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NEW WORLDS of SOUND

Electronics and the Evolution of Music in Canada

KATHARINE WRIGHT

CANADA SCIENCE AND TECHNOLOGY MUSEUMS CORPORATION

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NEW WORLDS of SOUND

Electronics and the Evolution of Music in Canada

KATHARINE WRIGHT

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Abstract

Developments in music technology since the late nineteenth century have had a profound effect on the nature of music. This document reviews the secondary literature in order to identify important themes and events, particularly in Canada. It begins with the application of electricity to carillons, pipe organs and orchestrions, and moves on to the various instruments that came out of telephony and telegraphy, which were meant to illuminate the ways in which the human voice might eventually be transmitted by wire. It covers the epic failure of the Telharmonium and the instruments based on the heterodyne principle: the theremin, Ondes Martenot and Mixturtrautonium. While this is not a history of recording, the advent of magnetic tape meant that music became malleable in a way that was entirely new. Beginning in the 1940s, composers took advantage of state- or university-sponsored music studios to examine the possibilities that recording offered for exploring the ideas of early-twentieth-century philosophy of music. Among these composers was the Canadian Hugh Le Caine, who also developed the first voltage-controlled synthesizer under the sponsorship of the National Research Council. Due to his lack of experience in bringing inventions to market, however, the instrument was never manufactured or sold. A consumer market for electronic and electric instruments had developed by the 1930s and 1940s, and a variety of instruments saw success: electric pianos, electronic organs (including the Hammond B-3) and the electric guitar, bass and associated effects. Other instruments, such as the violin, were also electrified but never gained much of a following. In the 1970s, Robert Moog brought out the first commercially successful voltage-controlled synthesizer. The development of cheaper digital technologies coincided with and encouraged an expanded market, and the MIDI (Musical Instrument Digital Interface) standard was developed so that the proliferation of instruments could have a common protocol. New genres of music, like hip hop and various forms of electronica, began to develop with the increasing malleability of music and the capacities of the available instruments. These genres contributed to the continued destabilization of ideas of performance, music production, listening and music consumption.

Résumé

L'évolution de la technologie musicale depuis la fin du dix-neuvième siècle a profondément transformé la nature de la musique. Le présent document examine les ressources documentaires secondaires afin de répertorier les thèmes et événements importants, particulièrement au Canada. Il commence avec l'électrification des carillons, orgues à tuyaux et orchestrions, puis se penche sur les différents instruments qui sont nés de la téléphonie et de la télégraphie, dont l'objectif était de montrer les façons dont la voix humaine pourrait éventuellement être transmise par des fils. Il aborde l'échec total du telharmonium, et parle des instruments qui s'appuyaient sur le principe de l'hétérodyne, soit le thérémine, les ondes Martenot et le mixturtrautonium. Bien que cet ouvrage ne porte pas sur l'histoire de l'enregistrement, il reste qu'avec l'arrivée du ruban magnétique, la musique est devenue malléable, et ce, d'une manière entièrement nouvelle. À partir des années 1940, les compositeurs ont profité de l'accès à des studios d'enregistrement financés par l'État ou par une université pour étudier les possibilités que l'enregistrement leur offrait en vue d'explorer les idées que la philosophie du début du vingtième siècle se faisait de la musique. Le Canadien Hugh Le Caine était un de ces compositeurs; grâce à une commandite du Conseil national de recherches, il a conçu le premier synthétiseur commandé par tension. En raison de son manque d'expérience dans la mise en marché d'une invention, son instrument n'a cependant jamais été manufacturé ou vendu. Dès les années 1930 et 1940 était apparu un marché pour les instruments électroniques et électriques, et un grand nombre d'instruments ont connu du succès : les pianos électriques, les orgues électriques (y compris l'orgue Hammond B 3), les guitares et les basses électriques ainsi que les effets connexes. D'autres instruments, comme le violon, ont également été électrifiés, mais ils n'ont jamais eu vraiment de suite. Dans les années 1970, Robert Moog a été le premier à commercialiser avec succès un synthétiseur commandé par tension. L'apparition des technologies numériques moins coûteuses a coïncidé avec l'expansion du marché, qu'elle a d'ailleurs contribué à développer; la norme MIDI (« Musical Instrument Digital Interface », interface numérique pour instruments de musique) a été instaurée afin que les instruments, qui commençaient à proliférer, se servent d'un protocole commun. De nouveaux genres musicaux, comme le hip hop et différentes formes de musique électronique, sont apparus avec la malléabilité croissante de la musique et les capacités des instruments existants. Ces genres ont contribué à la déstabilisation continue de l'idée que l'on se fait de l'interprétation, de la production musicale, de l'écoute et de la consommation de musique.

Foreword

More than a hundred years ago sound met electricity, and over the ensuing century our experience of music was transformed. In recent years, scholars have begun to study the complex relations that connect performer, composer and listener with musical sounds and the devices that make them. Much of this work, however, has focused on particular individuals, instruments or genres, and little has been written from a Canadian perspective. Katharine Wright's *New Worlds of Sound* is an important contribution in this regard.

New Worlds of Sound was written in support of collection development at the Canada Science and Technology Museum. Based largely on the secondary literature, it places the evolution of music and electronics within a general thematic framework: "The Transformation of Canada." As such it examines not simply technical invention and evolution, but also the ways in which technical objects and systems have functioned within a social and cultural context.

This context cannot be exclusively national. Canadians experienced the musical revolution as members of an increasingly global culture that paradoxically comprises both local and transnational movements and sub-cultures. *New Worlds of Sound* is global in another sense as well. Wright surveys the breadth and variety of electronic and electrified music. Her history spans the entire twentieth century and crosses all boundaries of style and taste, bringing together high brow and low brow, high culture and pop culture, *musique concrète* and heavy metal.

As we so often discover in survey histories, *New Worlds of Sound* reveals how little has been written about the history of musical technology in Canada (Gayle Young's exemplary work on Hugh Le Caine notwithstanding). New Worlds of Sound highlights the need for more research on everything from the university studios to the musicians and the instrument builders. It is our hope that this publication will inspire historians to take up the challenge by launching new explorations of this fascinating aspect of our cultural history.

Bryan Dewalt
Curator of Communications

Avant-propos

Il y a plus de cent ans, le son a fait la rencontre de l'électricité, et au cours du siècle qui a suivi, notre expérience de la musique s'est transformée. Ces dernières années, les chercheurs ont commencé à étudier les relations complexes entre, d'une part, l'interprète, le compositeur et la personne qui écoute et, d'autre part, les sons musicaux et les appareils qui les produisent. L'essentiel de ce travail a cependant porté sur des personnes, des instruments ou des genres particuliers, et peu de choses ont été écrites selon un point de vue canadien. L'ouvrage de Katharine Wright, *New Worlds of Sound,* constitue une importante contribution dans ce domaine.

New Worlds of Sound a été écrit afin de soutenir le développement de la collection de la Société des musées de sciences et de technologies du Canada. S'appuyant en grande partie sur les ressources documentaires secondaires, ce livre place l'évolution de la musique et de l'électronique dans le cadre thématique général appelé « la transformation du Canada ». À ce titre, il ne se contente pas d'examiner les inventions et l'évolution technique, mais également les façons dont les objets et les systèmes techniques ont fonctionné dans un contexte social et culturel.

Et ce contexte ne peut être exclusivement national. Les Canadiens ont fait l'expérience de la révolution musicale en tant que parties prenantes d'une culture de plus en plus mondiale qui, paradoxalement, comprend des mouvements et des sous-cultures locaux et transnationaux. *New Worlds of Sound* est également mondial dans un autre sens. Katharine Wright étudie l'étendue et la variété de la musique électronique et électrifiée. L'histoire qu'elle raconte couvre la totalité du vingtième siècle et traverse toutes les frontières de style et de goût, réunissant les diverses cultures, la culture pop, la musique concrète et le heavy metal.

Comme nous le découvrons si souvent dans les survols historiques, *New Worlds of Sound* nous apprend que bien peu de choses ont été écrites au sujet de l'histoire de la technologie musicale au Canada (à l'exception du travail exemplaire de Gayle Young sur Hugh Le Caine). New Worlds of Sound insiste sur la nécessité de faire plus de recherche dans ce domaine, qu'il s'agisse des studios dans les universités, des musiciens ou des fabricants d'instruments. Nous espérons que cette publication incitera les historiens à relever le défi et à entreprendre de nouvelles explorations sur cet aspect fascinant de notre histoire culturelle.

Bryan Dewalt
Conservateur, Communications

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Katharine Wright
Ottawa, 2013

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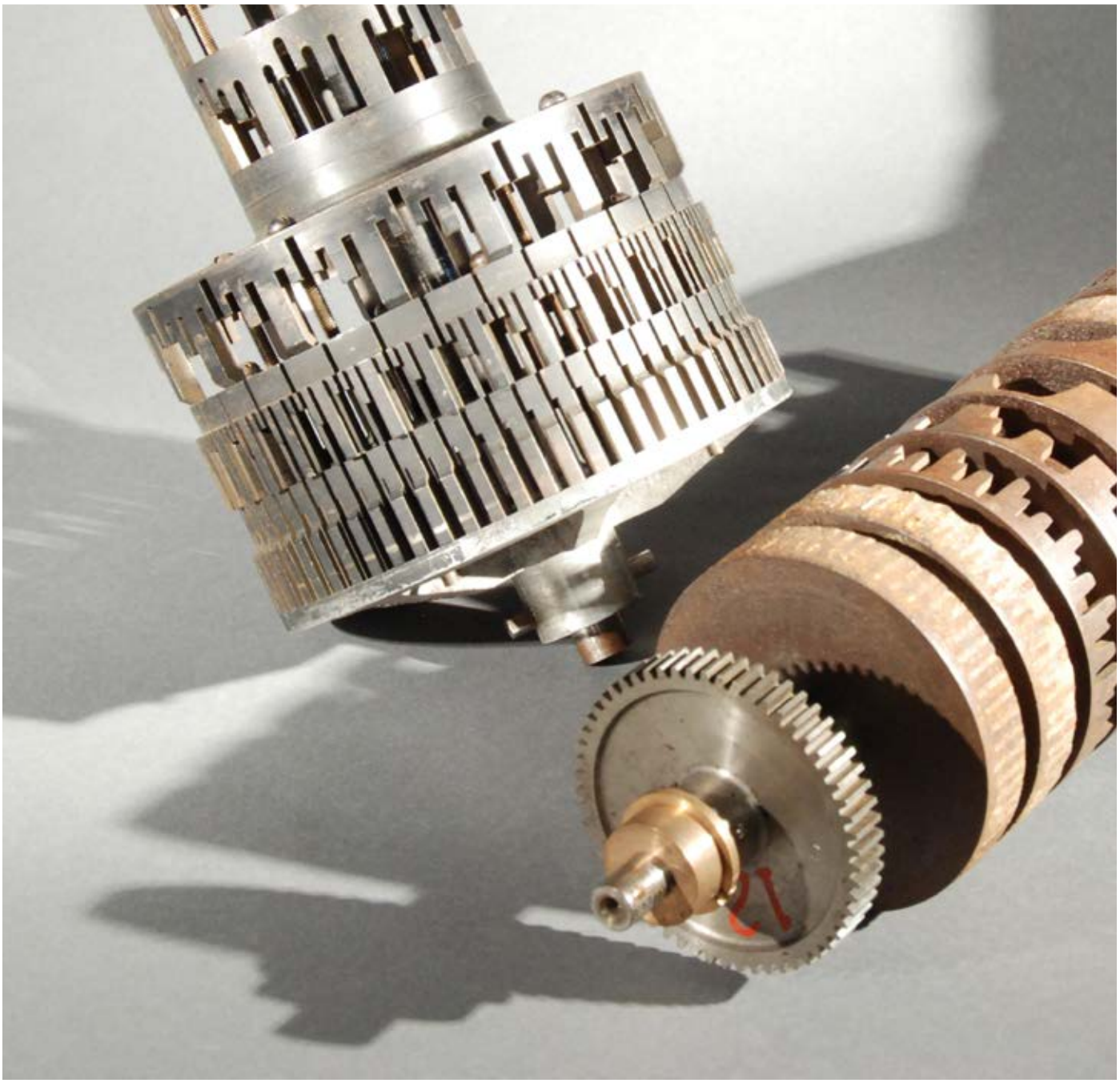
Katharine Wright
Ottawa, 2013

Introduction



Introduction

Question: What is the difference between the old blues and the new?
Answer: Electricity.

—Jimi Hendrix interviewed by Albert Goldman in 1968[1]

The application of electricity to music more than a century ago brought about the development of new instruments, new musical genres and a vastly changed role for the listener. It was a critical part of phenomena as diverse as the rise of rock 'n' roll and the youth culture associated with it, the metamorphosis of music into a commodity and the idea of music as something that can be excised from its original context and manipulated to become something else. The technological developments were both the agents of these cultural changes and their result: changing musical tastes and theoretical interests drove the development of new instruments and, in turn, changed the nature of music and the listener.[2] Canadians, as members of a musical culture that transcended national borders, were active participants in this transformation.

