instruments generally, as to which style or era of music s/he thinks that instrument is suitable for. Recording and its mechanical reproduction in 20th century has proven that star musicians have their characteristic sounds determined by their sense of aesthetics, touch and sensibility, and eventually timbre and sound quality of their instruments. However, one may argue that the most important factor amongst is the musician itself. A good example can be Agustin Maruri's The Andrés Segovia album (2007): in this album Maruri plays on one of the famous guitars Segovia played for years: 1962 Herman Hauser II. Although Maruri performs Segovia compositions on Segovia's most famous guitar, the end result, timbre or sound, is quite different from Segovia sound and feel. This particular example can elucidate on what tone and timbre mean for an acoustic instrument and its performer.

Professional musician, especially if their instrument is comparably affordable like guitar, tends to play music of different eras on different instruments. For instance Andrés Segovia used different guitars for different recording sessions; he generally used to record Spanish composers such as Enrique Granados and Isaac Albéniz with

his Manuel Ramirez guitar made of cedar (top) whereas he recorded much of his Baroque works on Herman Hauser (1937) guitar made of spruce (top).

However, sound quality, touch and timbre relations are pretty different and have been increasingly associated with the digital technology, MIDI and computer aid for electronic and especially digital keyboards. Smart interface and successful interaction enabled even an amateur to deal with sound itself that includes exchange of files on a medium and ease of use of the interface. Unlike acoustic instrument performer who can rarely afford more than three instruments if s/he is not a professional, digital keyboard performer has an opportunity to select from a great amount of alternatives beside manipulating and saving them, recalling later and the ability to share these customised sounds with other keyboard instruments and musicians, and this is made possible by keyboard interface. Having almost no limitation for endless different timbre alternatives also brought the consumerist attitude to musical works after especially 1980s. In this *sound consumerist* environment, timbre obsolescence became something very frequent, often no more than several product cycles, while in the past a keyboard instrument, let's say the piano, used to last for centuries at times. "*Musicians have not simply become consumers of new technologies but their entire approach to music-making has been transformed into one where consumption – the exercise of taste and choice – has become implicated in their practices in the most fundamental level*" (Théberge, 1993, p.267). As a result, instrument manufacture, software suppliers and technology have become more and more influential on music production; sound libraries and media that underpinned the exchange among keyboardists were two of many exterior factors by which music practice was deeply intervened. Buying and selling these sound samples and MIDI files generated a sub-market beside instrument market

which can be named as a *musical materialisation*. Characteristic pattern of materialisation in digital keyboard market can be summarised within three dimensions: increased diversity of products, frequency of purchase and increasing depth of commodity relations (Théberge, 1993, p.326).

By exterior interventions, purposefully supported by the consumerist industry with its own medium, so called trademark sound has become something that can be copied and shared, which means in other words, became somewhat belonging or commodity. Today, it is possible for a musician to have a very similar musical tone to that of Wakeman via what's called *sequencing* which is a process very close to recording (it will be argued later if it is recording or not) on some medium. Sequencing, as mentioned before, is a type of notational writing that is realised with performance gestures which takes place between abstract staff notation and exact audio recording and has many common points with the player piano rolls. According to Oswald (1986), the difference between recording tools and keyboard instrument has lessened, as almost all keyboards and synthesisers became tools that can turn performance into a kind of digital audio information.

In order to sequence, musician plays their instrument and his or her keystrokes are recorded digitally, and this digital data can be modified later. Also rhythm or other partitions can be added later, as well. MIDI sequencing virtually returns the *aura* (Benjamin, 1969) of musical performance into another realm, the digits and their different combinations. The end result turns to be a product which is both reproducible and exchangeable. In addition, unique characteristics of touch can be conveyed through sequencing and MIDI technology; which means in other words, a musician can sound similar to their favourite star keyboardist. This brings about

important questions on technology and music interface because sequencing can be classified as neither recording nor notation and it gives rise to accept sound as a *commodity* which can be shared and belongs to any keyboardist unlike how unique it was in the past. In addition, this commodity, namely the sound, is sold and purchased or shared like a product in increasingly commercialised marked. This should not be understood as merely buying and selling more and more keyboards; general pattern of music has become aligned to a consumerist style after the 1980s. Besides, a technology driven or centred style of musical attitude benefited from production, distribution and consumption levels in music.

Music production after the 1980s became a process much related to not only selecting a sound from a wide range of prefabricated material according to desired context but also giving order and adding harmonic parts by using existing data. According to that consumerist culture "*more is always better and musicians' magazines in the 80s were filled with the descriptions of recording sessions*" (Théberge, 1993, p.267). In such a market, timbre or sound extracted from the instrument and became an independent object, which can be calculated rationally. And keyboard interface could be argued to enable it to the greatest degree today.