Instruments like the Hammond organ, the electric guitar and the synthesizer, as well as more obscure inventions like the theremin or the Ondes Martenot were developed by inventors seeking new sounds or new characteristics, such as portability or affordability. The development of recording technologies enabled musicians to act on their interest in sound itself by giving them the means to take a piece of music or a sound apart and build it back up into a new kind of sound. Music studios were established in Canada and abroad to allow musicians to experiment this way. A market developed for devices that let musicians transform sound with reverberation or fuzz effects. Other musicians took matters into their own hands, slashing their speaker cones or breaking parts of their equipment in order to achieve a particular sound. New social roles appeared: the music producer, the recording star and the rock star, and the collector of recorded music and instruments. But as soon as the idea arose of music being something produced and then consumed, the distinction between these social categories proved difficult to sustain, as Jacques Attali has argued. Using commercial records to create new music (hip hop's sampling is perhaps the most obvious example) and choosing background music to shape the private environment to suit one's desires may also be considered creative acts.[3] Understanding these issues brings together not only the history of technology and the history of music, but a broad comprehension of cultural history that encompasses ideas about the changing understanding of silence and noise. Trevor Pinch and Karen Bijsterveld have called this emerging area "sound studies" and include under that rubric anything that touches on "some aspect of what we might call 'auditory culture.'" Like their work, this document focuses on "the materiality of sound, its embeddedness not only in history, society, and culture, but also in science and technology and its machines and ways of knowing and interacting."[4]

However, this document is not an introduction to sound studies. Rather, it is an overview of the history of electric and electronic music and instruments based on the secondary literature, and it fulfills two purposes. First, it provides a framework for collection development at the Canada Science and Technology Museum by identifying events, inventions, people and themes relevant to the material culture of music creation and consumption in Canada. Second, it makes this information accessible to a general readership. As a synthesis of existing research, this work mirrors the strengths and weaknesses of the secondary literature. Many omissions are a testament to just how recently electric and electronic instruments, associated musical genres and recording in general have become the subject of scholarly interest. Readers will not find a comprehensive treatment of synthesis and contemporary developments in microsound, a complete account of much of the audio equipment, or a history of commercial recording and its effects on instrument development. Many names and developments within particular musical genres—the avant-garde electric guitar tradition of Rhys Chatham and Glenn Branca, for example— are beyond the scope of an overview of electric and electronic music and instruments. But in most cases, omissions exist because the secondary material simply hasn't been created yet. In addition, some instruments that historians have covered—such as the theremin or the Telharmonium—can end up enjoying a level of attention that they probably do not deserve in comparison to inventions that have had a far greater degree of diffusion and use (automatic double tracking, for example). Overall, this is still a new field.

This is a particularly energetic time for people to turn their attention to electric and electronic music and instruments, as books like Steve Waksman's *Instruments of Desire: The Electric Guitar and the Shaping of Musical Experience* show. Waksman deals not only with the development of the technology but with the ways in which musicians and listeners made use of the technology. In *Analog Days: The Invention and Impact of the Moog Synthesizer,* Pinch and Frank Trocco

argue, "Although instrument designers may have dreams and aspirations for the sorts of music to which their instruments can be adapted, the way to find the meaning of an instrument is in its use by real musicians—in state-of-the-art recording studios and home basements, on the stage and on the road."[5] This can be a difficult standard to meet when working only from the secondary sources; however, examining the instruments in this way in addition to understanding the aims of their inventors remains an animating ideal of this document.

That instruments must be understood within the larger context of sound itself is demonstrated in the first chapter of this work: in developing the principles to understand sound mathematically and in terms of its constituent components, Hermann von Helmholtz developed what might be called the first synthesizer. The instrument, which uses an electrically driven tuning fork, is still known as a Helmholtz synthesizer. The inventors working in telephony and telegraphy also developed a number of instruments, but like Helmholtz, that was not their primary aim. These instruments were meant to guide their inventors along the path to successful transmission of human speech. The first new instrument developed for musical purposes was the mighty Telharmonium—some 200 tons of motors, generators and tone wheels that its inventor hoped would be used to transmit music by wire to subscribers. However, the twin developments of radio and the triode made the Telharmonium obsolete as soon as it had begun. Efforts to apply electricity to existing instruments to make them more predictable or easier to play were more successful, as in the electro-pneumatically assisted organs of the Quebec-based Casavant Frères in the late nineteenth century or the Miessner electronic pianos in the 1930s.

The philosophy of music was also changing rapidly during the late nineteenth and early twentieth centuries and was subject to the same ideas that were challenging notions of continuity and form in visual art and literature. In music, composers wanted to find a way to move beyond the architecture prescribed by 12-tone music. They became interested in microtonality (the infinite gradation of the octave) and used recordings and audio equipment in ways that forever changed the idea of composition. This contributed towards an overall experimental atmosphere that saw the favourable reception of instruments based on the heterodyne principle: the Ondes Martenot and the trautonium, as well as the better-known theremin. All of these produced a new kind of sound; eerie and otherworldly, it was well-suited to film soundtracks. While this may not have been what their inventors had in mind, it gave the sounds of these instruments an association with strong emotional sensation that found a natural home in some of the music of the 1960s counterculture.

Meanwhile, thanks to the split between highbrow, lowbrow and middlebrow or mass cultures still largely in place in the 1940s and 1950s, composers of tape music carried on in relative isolation in their state- or university-based studios.[6] Pierre Schaeffer in France and Karlheinz Stockhausen in Germany, as well as István Anhalt in Canada, experimented with tape and recording equipment to create a very new kind of musical experience that was highly dependent on technology for composition and performance. Indeed, the very idea of performance had become unstable, and composers like John Cage exploited the recording's ambiguous relationship with performance. The studio itself could be seen as a kind of instrument: the most famous Canadian example of this came not from the studio music composers, but from pianist Glenn Gould, who believed that the recording studio held greater creative potential than the concert hall. At the same time, recording had resulted in an expanding popular taste for styles of music that demanded electric instruments, but there was little cross-fertilization between popular forms of music and the tape music coming from the studios, outside of isolated incidents.

While this is not a history of recording, it is important to recognize that recorded music profoundly shaped the development and reception of electronic and electric music and instruments. It gave listeners a taste for musical genres and levels of musicianship to which they might not otherwise have been exposed. Various electric pianos and organs were developed for this increasingly vigorous consumer market in the 1940s and 1950s, notably the famous Hammond B-3. Harry Chamberlin used recorded sounds to create an early sampler, the Mellotron, that saw a reasonable degree of acceptance. Other inventions were not so commercially successful for a variety of cultural reasons: for example, Hugh Le Caine's Electronic Sackbut (the first voltage-controlled synthesizer, well in advance of the Moog) and the eccentric Raymond Scott's Electronium.

Far more influential was the electric guitar, which was first developed in the 1930s and then refined and mass-produced in the 1950s and 1960s. The secondary literature overwhelmingly treats the electric guitar separately from the history of electronic music. But there is no doubt that the electric guitar was a completely different instrument from its acoustic counterpart, and the experiments that guitarists and guitar-based bands made to transform the guitar's signal electronically (by deliberate feedback or distortion) show that no understanding of electric and electronic instruments is complete without an examination of the electric guitar. Waksman's *Instruments of Desire* has gone somewhat towards correcting this omission. The guitar is a particularly fascinating case study because the confluence of musical taste and its inherent qualities propelled it to an unexpected cultural dominance. At the beginning of 1920s, the smart money probably would have been on the violin. Yet the electric violin never saw much success because simple amplification with a

microphone made it satisfyingly loud and it did not become the defining instrument of a new musical genre as the guitar ultimately did. But by the end of the 1970s, the guitar had new competition in the form of the electronic synthesizer.

The success of the electronic synthesizer must also be understood in the context of the consumer market, because the one-off or more complicated synths (such as the Buchla Box and Hugh Le Caine's various instruments) never went into widespread production for a variety of reasons. Thanks to a deliberately commercial mindset, it was the Moog and then the Japanese synths that dominated the market. As Peter Manning points out in his indispensable *Electronic and Computer Music,* by the late 1970s and 1980s this market was split into three main groups: the high end, led by large and expensive digital instruments like the Synclavier and the Yamaha CS80; the low end, dominated by cheap digital portables from Japan; and the broad middle, which belonged first to the portable analog Minimoog and later to better-quality digital instruments from companies like Yamaha and Roland. As digital instruments came to dominate the market, the MIDI standard was developed to ensure that these instruments could communicate with one another. MIDI also paved the way to apply digital electronic techniques in new interesting ways to a more diverse group of instruments and made wind instruments a more interesting site for experimentation.

Throughout this period, the guitar remained the prevailing force in popular music, and the strength of popular music and the youth culture associated with it ensured that the guitar was the dominant instrument overall. Perhaps partly in response to the development of digital techniques and instruments that seemed more cerebral, both the audience and the promoters of guitar-based rock aggressively promoted the masculinity of talented and innovative players. Within a short time, however, this posturing contributed to the backlash against the guitar and its cultural associations through the rise of the anti-virtuosity of punk, the recognition that composition could happen on the turntable via hip hop, and the increasing visibility of women electric guitarists. With the advent of the digital chip, composers and musicians could sample what they wanted from a library of sounds, putting considerable stress on the idea of virtuosity. But it allowed musicians to compose with musical quotes and tropes far more easily than magnetic tape had. Dance music DJs took advantage of samplers and drum machines to do what they and others before them had already done with vinyl records and tape, but on a far grander scale than had been seen before. As a result, a number of legal and philosophical issues came to the fore, and they continue to simmer to some extent today. As Mark Katz writes in *Capturing Sound: How Technology Has Changed Music*, "Sampling is a rich and complex practice, one that challenges our notions of originality, of borrowing, of craft, and even of composition itself."[7]

By the mid-1990s, electronic dance music had risen to prominence in part on its promise of music that could suit or enhance the listener's every mood. The listener could now control what Canadian composer Murray Schafer called the "soundscape"—the sounds in which we are all immersed.[8] Schafer meant to broaden our notion of sound far beyond music, but due to the availability of personal listening devices (represented first by the Sony Walkman and eventually by Apple's iPod), the listener could now choose from an ever-increasing library of electronic and electronically mediated music to change or reflect a personal mood. As Pinch and Bijsterveld put it,

> Whereas Murray Schafer, true to the critical and gloomy atmosphere of the 1970s, underlined the alienating effect of the separation of original sounds from their reproduction, recent contributions to sound studies offer a more optimistic view in which there is the possibility of control over one's sonic accompaniment to daily life.[9]

In the 1930s, Theodor Adorno suggested that the availability of recorded music was going to lead to its desacralization. Thom Holmes, in his important book *Electronic and Experimental Music*, concludes that it does indeed seem to be the case that composers of contemporary music sample without regard to context, leading to a "proliferation and sameness of common ideas simply because it is easier to do." But at the same time, "arising from this common mass are the works of a new generation of composers who reject the norm and create highly original works because they understand the intimate relationship between the human spirit and music of the imagination."[10]

In the end, that is what all this energetic experimentation with electricity and music has been about: the relationship between the human spirit and the music of the imagination.

Notes

1 Albert Goldman, *Sound Bites* (New York: Random House, 1992) 87.

2 The relationship between technology and cultural change and the extent to which each may be considered the agent of the other is explored in Merritt Roe Smith and Leo Marx, ed. *Does Technology Drive History: The Dilemma of Technological Determinism* (MIT Press, 1994).

3 Jacques Attali, *Noise: An Essay on the Political Economy of Music*, Brian Massumi, trans. (Manchester Univ. Press, 1985).

4 Pinch and Bijsterveld, "Sound Studies: New Technologies and Music," *Social Studies of Science* 34, no. 5 (October 2004) 635, 636. See also Michael Bull and Les Black, eds. *The Auditory Culture Reader* (Oxford: Berg, 2003).

5 Pinch and Trocco, *Analog Days: The Invention and Impact of the Moog Synthesizer* (Harvard Univ. Press, 2002) 10.

6 See Lawrence W. Levine, *Highbrow/Lowbrow* (Harvard Univ. Press, 1990); Joan Shelley Rubin, *The Making of Middlebrow Culture* (Univ. of North Carolina Press, 1992).

7 Mark Katz, *Capturing Sound: How Technology Has Changed Music* (Berkeley:

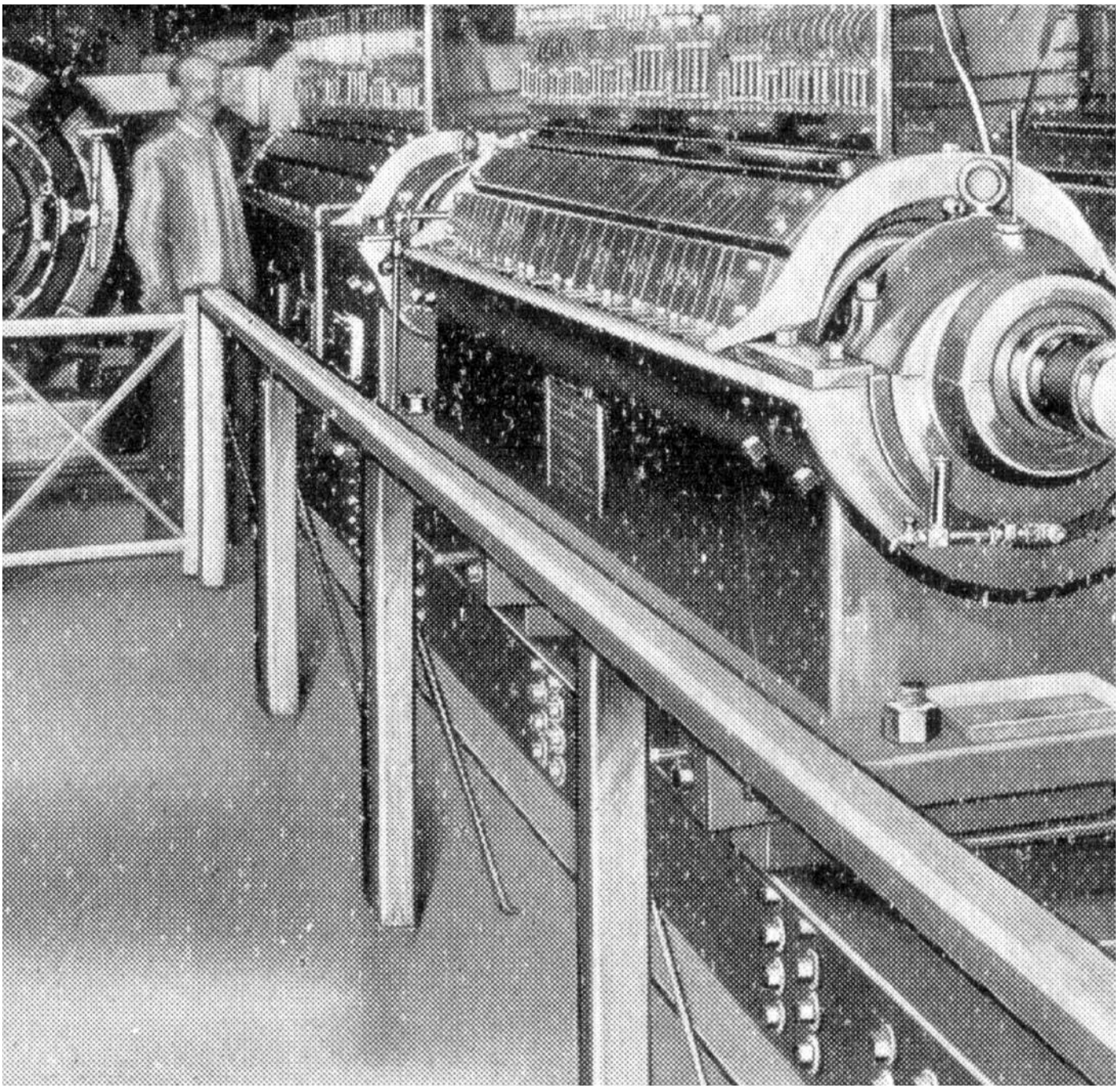
Univ. of California Press, 2004) 157.

8 See R. Murray Schafer, *The Tuning of the World* (New York: Knopf, 1977).

9 Pinch and Bijsterveld, 642.

10 Thom Holmes, *Electronic and Experimental Music* 2nd edn. (London: Routledge, 2002) 274.

1. Off To A Grand Start: Electricity Applied To Music



1. Off to a Grand Start: Electricity Applied to Music

1.1 The Science of Acoustics

Early electronic instruments did not typically depend on scientific theory to develop; like most of the inventions of the late nineteenth and early twentieth centuries, they depended on the dedication of talented inventors, who usually took more direct paths to development.[1] However, theory was not irrelevant—especially by the middle of the twentieth century—and it was inspired by similar interests.

In 1863, the German physicist and physiologist Hermann von Helmholtz published a formal physical and mathematical analysis of acoustics, *On the Sensations of Tone*.[2] The work demonstrated that the periodic vibrations characteristic of musical sound could be described as sine waves. When two tones are slightly out of tune, for example, the listener hears a periodic change in loudness called a beat. When these two tones are plotted as sine waves, we see that each beat corresponds to the net change in amplitude of the combined waves as they periodically approach cancelling each other out. Similarly, the distinctive timbre or tone colour of each instrument is a combination of the fundamental tone that the musician is playing and the harmonics that arise from the instrument's characteristic material and construction. These other harmonics or partials make up the total waveform and the instrument's particular sound. "The waveforms of traditional acoustic instruments are the result of many sine waves which occur in a ratio to the *fundamental* wave," as composer Herbert Deutsch puts it.[3]

The critical implication for the electronic synthesis of music is that the equation can be run backwards: putting together the synthesized harmonics will produce a musical sound. This process of adding sine waves to a basic waveform in order to build up a particular timbre and musical sound is called "additive synthesis," and it was the principle behind the first generation of electronic instruments. During the course of his research, Helmholtz constructed a primitive synthesizer. It consisted of a series of electrically driven tuning forks; each tuning fork matched with a metal resonating chamber that could pick up and amplify its particular frequency. By using a keyboard, one could alter the relative intensity of the various sound outputs to create different timbres. A Helmholtz synthesizer built by Parisian instrument maker Rudolph Koenig was one of the first devices acquired by the University of Toronto for Canada's first physics teaching laboratory, which opened in 1878. Used for years to instruct students in Helmholtz's theory of timbre, it survives to this day.[4] Helmholtz suggested that further development would rely on the basic principles of the organ, since organs already allowed musicians to control mixtures of sound through their keyboards and foot pedals. Although Helmholtz was correct, the electronic synthesis of sound would not really take off until after the invention of the triode in 1907. However, there was a great deal of interest in electricity's potential for music, including the application of electrical devices to improve or enhance aspects of acoustic instruments.

1.2 Carillons, Organs and Orchestrions

The earliest known application of electricity to a musical instrument predates Helmholtz's theory of acoustics by more than a century. In 1759, Jean-Baptiste de La Borde, a Rouen-based Jesuit scientist, invented the *clavecin électrique*. The instrument was "a clapper, hung between two electrically charged, unison-pitched bells," that "repeatedly struck both bells so long as their key, which

Figure 1: Helmholtz synthesizer (ca. 1876). Keyboard is visible at upper right. (David Pantalony / University of Toronto)

cut off current to one bell, was depressed." [5] Although its inventor called it a harpsichord (*clavecin*), the bells indicate it was really a carillon operated by a keyboard. Musicologist Laurence Libin points out that the two-octave instrument was not designed for any musical goal, but as a vehicle for scientific experiments in acoustics and electricity. With the advances in understanding and manipulating electricity in the nineteenth century, however, instrument builders began to take advantage of its power. The *cristallophone électrique*, a large carillon constructed in Dieppe, France in 1877, used electric action to operate large crystal bells via a keyboard.[6] Hugh Davies reports that major instrument manufacturers like Deagan, Schulmerich, Meneely Bell Co., Earle J. Beach and Son, and Stromberg-Carlson were all manufacturing electromagnetic carillons by the late 1940s. These were cheaper than their acoustic counterparts, both to install and maintain. Players of acoustic carillons fiercely defend their instruments' qualities, but the electromagnetic carillon is a part of the world's soundscape. The clocktower in the Kremlin has had an electromagnetic carillon since 1945—it was the sound of "The Internationale" broadcast by Radio Moscow for many decades. The ubiquitous chimes that precede public announcements in airports are the sound of electrically amplified struck rods, "which are sometimes bent at a particular node to produce a particular timbre." Newer installations tend to use recorded synthesized sounds.[7]

Pipe organ builders also turned to the potential of electricity to assist in controlling their instruments. Casavant Frères, a pipe organ company based in Saint-Hyacinthe, Québec, produced an organ with electrically operated pedals in 1891 for Notre-Dame Basilica in Montreal. In 1892, they completed the organ at Notre-Dame Cathedral Basilica in Ottawa, which was the first pipe organ in North America with electrically controlled valves. It was a notable achievement. While others had made significant experiments with electrical action (Hilborne L. Roosevelt had patented an electro-pneumatic key action in the United States in 1869, and Albert Peschard and Charles Spackman Barker held a patent on electric action in France), the Casavant brothers were the first to overcome the serious technical problems, such as shorting and rapid power depletion, that the high voltages and currents presented in a performance instrument. Casavant went on to build an organ for St. Patrick's Basilica in Montreal that replaced all the traditional mechanics with electrical parts. These organs ensured that the Casavant name would command a great deal of respect in the North American market; Casavant continues to have a leading position in the North American market today. The area around Saint-Hyacinthe became a hub for organ building, with Guilbaut-Thérien in La Providence in 1946, and Orgues Létourneau Ltée in Sainte-Rosalie in 1979.[8]

Noted organ builder Robert Hope-Jones also developed organs with electro-pneumatic action in the late nineteenth century and exploited the serious design advantage it presented: since the organ pipes could be located apart from the case housing the keyboards (since they were connected electrically), the player no longer had to toil in anonymity. The console could be placed somewhere visible in the church or theatre, while the pipes were located elsewhere. In his native England in 1886, Hope-Jones demonstrated an organ with electro-pneumatic action in which the console was out in the churchyard.[9] Other builders also took advantage of the new relay and switch systems to operate the pipe's pallet directly and bypass the pneumatic part of organ action altogether.[10] The next step was to make the pipe organ action electric, which the Wicks Organ Company did with its Direct-Electric System:

> [E]ach stop and coupler was controlled by a multiple-contact switch … These switches initiated couplers (in the console) and stops (in the relay cabinets or the console). Turning a stop or coupler "on" activated a magnet that moved an armature containing a phosphor bronze (silver after 1967) contact pin; these made a wiping contact with bronze leaves arranged in a row while closing a circuit for each note.[11]

Figure 2: Organ of Notre-Dame Cathedral Basilica in Ottawa, the first in North America with electrically controlled valves (1892). (Casavant Frères)

While the Wicks company promoted this as an improvement over electro-pneumatic action, players complained about the dangers of the large electrical currents, the noisiness of the consoles and a keyboard that felt "spongy." But fully electric action evolved and improved steadily throughout the twentieth century, incorporating solid-state relays in 1964 and transistors in 1979. While the market for pipe organs is small in comparison to the market for more portable and less expensive instruments, organ makers and users were able to exploit the developments of the consumer electronics industry. The Concert Hall grand organ at the Sydney Opera House in Australia is a mechanical action organ that can also be played via a computer-controlled electronic system. This "performance recording and playback facility" means that a player can evaluate a "live" version of his or her own performance from anywhere in the Concert Hall.[12]

Electric action was applied to the entire family of organ instruments. Mechanical instruments such as the orchestrion, an organ that used pinned barrels or perforated paper rolls to play orchestral or classical music, were obvious candidates for electrification since they were already automatic. In 1876, Schmoele Brothers of Philadelphia demonstrated an electric action orchestrion they called the Electromagnetic Orchestra. Barrel and fairground organs (sometimes also called orchestrions, although less sophisticated in their voicing capacity) as well as player pianos also took advantage of electrification. Some of the instruments added to pipe organs during this period also used electric action: in England, electro-pneumatically struck gongs were added to the organ at Westminster Abbey in 1895 and were also installed with the echo organs at Norwich Cathedral.[13] Electronic elements were also added to mechanical street organs in the 1950s.[14]

"[P]erhaps the most radical application of electricity to organ building," Barbara Owens and Peter Williams write, "was enabling any key to be connected to any pipe."[15] A system in which a single rank could be played at other ranks (transmission) and in which the keyboards and pedalboards could access more than one rank (duplexing) promised an organ that did not need a full set of pipes, which would be both smaller and cheaper. Robert Hope-Jones used these principles in his electro-pneumatic "unification" system in the 1890s. After coming to the United States in the early 1900s (reportedly to avoid a morals charge), Hope-Jones worked with the Wurlitzer company on the construction of the Wurlitzer Hope-Jones Unit Orchestra, a theatre organ.[16] These instruments were not capable of the subtlety of a church organ, but popular entertainment did not typically require fine nuance. Certainly, they offered greater tonal variety than the piano, which is what they typically replaced: in his history of Wurlitzer theatre organs, John Landon writes, "From the thundering power of cathedral effects to the soft whispers of the Vox Humana and Celeste, the gamut of human feelings could be expressed." Other builders included Christie and John H. Compton in England, Barton, W.W. Kimball, Moller, and Robert Morton in the U.S., and Standaart in northern Europe. But Wurlitzer was the most prominent, and the company name soon became the generic term for theatre organs. Some of these were really hybrid instruments: pipe organs with fully electronic solo voices (cello, woodwind, bells) or amplification. Not all cinemas were replacing just a piano. In some cases, theatre owners were hoping to replace a unionized orchestra with a single player. Since a theatre organ was cheaper than unionized musicians and did not present the same threat of labour unrest, theatre owners found these instruments very attractive. It turned out to be a far-from-permanent solution, since theatre organs in turn were replaced by recorded sound.

1.3 Experimenting with Music: Telephony and Telegraphy

Although fully electronic instruments remained a fairly limited area of interest until the advent of the triode in 1907, many of the inventors and engineers involved in telephony and telegraphy invented instruments. Typically, these were meant to illuminate the engineering of voice communications—music was merely a means to an end. In 1851, Edward Farrar sent electrical signals over the New Hampshire telegraph wires that were translated into musical tones by the receiver. While Farrar clearly thought of this as an instrument—he dubbed it the "reed melodeon"—his intent was to demonstrate the possibility of successfully transmitting speech by wire. Relaying the voice was considerably more complicated than transmitting standard telegraph signals, and the broader range of frequency and sound in music made it an obvious proxy for the relatively weak and high-frequency signal of the human voice. "Systems for [music's] transmission had to be able to reproduce the lowest of these sounds well above the noise on the system and also handle the highest without 'overloading' the equipment," notes a history of communication engineering.[17] Farrar ultimately abandoned the project on the advice of a Yale chemistry professor, who thought it unlikely to succeed. The prediction was probably accurate: a decade later, German Philip Reis invented a similar instrument but was unable to use it for effective speech transmission.[18] But music remained the lab rat of the telegraphy and telephony worlds. In the 1870s, Elisha Gray (famous for his patent dispute with Alexander Graham Bell over the invention of a successful speech-transmitting device, the telephone) invented a keyboard-operated device to send music over a telegraph circuit. Gray hoped the instrument would be a developmental stage in the eventual successful transmission of simultaneous messages at different frequencies (or multiplexing). Bell used music, too: beginning in 1877, he used concert transmissions to promote the telephone to auditoriums full of attentive listeners.

Not every instrument of the period was based on telephony or telegraphy. British engineer William Duddell took advantage of the humming of carbon arc street lamps. In 1899, while trying to reduce the annoying hum these lamps generated, Duddell discovered that he could control the sound by varying the voltage difference between two lamps. He called it the "Singing Arc" and equipped his instrument with a keyboard. He never took out a patent on it, and it had little effect on future instruments. But, like so many devices of that fertile period in electrical engineering, it fascinated the public, and Duddell exhibited it on national tours.[19] Still, it was the idea of transmitting concert music over the wires that held the most appeal for inventors and thinkers. This was part of a greater movement—providing professional-level musicianship to the masses at a price they could afford was a popular idea, as the attempt to capture the performances of pianists via the perforated rolls of the player piano shows.[20] Edward Bellamy's 1888 novel, *Looking Backward: 2000–1887*, suggested that professional musicianship would supersede the amateur American parlour in the near future. However, the technology would take several decades to catch up to these excited predictions. *A History of Engineering in the Bell System* notes,

> There was no dearth of imaginative prophets who foretold the time when large audiences would be entertained by opera and orchestral programs transmitted by wire. The fact was, however, that these early demonstrations were in the nature of stunts and the prophecies were premature since the technology to support commercial broadcasts of any kind was not available until high-power amplifiers became practical after World War I.[21]

Not that people didn't try: one memorable effort was the massive and quixotic instrument invented by Thaddeus Cahill. The music from his instrument was carried by wire to speakers elsewhere—a specially constructed concert hall, as well as to any businesses that took out subscriptions to its service. Unlike Gray's experiments or the reed melodeon, Cahill's goal was purely musical—something that would allow absolute control of tones by mechanical means. Its suitably ponderous name would be the Telharmonium.