5.2. Summary

In the late 19th century, the invention of the first tool that incorporates means of electricity, such as voltage and frequency, brought about interest and acclaim from the public. In subsequent years, engineers explored new possibilities and areas of use that they had not imagined before, which caused even more enthusiasm. Electricity and possibilities it renders would start to be used for many necessities from transportation to telecommunication, and take its indispensible place in future

prophecy. In such a world, Dynamophone was patented as the first electronic keyboard instrument of history, and then whether their looks are similar or not, many electronic instruments have been manufactured whose sound production or modification principles are dependent on frequency and voltage control. Almost all of these electronic instruments designed in the first half of the 20th century couldn't survive after the 1950s. However, in the way they opened other keyboard instruments evolved; which resemble conventional acoustic instruments, and therefore regarded as being much conservative in comparison. One of the most important of them is Hammond organ, which was designed as a rival to church organ and works with electromechanical principles. These instruments have gained enormous importance after 1960s due to improving technology, and second half of this century witnessed important shifts in the technology, which in turn altered their working principles.

1. Besides new musical possibilities and timbre alternatives supplied by electronic keyboards, they could be argued to have brought degeneration to music, especially when they are used for mimicking conventional instruments like violin or guitar. After the 1960s, mimicking possibilities were gained importance and it has been highlighted in their interface with numerous buttons each assigned for a different instrument.

2. Studio in general and home studio in particular has turned into an important place of both production and consumption of music since 1980s. Keyboard as the main instrument of the studio, due to its control over sound and timbre, serves as an important role for the musician. In addition, keyboard interface is indispensible for integration among other instruments in large concert halls. In short, keyboard could

be argued to have transformed space concept from concert halls to either large open spaces or home studios.

3. Due to increasing capability of the keyboard interface, especially after the 1970s digital keyboards could be regarded as one man bands.

4. Musical style and the design of the instrument (design of the interface and form of the keyboard) are greatly dependent. In many ways an instrument dictates the performer on the music style s/he plays.

5. Touchscreen centred interface after second half of the 1990s have gained importance. Besides disadvantages such as being imprecise and slow, touchscreen supplies the performer with efficient control over the instrument even at live performance.

6. Softkey and softknob driven, touchscreen centred interface would be an efficient working environment for MIDI which is thought to be an important step towards rationalisation in music.

7. Sophisticated interface design has enabled even the naïve performer to share files, recall and modify them without much difficulty which turned the so-called trademark sound into something that can be exchanged like a commodity.

5.3. Suggestions for Further Study

This research tries to elucidate on the evolution of keyboard instrument from mechano-acoustic instruments through electric, electronic and digital musical keyboards in terms of structure and sounding principles in general, and interaction and interface design in particular. Therefore, the interface between the performer

and the instrument is of great importance and thesis is constructed on technological improvements, such as MIDI, touchscreens, softknobs and their consequences on the evolution of music and changing identity of the musician, performance and interpretation.

In Turkish music, especially in popular music, electronic keyboard attracted great attention in 1980s and soon became very popular with particularly amateur popular musicians as usual in many parts of the world. However, different from many cultures Turkish wedding ceremony has adopted "*one man bands*" founded by a keyboardist as the main player and includes his assistants. These small bands, generally set up by not more than three staff members, have become very popular within several years and still are in demand by organisers. In wedding ceremonies these *one man orchestras* use digital keyboards and use related accessories, such as mixers, and take advantage of technology extensively. They often use MIDI and sequencing techniques, add new sounds and rhythms on existing audio records. These bands, which seem to be setup in contrast with wedding ceremony orchestras of pre-70s that used to include several instruments like electric guitar, drum and wind instruments, generally play a wide variety of music from popular songs to traditional and folkloric melodies. In addition, these digital keyboard centred ceremony orchestras were very individual in sense and approach; they don't seem to have been appreciated "music as a group" and tried to perform music in a more individual approach.

In Turkish music scene, some popular musicians are known as the ones who made one man orchestras root in 1980s; Ümit Besen can be an example to those musicians. He has a great influence on Turkish wedding ceremony culture and was followed by

many; his pieces were imitated or directly played in weddings. Also Cengiz Kurtoğlu, Arif Susam and Nejat Alp can be mentioned under this list. This thesis does not aim to carry on a detailed research on Turkish reflections of the digital keyboard; and this point can be a potential starting point for researchers who are willing to make a research on cultural approaches to the keyboard.

Although a new keyboard design is proposed as a part of the research, this thesis does not concentrate on design solutions to improve technical virtuosity. Also in this thesis the keyboard instruments that are used for control purposes in a set up is excluded. For instance, the keyboard can be used in order to control sound effects in cinema, or in some live electronic music performances DJs use the keyboard as a control device. These can also be subjects for further study.

This study is tended to elaborate on the keyboard and music without concentration on a musical style, although at some point specific examples and explanations can be found regarding classical music, rock and pop. However, it might be an option to elucidate on the evolution of the keyboard interface within a distinct musical style. For instance, the requirements of a jazz performer should be different from a pop keyboardist due to their needs for accompaniment, rhythm and timbre. In my opinion, approaching the electronic keyboard from the perspective of a music style could be another research project.

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