1.4 The Telharmonium

The Telharmonium is a thing of legend—an enormous creation whose commercial ambitions failed on an equally grand scale. Its history is further spiced by the fact that none of the three that were built survived, which has led to some imaginative expansions in telling its history. One article reports that a businessman was so enraged by the Telharmonium's interference with telephone circuits that he tore it apart with his bare hands and threw the pieces in the Hudson River. The Telharmonium's size—some 200 tons—indicates that this is a most unlikely story. The more prosaic truth is that the three versions were built sequentially, and each was dismantled so that its parts could be reused in the next version. The third and final version of the instrument was probably sold for salvage around 1918, as new technologies rendered it obsolete. Any parts that remained from the first two versions were likely scrapped when Cahill's house was sold by his younger brother in 1958.[22] Such was the ignoble end to the instrument that had been conceived as a replacement for amateur and professional musicians, filling churches, restaurants, waiting rooms, hospitals and private residences with electrically generated music.

The business plan was weak from the start. The Telharmonium was too expensive (nearly a million dollars to build and promote) to build more than one at a time. The economies of scale that might have come from mass production had not yet given rise to the kind of well-off citizen-consumers who could have taken out subscriptions to Cahill's project in large numbers. It was too big for mass production and too heavy for easy transportation. Worst of all, it was dependent on the goodwill of the telephone companies: the Telharmonium did not have independent poles, and using the telephone company's poles for its wires meant securing permission and maintaining their trust. The primitive shielding techniques of the time resulted in constant interference (thus the apocryphal irate businessman). The lavish concert hall built to excite interest and generate subscriptions proved to be a heavy financial burden, and a subscription base never materialized. It was soon made obsolete by the development of the triode, although it seems unlikely that the Telharmonium would have succeeded even if this had not been the case.

By nearly every measure, the Telharmonium was a failure. Why, then, does nearly every work on electronic instruments begin with at least a ritual nod in its direction? Although Cahill's work laid the groundwork for the rotating-tone-wheel instruments that followed (including many of the Hammond organs), the Telharmonium's endurance in popular literature is testament to our fascination with failed technologies. Like dinosaur skeletons, these failures are a powerful symbol of change, the casualties of progress and the final fate of all things. The Telharmonium embodies the twentieth-century theme of the bulky and expensive superseded by the sleek and cheap. It is a perfect fable for widely held ideas about the nature of technological change, and it has become a symbol rather than the time-bound subject of historical dissection. Canadian scholar Paul Théberge finds it difficult to restrain his irritation with the romantic and sometimes hagiographic accounts that result. He complains that the Telharmonium is an example of an invention that is "less the fruit of individual genius than the outcome of a particular interplay of social forces and local initiatives, resulting in an almost predictable

(if not always inevitable) sequence of events."[23] Even after the appearance of Reynold Weidenaar's rigorous *Magic Music from the Telharmonium* in 1995, the Telharmonium remains more often mentioned than examined.

Cahill's first attempt to patent the electrical generation and distribution of music in 1895 was not successful—the Patent Office deemed it too broad, leading to a lengthy written dispute—but two years later a more focused patent was granted. Weidenaar describes the patented apparatus as a

> mainframe that supported twelve physically identical pitch-shafts, one for each frequency of the equal-tempered scale…. Mounted on each of the pitch-shafts were "rheotomes," rotating cylinders with alternate sets of longitudinal conducting and insulating sections [i.e., periodic circuit interrupters].[24]

Or, as composer Herbert Deutsch describes it,

> The sound generating process was based on a principle of tone wheels. A number of steel shafts were set in rotation by a huge 185 horsepower motor. A combination of gears, belts, and rheostats (variable voltage controllers) determined the rotation speed of each shaft according to which key on the three-manual, five-octave keyboard was depressed.
>
> Bolted on each shaft was a series of toothed iron rotors, each of which spun within the electromagnetic field of an armature. As they rotated, the armature coil generated an alternating current, approximating a sine wave. The frequency of the wave was determined by the rotation speed of the shaft, as well as the number of teeth on the rotors, and generated overtones of up to the 16th harmonic for some notes. In order to further control timbre, the performers—using the rheostats—could attenuate the amplitude of each harmonic.[25]

The instrument was also touch-sensitive: by pressing the keys harder, the operator could produce stronger currents and therefore a louder tone. Many of the smaller electronic organs that followed the Telharmonium used less intuitive methods to govern volume, so the Telharmonium could claim technological superiority in that area, at least.[26]

It took Cahill until 1901 to build a working instrument. It was 200 tons of generators, wires, telephone receivers and amplifying horns, all controlled through a keyboard. To launch the Telharmonium as a business, however, Cahill had to find investors who found the idea of long-distance music as alluring as he did. One of the backers insisted the Telharmonium be built in Holyoke, Massachusetts, and Cahill had little choice but to comply. In 1906, he demonstrated the Holyoke Telharmonium. The audience included a hyperbolic

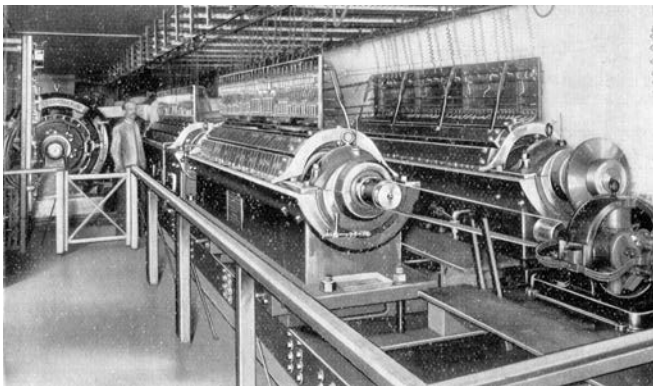


Figure 3: Tones for the Telharmonium were generated by 145 alternators running on eight 11-inch shafts. (Collection of Reynold Weidenaar)

writer for the magazine *Electrical World*, who believed that these new instruments would "afford a finer, more delicate control than possible on any known instrument." But it was the size of the thing that particularly captured the journalistic imagination (and continues to do so today): "There were eight 11-inch steel shafts bearing 145 alternators. The 60-foot mainframe was built of 18-inch steel girders set on brick foundations. Ten switchboard panels contained nearly 2,000 switches. The weight was 200 tons; the cost $200,000."[27]

The journalist from *McClure's Magazine* was only slightly more restrained. He was taken with the fact that the instrument itself made no musical noise—the listener had to be within range of the speakers for that. "Switchboard clicks could be heard, even the pop of a flashing spark, but no notes emanated from the noisome machinery."[28] The three musicians who controlled the instrument's keyboards were not doing anything that looked like traditional musicianship. The notes not only looked like they were coming from nowhere, they sounded like they were coming from nowhere—the traditional mechanics of breath in tubes and hammers, bows or fingers on strings all produced distinctive sounds that were missing from this music. Additive synthesis was not yet the equal of the complex timbres of traditional instruments. But the sound was so different and the size so impressive that ordinary listeners were unlikely to judge it inferior, and many commented on its "purity." As Weidenaar puts it, "The very novelty of these sounds encouraged the judgment by some that the disappearance of such sound components imbued greater musical eloquence."[29]

While not everyone was convinced that the Telharmonium had an unbeatable musical advantage, there was no arguing with its potential to broadcast professionally performed music. The Telharmonium was ready to make its debut in New York, where Cahill (and the majority of his backers) believed it belonged. Transportation from Holyoke took most of the summer of 1906. With the cooperation of

the New York Telephone Company, Telharmonium wires were hung from the telephone poles in preparation for the opening of Telharmonium Hall at the corner of Broadway and 39th Street, in the heart of the theatre district. A large and eager audience assembled on September 26 to hear the Telharmonium played by four performers—one for the three keyboards and pedalboard that controlled pitch, one for the control switches for dynamics and timbre and two for the four swell pedals. It was hard work, physically and musically. Weidenaar remarks, "A performer's nightmare come true, the Telharmonium must have been one of the most hair-raisingly complicated instruments to play in all the history of music."[30]

There was some confusion among audience members and the public about the source of the music—some believed it was an elaborate version of the gramophone and played recorded music. But the fact that the Telharmonium was played by musicians did little to soothe musicians' unions, who (rightly) thought that the Telharmonium aimed to do them out of a job. Cahill and his backers hoped that restaurants would take out subscriptions, since Telharmonium service was available at cheaper rates than the orchestras that were an expected part of the turn-of-the-century dining experience. Restaurant musicians demanded remuneration commensurate with their skill: "The players were generally highly qualified graduates of the best conservatories, and felt very much on par with their colleagues at the Met." But despite Cahill's attempts to remind everyone of the costliness of orchestras, restaurant owners could do little about it when there were no wires to reach their places of business. Cahill needed a subscription base in order to proceed with the expense of increasing the range of the Telharmonium's wires, but most restaurants and hotels were understandably reluctant to take out an expensive subscription to something so speculative.[31] No one could find a solution to the impasse.

Meanwhile, expenses mounted: Telharmonium Hall was an extravagance, and there was not enough income to meet the franchise payments for the borrowed telephone poles. The large Telharmonium currents interfered with telephone currents, and the New York Telephone Company, anxious to stave off government regulation, balked at new wiring and the complaints that it would surely bring. The Telharmonium stalled at a mere two miles of wire. The engineer Lee De Forest suggested that its future lay in wireless broadcast and demonstrated this with receivers on top of a nearby hotel.[32] But the Telharmonium investors were stubbornly attached to the original vision. With revenue badly lagging behind capital costs, the New York Electric Music Company went bankrupt in 1907. The Telharmonium was shipped back to Holyoke, where the tireless (or perhaps desperate) Cahill produced a third version with an improved alternator design that allowed for greater expressiveness, but it never generated much interest.[33] By then, the Wurlitzer Company had moved in with its theatre organs, and it would not be long before radio broadcasts would make the Telharmonium yesterday's news.[34] Paul Théberge concludes that "the Telharmonium did not succeed … for two reasons: first, because of basic problems of cost and design, and second, because of Cahill's own limited perception of the role such an instrument could play in musical culture."[35] It would, in fact, be decades before manufacturers and inventors would successfully marry electronic instruments to a more evolved consumer culture.

The Telharmonium attracted the interest of visionary composer Ferruccio Busoni, who had read the *McClure's Magazine* article while writing his 1907 *Sketch of a New Aesthetic of Music*. Although he had never heard the instrument, he believed the description implied that the Telharmonium would allow composers to exploit the infinite gradation of the octave, rather than the tones and semitones that were the legacy of the Western musical canon. The avant-garde composer Edgard Varèse remembered this promise of microtonality and sought out the Telharmonium while in the U.S. in 1915. He was disappointed, since the Telharmonium could do no such thing and offered little to anyone interested in musical innovation.[36] By the end, the Telharmonium seemed to disappoint everyone. Weidenaar suggests that had Cahill focused on building and selling smaller versions, they might have been the first electronic organs, along the lines of the Choralcelo, an electric-acoustic hybrid that was still large but could fit into the basements of most public buildings or large homes.[37] Electronic music composer David Dunn thinks the Telharmonium's problems went deeper, since it offered nothing musically innovative. He suggests that as an electronic version of the pipe organ—complete with keyboards and pedals and a lack of portability—the Telharmonium was the product of nineteenth-century ideology. It was construction on a grand scale, but not innovation.[38] Cahill and his backers never seriously considered altering their approach. In the end, Weidenaar says, the Telharmonium was "typically American … big, slightly crazy, and unable to work exactly as planned."[39]

Its fate was sealed, in any case, by the development of the triode. By adding a third plate between the conventional diode's cathode and anode, engineer Lee de Forest found that a small input to its circuit produced a large power output from the device. In other words, it could amplify a weak incoming signal. De Forest was issued a patent for the triode (he called it an "audion") in 1908, but it was several years before its usefulness was recognized. At Bell, H.D. Arnold improved the triode by putting it in a vacuum, which allowed a higher plate voltage and therefore a higher output power. A few years later, Edwin Howard Armstrong fed the outgoing current back into the grid, which gave the comparatively miniature triode the capacity to generate radio waves as well as to detect them.[40] It would be key to the development of smaller, commercially viable electronic instruments.

Notes

1 See, for example, Thomas Hughes, *American Genesis: A Century of Invention and Technological Enthusiasm, 1870-1970* (New York: Viking, 1989), David Freeman Hawke, *Nuts and Bolts of the Past* (Harper and Row, 1988), and Carroll W. Pursell, *The Machine in America: A Social History of Technology* (Johns Hopkins, 1995).

2 Sources sometimes cite the date of publication as 1862; in *The New York Times* obituary, the date is given as 1863. "A Distinguished Scientist; Career of Baron Hermann iron Helmholtz Who Died in Berlin," *The New York Times* (Sept. 9, 1894) 5. Of Helmholtz's physiology work, it is mostly vision, rather than hearing, that has attracted attention, e.g., David Cahan, *Hermann von Helmholtz and the Foundations of Nineteenth Century Science* (Berkeley: University of California Press, 1993) and R. Steven Turner, *In the Eye's Mind: Vision and the Helmholtz-Hering Controversy* (Princeton University Press, 1994).

3 Herbert A. Deutsch, *Electroacoustic Music: The First Century* (Miami FL: Belwin Mills, 1993) 56.

4 David Pantalony, *Altered Sensations: Rudolph Koenig's Acoustical Workshop in Nineteenth-Century Paris* (Dordrecht: Springer, 2009), 122, 217-8.

5 Laurence Libin, "The Instruments," in Robert L. Marshall, ed. *Eighteenth-Century Keyboard Music*, 2nd edn. (New York: Routledge, 2003) 28. The monograph that brought de La Borde's instrument to everyone's attention (at least in the English-speaking world) was translated by E. Ann Grannis, and appears to have been self-published by the editor, A.R. Biasini. Jean Baptiste de Laborde, *The Electric Harpsichord, with a New Theory of the Mechanism and Phenomena of .Electricity* (Bellingham WA: A.R. Biasini, 1979).

6 The *cristallophone électrique* is listed in Malou Haine, *Les facteurs d'instruments de musique # SYMBOL 224 \f "Times New Roman" \s 10# Paris au XIX si# SYMBOL 232 \f "Times New Roman" \s 10#cle* (Brussels: # SYMBOL 201 \f "Times New Roman" \s 10#ditions de l'Universit# SYMBOL 233 \f "Times New Roman" \s 10# de Belgique, 1985) 184.

7 Hugh Davies, "Electronic Instruments," *Grove Music Online*

8 Antoine Bouchard, "Casavant Frères," *Encyclopedia of Music in Canada*, 2nd edn. (University of Toronto Press, 1992) 226; Barbara Owen, "Casavant Frères" *Dictionary of Music and Musicians* 2nd Edn., Stanley Sadie, ed., 229-30; "A Brief History of Electronics in Pipe Organs," http://www.organworks.com /web/about/OrgHistory.asp Jeanne D'Aigle, *Histoire de Casavant Frères* (St-Hyacinthe, 1988); H.D. McKellar, "Casavant Frères Anniversary, 1879-1979," *American Organist* vol. 14, no. 1 (1980) 57-9; "Casavant History," http://www.casavant.ca/new_temp/img/home/HomeFrame.htm; Christine Ammer, "Organ," *The Harper Collins Dictionary of Music* 2nd Edn. (Harper Collins, 1991) 293; Barbara Owen and Peter Williams, "Electricity and the Organ," *Dictionary of Music and Musicians*, 628-630; http://guilbault-therien.ntic.qc.ca; www.letourneauorgans.com; K. J. Raudsepp, *Organs of Montreal* (Quebec, 1993). On earlier organ construction in what is now Canada, see H.D. McKellar, "Canadians and their Organs, 1660-1815," *American Organist*, vol. 12, no. 6 (1978) 44-7; E. Hanbury, "The Organnes of New Founde Lande," *American Organist* vol. 31, no. 5 (1997) 60-65. James H. Cook, "Casavant Frè#res," has the 1891 and 1892 dates reversed. *The Organ: An Encyclopedia* ed. Douglas E. Bush and Richard Kassel (New York: Routledge, 2006) 94.

9 John W. Landon, *Behold the Mighty Wurlitzer* (Westport, Connecticut, 1983) 6.

10 Lynn A. Dobson, et al. "Action," *The Organ: An Encyclopedia*, 11-12; Richard Kassel, "Relay and Switch Systems," 459-60.

11 Lynn A. Dobson, et al. "Action," *The Organ: An Encyclopedia*, 13. On Robert Hope-Jones, see David H. Fox, *Robert Hope-Jones* (Richmond, VA: The Organ Historical Society, 1992).

12 "Concert Hall Grand Organ," http://www.sydneyoperahousecom/ uploadedFiles/ About_Us/Venues/ Content_AboutUs_TechSpecsGrandOrgan.pdf

13 Barbara Owen and Arthur W. J. G. Ord-Hume, "Orchestrion," and Durward R. Center and Arthur W.J.G. Ord-Hume, "Fairground Organ," *New Grove Online.* The authority on mechanical instruments, Arthur W. J. G. Ord-Hume, has recently published a history of the street organ: *Automatic Organs: A Guide to Orchestrions, Barrel Organs, Fairground, Dancehall and Street Instruments Including Organettes* (Atglen, PA: Schiffer, 2007). It includes a chapter on automatic organs in the 21st century.

14 Hugh Davies, "Hybrid Organs," *Grove Music Online*, L. Macy, ed. Landon, *Behold the Mighty Wurlitzer*, 15; John Foss, et al., "Theater Organ," *The Organ: An Encyclopedia,* 563.

15 Barbara Owen and Peter Williams, "Electricity and the Organ," *The Organ: An Encyclopedia,* 629.

16 Landon, *Behold the Mighty Wurlitzer*, 6. Hope-Jones sold his patents to Wurlitzer before his death. Richard Kassel, "Unit Chest" *The Organ: An Encyclopedia*, 583.Barbara Owen and Peter Williams, "Electricity and the Organ," 630. Owens and Williams seem to have had no great love for the theatre or cinema organ: they note that the ease of construction comes at the expense of tone quality. The best organ makers, they say, will use the unit chest "discreetly."

17 S. Millman, ed., *A History of Engineering in the Bell System, Volume 1: The Early Years (1875-1925)* (AT&T Bell Labs, 1975) 296.

18 Reynold Weidenaar, *Magic Music from the Telharmonium* (Lanham, MD: Scarecrow Press, 1995) 1. On early music broadcasting, see Elliot N. Sivowitch, "Musical Broadcasting in the Nineteenth Century," *Audio* (June 1967) 51.

19 See "William Duddell" in the IEEE virtual museum exhibit on electronic music, "Songs in the Key of E." www.ieee-virtual-museum.org/collection/people.php?taid=&id=1234785&lid=1. There is also information at "120 Years of Electronic Music," a website anonymously but lovingly maintained at www.obsolete.com/120_years. This site has a comprehensive list of inventions, from the famous to the very obscure, with descriptions and occasionally with primary references. However, it is unclear whether the information is taken directly from those primary references, or whether they come from an uncited secondary source. Note that some of the links to other websites are broken, and some of the information is inaccurate. The most comprehensive summary of all is Hugh Davies, "Electronic Instruments," Stanley Sadie, ed. *The New Grove Dictionary of Musical Instruments* (London: Macmillan Press, 1984) – out-of-date, but very useful. Hugh Davies has worked on the collection and conservation of electronic instruments at the Gemeentemuseum in The Hague. See "The Preservation of Electronic Musical Instruments," *Journal of New Music Research* 30 (2001) 295-302.

20 The player piano, invented in the 1880s, is not an electronic instrument, but a modified conventional piano controlled by rolls of perforated paper. The authoritative work on player pianos is Arthur W.J.G. Ord-Hume's *Pianola: The History of the Self-Playing Piano* (London: George Allen and Unwin, 1984). More recently, Arthur A. Reblitz has written an affectionate account of these curiosities: *The Golden Age of Automatic Musical Instruments* (Woodsville, NH: Mechanical Music Press, 2001). See also Craig H. Roell, *The Piano in America, 1890-1940* (Chapel Hill: Univ. of North Carolina Press, 1989), who says on p. 155 that at their peak, player pianos made up 56% of piano sales. In the early 1990s, the National Association of Music Merchants began to track sales of a new kind of player piano, which used disks and MIDI-mechanisms to control a hybrid digital/acoustic piano: Paul Th#éberge, *Any Sound You Can Imagine* (Hanover, NH: Wesleyan Univ. Press, 1997) 39.

21 *A History of Engineering in the Bell System*, vol. 1, 425.

22 The irate businessman is reported by Mark Sinker, "Singing the Body Electric," *The Wire* 139 (September 1995), archived online at www.thewire.co.uk/archive/essays/theremin.html, and also in the entry for Telharmonium on www.obsolete.com/120_years. In common with many of the early electronic instruments (including the theremin and the electronic sackbut) there is one major secondary source on the Telharmonium. This section relies on Reynold Weidenaar's thoroughly detailed *Magic Music from the Telharmonium*. There is an accompanying video production (1998), which is available for streaming and purchase on Weidenaar's website, magneticmusic.ws. The video recreates the sound of the Telharmonium with a Yamaha TX802 Tone Generator. Note that Cahill originally called the instrument a Dynamophone, and this is the name that Peter Manning uses in *Electronic and Computer Music*. Weidenaar was for a time a composer in Robert Moog's synthesizer factory in Trumansburg, New York, and edited their magazine, *The Electronic Music Review.*

23 Paul Théberge, *Any Sound You can Imagine: Making Music/Consuming*

Technology (Hanover, NH: University Press of New England, 1997) 43.

24 Ibid., 28.

25 Deutsch, *Electroacoustic Music*, 8, drawing on Weidenaar's original Ph.D. dissertation.

26 Weidenaar, *Magic Music from the Telharmonium*, 28, 31. Touch sensitivity would later guide Canadian Hugh Le Caine in all his instrument design. See Section B, Part 6.

27 Weidenaar , *Magic Music*, 68.

28 Ibid., 78.

29 Ibid., 76.

30 Ibid., *Magic Music*, 117.

31 Ibid., 83, 133. A 100-piece orchestra cost $182,500 per year, according to Cahill's estimate in 1908. Since he was trying to secure funding, this is likely on the high end of what a restaurant might pay.

32 Ibid., 223, 177-78.

33 Ibid., 238.

34 Weidenaar speaks far more often about restaurants than about movie theatres. Assuming that this accurately represents the primary material, perhaps the New York Electric Music Company was doomed by changing customs in the restaurant business, since it never seemed to go after the theatre market. It may not have made any difference, since Wurlitzer pipe organs were considerably cheaper than Cahill's generous estimate of the annual cost of an orchestra. The New York Electric Music Company seems to have gone after the clients it thought were the most prepared to part with a lot of money. On the Wurlitzer organs, see John W. Landon, *Behold the Mighty Wurlitzer: The History of the Theater Pipe Organ* (Greenwood Press, 1983).

35 Théberge, *Any Sound,* 43.

36 Weidenaar, *Magic Music*, 238, 245, 254.

37 Weidenaar, *Magic Music*, 291. The choralcelo was developed by Melvin Severy in 1909. It used tone wheels (like the Telharmonium) but also had hammered and electromagnetically vibrated strings to produce its sound. Weidenaar, whose book was published in 1995, reported that there were two surviving choralcelos and neither had been reconstructed, information he seems to have taken from Hugh Davies, "Choralcelo," in Sadie, ed. *The New Grove Dictionary of Musical Instruments* pp.363-364. Resources on the choralcelo are scant, although it tends to get passing mention as one of the early instruments – see, for instance, www.obsolete.com/120_years under 'Choralcello' [sic] and Mark Sinker, "Singing the Body Electric", who says that it may have been in use until the 1950s. A recent web document, claiming forty years' acquaintance with the instrument, purports to have three "at hand." ("The Choralcelo," http://jenkinsw0.tripod.com.) The magazine *Nineteenth Century,* published by the Victorian Society in America, has a recent article: Dymbrowski, "The Choralcelo, A Pioneer Electronic Keyboard Instrument," *Nineteenth Century* 22 no. 1 (2002). Older sources cited by Weidenaar are Edith Borroff, "An Early Electro-Magnetic Experiment," *College Music Symposium* (Spring 1979) 19: 1, pp. 54-59, and "The Choralcelo: One Uniquely American Instrument," *College Music Symposium* (Spring 1982) 22:1, pp. 46-54, both also cited in Hugh Davies, "Choralcelo." Hugh Le Caine refers to William Duddell's 'choralcello' patents in the 1930s (Young, *The Sackbut Blues*, 36). The word is in quotation marks in the original, and the attribution to Duddell seems to be the author's inference. Whatever Le Caine was referring to, it does not seem to have been anything Duddell was involved in – William Duddell died in 1917.

38 David Dunn, "A History of Electronic Music Pioneers," *Eigenwelt Der Apparate-Welt (Pioneers of Electronic Art)* (Ars Electronica, 1992) 23-24. This is a catalogue for a 1992 exhibit of early electronic devices in Linz, Austria, and is archived online at Steina and Woody Vasulka website, www.vasulka.org/Kitchen/PDF_Eigenwelt/Eigenwelt.com. The Vasulkas are video artists whose installations have often combined imagery with electronic music.

39 *Magic Music*, 291.

40 *A History of Science and Engineering in the Bell System,* vol. 1, 262.

2. Music from the Ether

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2.1 Aesthetic Revolution and Performance

The vigorous inventive spirit of the late nineteenth and early twentieth centuries was not limited to engineers. While the avant-garde would not join electronic engineering until Leon Theremin settled in New York with his eponymous instrument in the 1920s, the artistic spirit of the times was a heady mix of radicalism and insistence on the new that made the potential reception of new instruments very favourable.[1] The Italian Futurist movement, for instance, insisted that industry and machines were the basis of a new and desirable aesthetic. In 1910, Balilla Pratella produced the "Manifesto of Futurist Music," followed the next year by the "Technical Manifesto of Futurist Music." He urged composers to "represent the spirit of crowds, of great industrial complexes, of trains, of ocean liners, of battle fleets, of automobiles and airplanes. It must add to the great central themes of the musical poem the domain of the machine and the victorious realm of electricity."[2] In 1913, Luigi Russolo published the "Art of Noises" manifesto. "We must break out of this narrow circle of pure musical sounds," he proclaimed, "and conquer the infinite variety of noise sounds." Russolo was fascinated by the potential of acoustic science to inspire new kinds of instruments. In his comprehensive history of electronic music, Peter Manning comments, "The Futurist movement did not succeed in its attempt to produce a major revolution in the path of new music, but its challenging of traditionally accepted relationships between the science of acoustics and art of musical sound production was to prove singularly prophetic."[3] On the other hand, it was not going to be easy to gain an audience. Mark Sinker, a writer for *The Wire*, a British magazine covering the avant-garde music scene, comments on Russolo's dictum *"Noise has the power to bring us back to life"*: "If by 'life,' he means hostile audiences hurling vegetables, he is not wrong."[4]

Among less provocative composers, a number of very influential people had also been taken by the kind of first-principles investigations of acoustics that Helmholtz had carried out. Composers like Gustav Mahler, Erik Satie, Maurice Ravel and Claude Debussy believed that the tonal system of Western music had lost its capacity "to create tension and thereby to generate convincing 'form.'" The very idea of music, therefore, had to be completely rethought and traditional musical forms rejected in favour of treating music as individual sound events.[5] The work of Richard Wagner was a particularly important indication that tonal music and the entire related structure of European music had reached a critical turning point. Igor Stravinsky and Arnold Schoenberg experimented with unorthodox harmonies by redefining rhythm and scales. Jazz, with its characteristic blue notes—half-flatted notes in between natural and flat—encouraged classical music composers to investigate the microtones that lay between the 12 tones and halftones of the conventional chromatic scale.[6]

2.2 From Avant-Garde to Mainstream: The Theremin

It was against this experimental backdrop that the Russian physicist and musician Lev Sergeyevich Termen introduced the aetherophone, soon known by the Gallic version of the inventor's surname: the theremin.[7] The theremin's continued presence in the musical world is as much the result of the dramatics of performance as its musical qualities. The player stands between two antennae, and moves his or her hands to control pitch and volume. The sound that results depends on the electrical charge that the human body can store, a phenomenon known as natural capacitance. The musician never touches the instrument. Other electronic instruments adapted the keyboards or fretwork of traditional instruments to give the player control over the notes. The Ondes Martenot, for instance, which depends on the same principles, uses a keyboard, although an early version of it had only a dummy keyboard. But the thereminist is working without a map. There is no intermediary device, turning the player into a part of the instrument in a more fundamental way than fingers or breath ever could.[8] It looks like magic and, even to those who understand how it works, it is an arresting sight. "Music from the Air!" many of the concert leaflets proclaimed.

These dramatics ensured that the theremin enjoyed a great deal of attention from the start. Following a successful European tour in the 1920s, Leon Theremin took his instrument to New York, where he performed at Carnegie Hall. Classical composers were intrigued by the theremin's sliding tone, which offered a way to explore microtonality and differently tempered scale systems. Percy Grainger and Joseph Schillinger wrote music to explore the theremin's distinct sonorous qualities. The theremin's unique, not-quite-vocal sound also made it popular in Hollywood to evoke an unsettled or excited mood: it served as the hornet sound for the radio show *The Green Hornet*. The films *Spellbound* (1945) and *Forbidden Planet* (1956) used it to great effect, although

its heavy use in kitsch 1950s B-movies may have damaged its reputation among serious movie makers.[9] Rock adopted it in different versions in the later 1960s, most famously as the solo in the live performances of Led Zeppelin's "Whole Lotta Love." Synthesizer inventor Robert Moog credited the theremin with sparking his early interest in electronic instruments. Against all probability, the theremin continues to attract musicians, despite the advent of more sophisticated electronic instruments that are considerably easier to play. Much of the current interest, kept alive in internet chat rooms and message boards, was fuelled by Steven M. Martin's 1993 documentary, *Theremin: An Electronic Odyssey*, which tells the story of its charismatic inventor, who moved in the artistic circles of some of the most glittering Jazz Age cities. And so the theremin has embarked on an unlikely fourth act, nurtured by bands like Phish and Portishead, as well as mild interest from representatives of the orchestral tradition. As Paul Théberge notes, for all its relative obscurity, the theremin has "achieved a significant level of diffusion." In 2006, the unreleased tracks from a 1975 recording by the most famous of Theremin's protégées, Clara Rockmore, were packaged as an album and released. Albert Glinsky writes in his superb history of the theremin and its inventor, "No other early electronic instrument boasts such an eclectic set of uses, from vaudeville to big band, from nightclubs to films, from rock to the avant-garde."[10]

Leon Theremin did not start out to build an instrument. He was trying to exploit the body's natural capacitance, which could interact with a nearby electrical circuit, in the service of a burglar alarm. The thief's own body would trip the circuit and set off an alarm, turning him into the agent of his own capture. Theremin would continue to work on alarms throughout his life, but it was the effect that the body's capacitance had in alternating the oscillating frequency of the circuit that would lead him to electronic music. He set up two high-frequency oscillators tuned to 300 kilohertz, beyond the range of human hearing. One oscillator was fixed. The other varied with the movements of the hand near a vertical antenna. As the hand entered the electromagnetic field of this antenna, the frequency of the oscillator would rise, resulting in a corresponding change to the pitch. The pitch was controlled by moving the hand back and forth in relation to the pitch antenna.

> In addition to the pitch antenna, there was a secondary loop antenna, usually positioned horizontally, or [later] a foot pedal, to control the loudness of the sound. Bringing the hand close to or touching the volume antenna would silence the sound.[11]

Neither oscillator was within the range of human hearing; the mixing of the two high frequencies resulted in a beat frequency that people could hear.[12] This was the heterodyne principle, first articulated by Reginald Fessenden, the Canadian radio pioneer, in 1901. Lee de Forest used the triode and heterodyning to create an instrument in 1915, a few years earlier than Theremin. The "Audion Piano" (or "Squawk-a-phone," as de Forest cheekily called it) was the first vacuum-tube instrument but, like the instruments of the telegraphy age, it was intended primarily to demonstrate the possibilities for vocal transmission.[13] Edwin Armstrong, working for RCA, used heterodyning to create a radio receiver that could amplify radio signals without putting it on the verge of oscillation (which turned the receiver into a transmitter, usually swamping reception in the surrounding area). Armstrong developed the "superheterodyne" receiver for RCA around 1918, but it was not commonly available until 1924.[14] Meanwhile, Theremin was using the same principle to capture the sound of electricity itself: "No friction of physical soundmakers rubbing against each other," Glinsky notes. "No mechanical energy. Just the free voice of electrons."[15] Others would develop musical instruments based on heterodyning and body capacitance: Jörg Mager used both phenomena in his microtonal instruments in the 1920s (the best known is the Sphärophon, which used a keyboard to control quartertones produced by the radio frequency oscillators). Armand Givelet, the engineer and president of the Radio Club of France who invented a handful of electronic instruments, demonstrated the *Clavier à Lampe* in 1927. However, neither Givelet nor Mager was terribly interested in promotion.[16]

Theremin, on the other hand, enjoyed being the centre of attention. In the 1920s, he began touring the major European cities. Glinsky notes that these tours were underwritten by the Soviet government with the aim of demonstrating their command of this music from the ether. As agitprop, it was probably a waste of money: even when rumours of Theremin's spying began to circulate many years later, few Westerners made much connection between the theremin and the USSR, if they remembered the theremin at all. But from the point of view of the history of electronic music, the tours were a raging success: "By the time Theremin had finished his sweep through Europe," Glinsky tells us, "he had accomplished something no one else ever had: he managed to ignite large-scale curiosity and a genuine interest in the idea of electrical music." [17]

The apparent ease of playing the instrument was part of the attraction for the audience. However, those who tried it found their enthusiasm tested. Canadian electronic instrument inventor Hugh Le Caine, for one, thought the lack of keyboard or fretwork a grave flaw: "Theremin produced five or six instruments of which the poorest one, called the 'Theremin,' caught the public's fancy because of its weird and impractical controls." he said dismissively.[18] Because early versions of the theremin were always on, the player had to work to create pauses in the music. Clara Rockmore, who became quite well known for her theremin performances in the

1930s, had to develop techniques to adapt the instrument to the classical music repertoire, particularly staccato passages. (Legato, glissando or portamento passages, all of which direct the musician to slur the notes to various degrees, are better suited to it.) Finally, in common with all electronic instruments, the theremin is highly dependent on the audio equipment that transmits its sound. As Robert Moog remarked, "no matter how well its tone circuit is designed, [the theremin] can sound only as good as its amplifier and speaker."[19] Accomplished thereminists made it look easy, and the publicity suggested that the player was a mere conduit for music already present in the air—the lucky recipient of a gift rather than a trained and disciplined musician with good equipment. For many people, this was part of the attraction—although Theremin developed a fingerboard version of the instrument (played in a fashion similar to the cello), it never caught the imagination the way the original did. The way the theremin is played is key both to its attractiveness and to the reason so few musicians play it. Théberge writes:

> The failure of the Theremin to enter into musical practice meaningfully highlights the problem of designing musical instruments so that they bear no resemblance to any existing musical technology, thus requiring musicians not only to adapt to unfamiliar sounds, but also to learn an entirely foreign set of performance techniques.[20]

Rockmore was an exception. She was the most famous of the thereminists, with the artistic hauteur of a European in New York and a stage presence born of her early years playing the violin. A former violinist who had developed severe pain in her hands, Rockmore insisted that the theremin was much like a violin with a very long bow since it could play indefinitely long notes.[21] She argued for its place in the classical world, dismissing those who believed it a mere novelty and reserving her serious scorn for those who thought of it as something to be deployed for weird aural effect rather than for making music.[22]

Years later in Steven Martin's documentary, she still held to this opinion but was nearly alone in this view. Rockmore, who toured with the New York Philharmonic and the Philadelphia Orchestra, was attempting to bridge a divide that was growing larger by the day—the gulf between classical musicians, whose repertoire had solidified in the nineteenth century, and the experimental interests of the avant-garde. She would find little support. Most classical musicians were not interested in the theremin, which offered no obvious musical advantages for playing Mozart or Beethoven. Nor was the avant-garde wholly on her side: composer John Cage, for instance, thought the classical thereminists were reactionary obstacles to musical progress. Rockmore toured Canada in 1941, visiting Ottawa, Winnipeg, and Vancouver. Glinsky does not mention what was behind this choice of cities, but the absence of the largest cities – Toronto and Montreal – suggests that the theremin was still pretty far even from what might be called the mainstream avant-garde.[23] More recently, musician and thereminist Anthony Ptak, who has studied with classical thereminist Lydia Kavina, said, "You know, in some real sense, Clara Rockmore may have been the worst thing that ever happened to the thereminist."[24]

Rockmore's classical snobbery did not deter at least a few important experimental composers from examining the theremin's potential as a vehicle for exploring different scale systems and microtonality. After composing *Free Music No. 1* for four theremins and *Free Music No. 2* for six theremins, Percy Grainger hoped to develop an automatic theremin that would allow the composer to bring music directly to the public without the interference of the performer's interpretation—a theme that would become increasingly common among the inventors of electronic instruments and techniques in the decades to come.[25] Composer and music theorist Joseph Schillinger, who helped Theremin design the commercial version of the instrument, also was interested in the new tonal possibilities it offered. He composed a promotional piece, *Airphonic Suite for RCA Theremin and Orchestra*, first performed in 1929.[26]

Composers who hoped to eliminate the performer from music would have found Rockmore difficult to shunt to the sidelines. She shared many qualities with the theremin's charismatic inventor, and they became—in her words—"very, very friendly."[27] Their combined continental exoticism (she was born Clara Reisenberg in Lithuania and trained at the St. Petersburg Conservatory) was a perfect match for New York bohemianism. Her mystique was enhanced by her capacity for perfect pitch, that most arbitrary of gifts. Certainly, to play the theremin with skill required an excellent ear, since there was nothing but the placement of the musician's hands in the air to dictate what the note would be. She later described this as part of the attraction of the instrument:

> There is a certain terrific freedom. You feel like a conductor in front of an orchestra. There is no instrument between you and the music. Sure, there is a theremin standing there, but you're in the electromagnetic field. Every movement you make is a perfect synchronization of sound and motion.[28]

This "perfect synchronization" inspired Theremin to build an even more exotic instrument, the terpsitone. Theremin designed the terpsitone so that the player's entire body controlled the pitch. Volume and vibrato were controlled by another player. The idea was to match music to dance, but it was not successful—Theremin could not find any dancers to play it.[29] He was also in increasing financial difficulty. RCA had purchased the patent rights to several of Theremin's inventions but projections of a theremin in every parlour were unrealistic. Production was rushed and ill-planned, and rosy

Figure 4: RCA Theremin (1930–31), viewed from the front (Tom Alföldi / Canada Science and Technology Museum (CSTM) 1971.0502)

advertisements unwisely emphasized its ease of use—people would just wave their hands in front of the thing and music would play, almost like tuning a radio. "Anyone can make exquisitely beautiful music with nothing but his own two hands!" the publicity chirped. Purchasers were bound to be disappointed. They were going to have to get used to it: marketers of electronic instruments for the home market would continue to emphasize quick results for years to come. (In the 1950s, Hammond Organ buyers were told that they could play without being able to read music and that they would "never have to work on boring scales and exercises.") Poor tactics were compounded by a patent battle with the De Forest Radio Company over the radio tubes used in the instrument, which ended with RCA paying $6,000 in damages.[30] On September 15, 1938, Theremin abruptly left the U.S., boarding a ship back to the USSR.[31]

Despite the commercial difficulties of the device and its inventor, the theremin's distinctive sound made it a popular soundtrack instrument. Miklós Rósza used it in the soundtrack for Alfred Hitchcock's *Spellbound* (1945). Although he

Figure 5: RCA Theremin (1930–31), viewed from the back. (Tom Alföldi / CSTM 1971.0502)

first asked Clara Rockmore to play, she was suspicious and disdainful of Hollywood and refused.[32] Part-time violinist Samuel Hoffman lucked into the part—as the only person in the musicians' union who could sight-read and play the theremin—and went on to play in many other Hollywood scores. In 1956, composers Louis and Bebe Barron showcased the theremin in the exclusively electronic soundtrack for the highbrow sci-fi film *Forbidden Planet*. The Barrons had been experimenting with tape compositions in the home studio they had set up in 1948. They had collaborated with John Cage and had done background music for various short films. Deeply influenced by the fashionable cybernetics movement, they saw in their tuned circuitry the mimicry of emotional states, and so they developed particular themes for each of the characters in the movie. Their music served as both score and special effects, and thus did little to dissuade those who suspected that electronic music was as much about sound in general as about anything that was usually called music.[33]

Forbidden Planet is the famously arty exception to the more typically louche 1950s sci-fi flick where the theremin was used extensively. A sampling of Hoffman's theremin career in Hollywood demonstrates its reversal of fortune: *The Lost Weekend* (1945), *Lady in the Dark* (1944), *The Fountainhead* (1949), *Rocketship X-M* (1950), *The Thing* (1951) and *The Day the Earth Stood Still* (1951). A move back to the mainstream with *The Ten Commandments* (1956) did not stick and was followed by *Earth vs. the Spider* (1958) and *Billy the Kid vs. Dracula* (1966). Music writer Thom Holmes comments, "I guess you could say that there's no going up after you receive the Oscar for your very first project."[34] The

theremin was just too strange-sounding, too outrageous and too closely linked with the idea of mad scientists to maintain a position in serious movies. Jerry Lewis fooled around with a theremin to hilarious effect in *The Delicate Delinquent* (1957, Hoffman was the actual thereminist, and excerpts are included in Martin's documentary), and in 1994 the theremin showed up in the score of Tim Burton's homage to bad movies, *Ed Wood*.[35]

The theremin also made its way into the intimacy of hi-fi–equipped living rooms through the Harry Revel recording *Music Out of the Moon* (1947). The record, which sold well, had a sound which was to become typical of 1950s space-age pop:

> [There were] underlying "Latin" rhythms; the choir that sings vocables, not words, emphasizing the otherworldliness or ineffability of its subject … the lush, full jazz orchestra backing … and the electronic instrument—the theremin in this case—signifying this ideological complex of science/technology/future at an uneasy distance.[36]

Or to put it more mundanely, suburban husbands wanted to show that their taste was as up-to-date as their fancy new hi-fis. The theremin may have been more than twenty years old by this point, but its unearthly sound still signified the future and those things so closely associated with it—high technology and space exploration. This was broadly true for certain styles of electronic music through to the end of the twentieth century, although by this time futurism was mixed with nostalgia. Vince Clarke of the Britpop band Erasure has said, "I like music that sounds like clockwork. I prefer my music coming from the moon."[37] This same self-conscious appreciation for the power of the technological and scientific to transport the listener is manifest in a variety of artist names and albums, like Sun Ra's *It's After the End of the World* (1970), Kraftwerk ("power plant" in German), and Laurie Anderson's *Big Science* (1982), which includes the track, "Let X=X."

It is not surprising then that the theremin's fortunes rose again. In the late 1950s, a young graduate student in physics, Robert Moog, had begun building theremins for a little extra money. Moog, who became famous for the synthesizers that bear his name, credited the instrument with sparking his early interest in electronic music. "Leon Theremin has been my hero and virtual mentor for most of my life," he later said.[38] In 1961, he offered for sale the Melodia, a "portable, completely transistorized theremin."[39] It was the Melodia that brought Moog to the attention of Herbert Deutsch, an experimental composer and professor of music at Hofstra University. Deutsch and Moog began sharing ideas—Deutsch would explain what kinds of sounds he wanted, and Moog would design electronic devices to generate them. It was partly through this collaboration that Moog developed his voltage-controlled synthesizer in 1964. It may have been too *outré* for many musicians and composers, but the theremin is an integral part of the story of Moog's more famous instrument.

In addition to Moog's Melodia Kit theremins, circuit diagrams in hobby magazines encouraged readers to build the instrument themselves. A new generation of musicians was untroubled by its association with Hollywood mass culture and its strange sound. Indeed, in the burgeoning psychedelic youth culture of the mid-1960s, the theremin's weirdness was just what some people wanted. Brian Wilson of the Beach Boys used it to evoke the idea of "vibrations"—"the emotional signals that people and animals communicate to each other telepathically." He asked Hollywood musician Paul Tanner to come into the studio to add electro-theremin tracks to the new song. The electro-theremin was Tanner's own invention—after watching Hoffman play for a film, Tanner added a contact switch to the theremin (to facilitate staccato passages) and a keyboard. "Tanner had effectively 'solved' the problem of the theremin's inherent pitch glide," Glinsky writes, "but in the process he eliminated the very fascination of the space-control method."[40] It was indeed less theatrical, but far easier to play. Tanner later declined to tour with the group, and the Beach Boys turned to Moog for a theremin. When they learned how difficult the standard theremin was to play, they asked if it was possible to add something like guitar fretwork to it so that they would know where the notes were. Moog obliged with the "stringer," a ribbon-controlled oscillator that they could adjust with their fingers. This would later provide Moog with the basis for the continuous controller on his synthesizers.[41]

2.3 The Ondes Martenot, the Trautonium and the Mixturtrautonium

Although it doesn't have the popular fame of the theremin, the Ondes Martenot has also been used in many film and theatre scores and, in addition, enjoys an orchestral repertoire and the status of a more "serious" instrument. French musician Maurice Martenot (who originally called his instrument the Ondes Musicales) used the same principles that govern the theremin but included a finger ring attached to a metal wire, which meant there was a reference point for the notes. Martenot's 1928 design included a showpiece cabinet, which indicated that the inventor believed the instrument's rightful place was in the orchestra. The finger ring was soon supplemented by a keyboard, which allowed control over a number of things— a key could be jiggled laterally for vibrato, and (a marked improvement over the theremin) the instrument was silent until a key was depressed. The right hand played the melody, while the left hand and knee were free to operate keys that controlled the character of the sound.

Figure 6: Finger ring and keyboard, Ondes Martenot. (Cantos Music Foundation)

Martenot also designed several different speaker systems to project its sound.[42] Several composers, mainly French or French-speaking, took an interest in the delicate and eerie-sounding instrument, and it now has a repertoire of more than 250 concert pieces. Like the theremin, its best known players (besides Martenot himself) were women: Martenot's sister, Ginette, was a concert musician and performed in Montreal for Radio Canada in 1950. She was invited by another of Martenot's protégées, Montrealer Andrée Desautels. (Gender roles seem to have strongly supported the masculine inventor and the feminine muse, and in the case of the theremin and the Ondes Martenot, it is possible that they tended to be played by women because they also sounded like a female voice.) The connection between the Ondes Martenot and Quebec proved strong, and there is a substantial body of Ondes Martenot work composed by Canadians. Popular musicians adopted it, too: Beau Dommage used it on *Où est passée la noce* (1975) and the band Harmonium used it on *Si on avait besoin d'une cinquième saison* (1975). More recently, the Ondes Martenot was used in the soundtrack for the French movie *Le fabuleux destin d'Amélie Poulain.*[43] It also displayed a less serious side as the sound of the coffee pot in the Maxwell House coffee commercials of the mid-1960s.[44]

By using neon tubes rather than vacuum-valve oscillators, a German professor of acoustics, Friedrich Trautwein, invented an instrument similar to the Ondes Martenot but much richer in timbre. Composer Paul Hindemith, who became interested in the instrument in the late 1920s, agreed to compose music for it if Trautwein would build three of them by 1930. Hindemith's student Oskar Sala helped to build them and became closely associated with the trautonium after the war. But Trautwein, a Nazi sympathizer, found himself an outcast in the postwar artistic world. "It is ironic that, prior to the war, he was instrumental in preserving the trautonium project during a fitful time for the arts in Germany," Thom Holmes observes.[45] It didn't help that Joseph

Figure 7: A 1975 Ondes Martenot. The instrument had an enduring appeal among composers and musicians in Quebec. (Cantos Music Foundation)

Goebbels had been a fan of the instrument and had wanted to use it to promote the Nazi Party.[46] When Sala improved the instrument's controls and expanded its mixture of harmonics after the war, he rechristened it the Mixturtrautonium and continued to produce versions of it well into the semiconductor era. In 1961, he and composer Remi Gassman scored the George Balanchine ballet *Electronics.* In 1963, Alfred Hitchcock asked Sala to write the soundtrack for his film *The Birds*. Sala went beyond evocative music, composing even the sounds of the birds themselves. As Holmes notes, "It was a highly effective technique that further reinforced the surreal elements of the film's plot."[47]

Throughout the 1950s and 1960s, Hollywood increasingly turned to electronic music to signify a highly charged mental atmosphere. In his history of electronic music, Peter Manning suggests that this may have been what the purely electronic monophonic instruments like the theremin and the Mixturtrautonium were best suited to: "outside this particular sphere of activity these instruments failed to establish any lasting position of significance."[48] However, they at least established a presence. Many electronic instruments did not survive at all. In the period of rapid change and feverish invention lasting through the 1960s, a great many instruments were built, most of which became mere footnotes in the literature. Thom Holmes comments on the Hellertion, a vacuum-tube instrument operated by a keyboard:

> Like so many other early electronic instruments, the Hellertion faded quietly into the pages of history, a history that is rich in experiments and inventions with quaint, faintly scientific names: the Croix Sonore, Dynaphone, Emicon, Magettron, Melodium, Ondioline, Oscillion, Photophone, Pianorad, Univox, and the Warbo Formant Organ.[49]

In Hollywood, however, the use of instruments like the Mixturtrautonium and the theremin to evoke certain moods became so common as to be habitual. Even film musicians

did not always recognize the instrument in Alfred Hitchcock's *Psycho* as a normal acoustic violin, so unexpected was it in that context.[50] The sound of normal acoustic instruments was increasingly swamped by the many commercially available electronic instruments. By the later decades of the twentieth century, Paul Théberge believes,

> Changes in musical styles and tastes and advances in technical design and marketing [had] transformed electro-acoustic instruments—electric guitars and amplifiers, electric organs, digital pianos, synthesizers, and signal processors—from idle engineering experiments into what must be regarded as the "most characteristic instruments of our time."[51]

But in order to become the "most characteristic instruments of our time," a majority of people would have to become accustomed to their sound. Most people did become accustomed to the sound—so much so that it became a part of the aural geography of the later twentieth century. But people did not become listeners because they started attending avant-garde concerts in large numbers—they came to accept and even expect electronic sounds because recording and broadcast technologies meant that these sounds were audible so much of the time.

Notes

1 This is still the case, as a cursory glance at any popular material on Theremin shows.

2 This passage is cited by Mark Sinker, "Destroy All Music," in Rob Young, ed., *Undercurrents: The Hidden Wiring of Modern Music* (London: Continuum, 2002) 183.

3 Manning, *Electronic and Computer Music*, 7. The Russolo passage is cited on the same page. See also Luigi Russolo, *The Art of Noise*, Robert Filliou, trans. (New York: Something Else Press, 1967).

4 "Destroy All Music," 184.

5 Elliot Schwartz, *Electronic Music: A Listener's Guide* (New York: Praeger, 1973) 18.

6 'Classical' is a tricky term, since it also applies to the style specific to the period from about 1750 to 1820, when the familiar forms of symphonies and sonatas solidified. However, the only other term in use to distinguish twentieth century figures like Schoenberg or John Cage from all the other composers working in more vernacular styles is 'serious music.' Neither of these is satisfactory; but where it is necessary to draw a distinction, and the terms 'avant-garde' or 'experimental' do not fit, 'classical' is preferable to 'serious.' On scale systems and microtonality, see Edward M. Burns, "Intervals, Scales, and Tuning," in Diana Deutsch, ed., *The Psychology of Music*, 2nd ed. (San Diego: Academic Press, 1999).

7 Distinguishing the instrument from its inventor can be a tricky thing. Here, I will use 'Theremin' to refer to the man and 'theremin' to refer to the instrument.

8 Richard Orton and Hugh Davies, "Ondes Martenot," *Grove Music Online*. In addition to Glinsky's book, see the theremin performance book by Carolina Eyck, *The Art of the Theremin* (Berlin: SERVI Verlag, 2006) and Max Baars, "The Theremin – How It Works," www.thereminvox.com/article/articleview/134/1 / 2/, posted December 29, 2004. This website has a wealth of useful archival pieces, including the 1929 RCA Theremin service manual, concert programs, and interviews with some of the major figures in its history. It represents the more highbrow tradition of Theremin himself and his protégés and heirs. The popular theremin tradition carries on with its business at thereminworld.com.

9 Hugh Davies reports that the theremin made its debut in *King Kong* (1933), but Glinsky does not mention this at all. "Electronic Instruments," *The New Grove Dictionary of Musical Instruments*, 679. It is widely believed that the theme for the original *Star Trek* television series uses a theremin. Some believe it that the instrument was an Ondes Martenot and some claim that it was a vocalist (see the wikipedia.org entries for "Ondes Martenot" and "Star Trek: The Original Series (theme song)"). Given that no serious histories of electronic music include any mention of *Star Trek* at all, it seems unlikely to have been either a theremin or the Ondes Martenot. It was probably a vocalist, but perhaps the instrument's long association with science fiction influenced both the styling and the listeners' ears.

10 Théberge, *Any Sound,* 44; *Clara Rockmore's Lost Theremin Album* (Bridge Records, 2006); the previously released tracks are on *The Art of the Theremin* (Bridge Records, 1977). See also Daniel J. Wakin, "From the Archives, Just for Theremaniacs," *The New York Times* (January 21, 2007). The website www.thereminworld.com maintains a list of pop and rock music bands who have used or are using theremins. As of this writing, it has 777 entries. Albert Glinsky, *Theremin: Ether Music and Espionage* (Urbana and Chicago: University of Illinois Press, 2000) 341. On Grainger's Free Music, see Burnett Cross, "Grainger Free Music Machine," *Recorded Sound: Journal of the British Institute of Recorded Sound* (January-April 1972) 17-21.

11 Thom Holmes, *Electronic and Experimental Music: Pioneers in Technology and Composition* (London: Routledge, 2002) 54.

12 If we look at the acoustics of the different frequencies, we can see why – when the two frequencies are mixed, they create two new frequencies at the sum of the two originating frequencies and at their difference. The difference frequency is the lower one that is within the range of human hearing.

13 Lee de Forest, *Father of Radio* (Chicago: Wilcox and Follett, 1950) 331-332.

14 See Hugh G. J. Aitken, "Allocating the Spectrum: The Origins of Radio Regulation," *Technology and Culture* 35, no. 4 (October 1994), 698.

15 Glinsky, *Theremin*, 24.

16 There are no published secondary sources that deal with these instruments in any sustained way. For an examination of the primary material, see Richard Schmidt James, *Expansion of Sound Resources in France, 1913-1940, and Its Relationship to Electronic Music* (Ph.D. dissertation, University of Michigan, 1981). Armand Givelet's full name was Joseph Armand Givelet, and he is often (confusingly) referred to as both Joseph Givelet and Armand Givelet.

17 Glinsky, *Theremin*, 71.

18 Young, *The Sackbut Blues*, p. 37, note 11.

19 Glinsky, *Theremin*, xi.

20 Théberge, *Any Sound,* 44.

21 It seems likely that the pain was repetitive stress disorder, a condition that plagues many musicians.

22 "In Clara's Words," interview with Robert Moog, November 1, 1977. The interview was part of the press kit for the record *The Art of the Theremin* and was posted on the thereminvox website in 2002. See www.thereminvox.com/article/articleview/21/1/22/.

23 Glinsky, *Theremin*, 246. The Cage passage is cited on p. 251.

24 D. Strauss, "Clara Rockmore," *Remix* (June, 2006). Archived online at remixmag.com/artists/remix_clara_rockmore.

25 Any plans for an automatic theremin were scuttled when Theremin left abruptly for the USSR in 1937. Glinksy, *Theremin*, 252. From the beginning, American publicity for the theremin echoed the arguments Cahill had used to sway investors to fund the Telharmonium. According to a Russian-language newspaper in New York, the theremin could be played "without any training and eliminates the 'monopoly' of professional, well-trained musicians in the savoring of music." Cited in Glinsky, *Theremin*, 73.

26 A recent recording of the Schillinger and Grainger pieces is on Lydia Kavina's *Music from the Ether* (Mode, 1999).

27 Cited in Glinksy, *Theremin*, 143.

28 Moog, "In Clara's Words."

29 Moog, "In Clara's Words." It was via his interest in dance that Theremin met his second wife, Grace Lavinia Poole Williams of the American Negro Ballet (Glinsky, *Theremin*, 143-144, 175). (Theremin was already married to someone, Katia, who had come to the U.S. with him. They were separated, although they never formally divorced. Theremin did not see his first marriage as an obstacle to an American remarriage – he proposed marriage to Clara as well.) According to Wilco Boetermans's thesis, "De theremin aan het begin van de 21ste eeuw," ("The Theremin at the Start of the 21st Century"), there is a surviving terpsitone in Moscow. Boetermans says that he studied with Lydia Kavina in Moscow, so he seems likely to know. The thesis was completed as part of a program in Music Technology at the Utrecht School of Arts in 2000 – it is unclear for what degree – and has been posted online in Dutch and English at www.theremin.nl/scriptie/eng/enindex.html. See the section "Short History of the Instrument." Another Russian, the futurist painter Vladimir Baranoff Rossiné also developed an instrument to coordinate movement and sound, although in his case it was the movement of light through revolving coloured glass disks. See the entry "The Optophonic Piano" on www.obsolete.com/120_years.

30 Cited in Glinsky, *Theremin* 102 (italics in original). See Chapter 4, "A Theremin in Every Home." The Hammond organ material is from Théberge, *Any Sound,* 31. Thereminworld.com maintains the results of a project initiated in 1996 to track down the RCA theremins; the still partial results are a fascinating window into the fortunes of an obsolete mass-marketed technology.

31 Theremin had been passing information about American technology to the Soviets since his arrival in 1927. Immediately on his return to the Soviet Union, Theremin was arrested—ironically, for spying— his instruments were confiscated, and he was sent to a labour camp in Siberia. After several months in terrible and inhumane conditions, he was transferred to Moscow, where the Soviets put him to work on military projects. It was only in his final years that Theremin was free to talk about his music, and by then, the Soviet culture of secrecy and his advanced age had taken their toll on his memory. Glinsky, *Theremin*, 185, 190, 193, 231, 308.Glinsky bases his account of Theremin's Soviet years in large part on Bulat Galeyev's Russian-language biography: Bulat Galeyev, *Sovietskyi Faust (Lev Termen – pioner elektronnogo iskusstva)* (Kazan: Biblioteka zhrunala 'Kazan,' 1995).

32 According to Steven Martin, by her later years, her disdain for Hollywood had subsided, although she shows little evidence of it in his documentary: "But later she said to me, 'Maybe I was wrong. A movie, why not?'" Cited in D. Strauss, "Clara Rockmore," *Remix* (June, 2006). Archived online at remixmag.com/artists/remix_clara_rockmore/

33 Rebecca Leydon, "Forbidden Planet: Effects and Affects in the Avant-Garde," *Off the Planet: Music, Sound, and Science Fiction Cinema*, Philip Hayward, ed. (London: John Libbey, 2004) 61-76; Elizabeth Hinkle-Turner, *Women Composers and Music Technology in the United States* (Burlington VT: Ashgate, 2006) 15. C. Roads reviewed the re-releases of *Forbidden Planet* and Pierre Henry's *Le microphone bien temperé* in *Computer Music Journal* 7 (Spring 1983) 73-76. In 2005, American public radio network NPR broadcast a piece on the Barrons on their flagship program *Morning Edition*: Susan Stone, "The Barrons: Forgotten Pioneers of Electronic Music," (February 7, 2005), available online at www.npr.org/templates/story/story.php?storyId=4486840.10/17/07 Electronic musician Gordon Mumma was also taken with cybernetics. He would later experiment with 'cybersonics' in Ann Arbor, Michigan, using "performance circuits that could actively respond to signals during a live performance." Holmes, *Electronic and Experimental Music*, 228.

34 Holmes, *Electronic and Experimental Music*, 61.Timothy Taylor cites the Barrons' liner notes from a recent re-release of the *Forbidden Planet* soundtrack in *Strange Sounds: Music, Technology, and Culture* (New York: Routledge, 2001) 94. On *The Day the Earth Stood Still*, see Rebecca Leydon, "Hooked on Aetherophonics: *The Day the Earth Stood Still*" in *Off the Planet*, 30-41.

35 The thereminist for the *Ed Wood* score is Lydia Kavina. Joe Cortez, "From Elfman to Theremin: The Sonic World of Tim Burton," timburtoncollective.com/sonic.html. Philip Hayward discusses the fortunes of the theremin's strength as a signifier of the futurism and nostalgia in "DANGER – RETRO-AFFECTIVITY! The Cultural Career of the Theremin," *Convergence* vol. 3 (Winter 1997) 28-53. The theremin did not disappear entirely from highbrow culture in the 1950s – see the literary references that Glinsky has collected on p. 286.

36 This album (with Samuel Hoffman playing the theremin) was reissued as part of the CD box set: *Dr. Samuel J. Hoffman and the Theremin* (Basta Records, 1999). The passage is from Taylor, who goes into some detail on the semiotics of this and similar recordings, including a fascinating look at the album cover art, in *Strange Sounds*, pp. 83-95. See also chapter 6 of Tim J. Anderson's *Making Easy Listening: Material Culture and Postwar American Recording* (University of Minnesota Press, 2006).

37 Rule, "Vince Clarke of Erasure: Electro-Luddite," in Greg Rule, *Electro-Shock! Groundbreakers of Synth Music* (San Francisco: Miller Freeman, 1999) 167.

38 Glinsky, *Theremin*, ix.

39 Ibid., 287-288.

40 Ibid., 290. There is an electro-theremin webpage at electrotheremin.com/PTE-Tpage.html.

41 Ibid., *Theremin*, 296.

42 Holmes, *Electronic and Experimental Music*, 67.

43 David Keane, "Electro-Acoustic Music in Canada: 1950-1984," cec.concordia.ca/econtact/Histories/EaMusicCanada.htm; Holmes, 67-69. Keane reports that "a dozen or more" Canadian composers have written for the Ondes Martenot. The Encyclopedia of Music in Canada lists 22 Canadian composers: Pierre Rochon, "Ondes Martenot," www.thecanadianencyclopedia.com.

44 Deutsch, *Electroacoustic Music*, 15. Pinch and Trocco report that the percolating sound was composed by Eric Siday. Trevor Pinch and Frank Trocco, *Analog Days* (Cambridge MA: Harvard Univ. Press, 2002) 56.

45 Holmes, *Electronic and Experimental Music*, 71. See also Dunn, "History of Electronic Music Pioneers," 26.

46 *Analog Days*, note 3, pp. 336-337.

47 Holmes, *Electronic and Experimental Music*, 73. See also www.trautonium.com and "The Trautonium Project," doepfer.de/traut/traut_e.htm. Doepfer is a manufacturer of electronic instruments, and they explain how to put together a contemporary trautonium using their modules. They also have pictures and a schematic of the original instruments. Holmes reports that there were only two original Mixturtrautoniums surviving at the time of his writing in 2002 (p. 73).

48 Manning, *Electronic and Computer* Music, 5.

49 Holmes, *Electronic and Experimental* Music, 76. The Warbo Formant-Orgel was *not* an organ, but is often mistakenly called such. Some of the instruments mentioned in this passage are discussed briefly in the section below on electronic organs.

50 Jack Sullivan, *Hitchcock's Music* (Yale University Press, 2006); "Bernard Hermann" posted on thereminvox.com July 16, 2003, www.thereminvox.com/article/articleview/50.

51 Théberge, *Any Sound*, 11.

3. Music on Tape

3.0 Music on Tape

3.1 Recording and Composition

There is a conspicuous omission—dare we call it a silence?—in this document. This is an overview of the work that has been done on the history of electronic music and instruments, but without the concurrent rise of recording and the emergence of music as a commodity, even the electric guitar might have remained much as the theremin did in the pre-war era: a compelling novelty that seemed to stand deliberately to one side of the mainstream. Recording fundamentally changed the way that music was produced and consumed, which in turn affected instruments and even the idea of what counts as an instrument. The emergence of music as something that could be enjoyed whenever one pleased was distasteful, even abhorrent, to some. The American composer John Philip Sousa, for instance, is generally credited with coining the term "canned music." "Clearly, he meant the comparison to be derogatory—canned food did not taste as good as fresh food, and canned music was not as good as 'fresh' music," Jonathan Sterne says in his history of recorded sound.[1] In a 1931 article titled "In Defense of Canned Music," Garry Joel August explained why a record collection was so nice to have—reasons that have not changed substantially into the era of the MP3 and its successors:

> The man with a taste and the necessary means and leisure to indulge it … can have the world's delights as the whim of the moment dictates—and by a mere glance at his shelves. While at unbuttoned ease he smokes a fat after-breakfast cigar, there are Bach and Haydn and Schubert to glorify the clear morning, or a Mozart quartet, essence of youth, vigor and good cheer…. Nothing breaks the link between himself and the music, no scraping or creaking, no sight of perspiring flautist or gawky bull-fiddler. It is music undefiled…. It is the true fashion in which melody should be enjoyed, informally, carelessly, with at most a friend or two by one's side.[2]

Although he later modified his position somewhat, the great German critic Theodor Adorno worried about the effects that recording and radio would have on music. Writing only a few years after Garry Joel August, Adorno claimed that this ready access was precisely the trouble and was part of the larger problem that Walter Benjamin had identified in understanding art in the age of mechanical reproduction: "The change in the function of music involves the basic conditions of the relation between art and society," Adorno wrote. The capacity to listen to a particular piece of music whenever you wished, whatever you were doing and for however long you chose would make the sacred vulgar. "The man who in the subway triumphantly whistles loudly the theme of the finale of Brahms's First is already primarily involved with its debris."[3] Snipping music apart to pick out the bits you liked—in the subway, of all places!—was a profoundly sacrilegious act.

That recording made music into a commodity was well recognized in the 1930s.[4] Less remarked upon was another aspect of recording—the very thing that made it so attractive to August and so worrisome to Adorno. Listening to music could now be a completely private experience. Much as the spread of literacy had made reading a fundamental part of the development of private life in the seventeenth and eighteenth centuries, recording would make listening to music part of the experience of private life in the twentieth century. "Audile technology," Sterne argues, "requires the sonic equivalent of private property." Although he is dealing here with the specific context of the telephone conversation, what he says applies to recorded music as well:

> This suggests that the diffusion of audile technology is also the dissemination of a specific kind of bourgeois sensibility about hearing and acoustic space over the course of one hundred years…. As a bourgeois form of listening, audile technique was rooted in a practice of individuation: listeners could own their acoustic spaces through owning the material component of a technique of producing that auditory space—the "medium" that stands in for a whole set of framed practices. The space of the auditory field became a form of private property, a space for the individual to inhabit alone.[5]

While this would have been true even if the phonograph and the vacuum tube radio had remained the primary means of listening to music, the advent of the portable transistor radio and the (transistorized) car radio, in conjunction with the intensely personal yet publicly dissected formative experiences of the postwar baby-boom generation, meant that the narrative of one's personal life now had a soundtrack.[6] Evan Eisenberg explores some implications of this in his book on the meaning of recorded music, *The Recording Angel*. In one of several chapters detailing the meaning that records can have, he talks to a collector who says, "When I play a record … it's as though someone else were expressing my feelings. When I play the piano, it's as though I were expressing someone else's feelings." The collector concludes, "I actually think I participate when I listen. I think it's vicarious per-

formance."[7] Without this understanding of the meaning of recorded music and the role it played in structuring people's lives, it is impossible to understand fully the reasons that the electric guitar became the object of desire for millions of teenaged boys (and, later, somewhat smaller numbers of girls), nor is it possible to grasp the way that music changed into something quotable and manipulable, which was the source from which everything from 1950s electronic music to 1990s hip hop sprang. Eisenberg reminds us that the pioneering work of studio music composer Karlheinz Stockhausen makes it clear that the "logical extreme of phonography is electronic music." And the experience of listening alone gives rise to, as Stockhausen put it, "visions in time and space which overstep what the laws of the physical world around us permit; spatial perspective and the logic of cause and effect in temporal events are both suspended."[8]

The malleability of the recording was not widely recognized at the start. Up until the late 1940s, machines to preserve sound were used primarily for aural record-keeping of music or speech. Any capacity they had for more creative musical use was unexploited. "Edison spoke of 'phonographing a sound,' on the linguistic model of 'photographing a scene,'" Robert Philip writes in his history of the changes brought to music by recording, "and for decades people thought of sound recording as a kind of sound photography, meaning a technique, despite the fact that photography was recognized to be an art."[9] The grooved discs that phonographs played, developed originally by Emile Berliner in 1887, were not very manipulable and encouraged people to think of recording as faithful reproduction of the original sound. It would be some time before recorded sound could be considered analogous to the artistic use of photography or film, rather than as a way of preservation or reproduction. The reason that inventors set to work to synchronize sound and image on film, for instance, was because they hoped to develop a method for faithful reproduction of the sight and sound of a particular moment. From the late nineteenth century, there were numerous attempts to develop a reliable technique for reproducing sound optically on photographic film, but this technique never became very widespread.[10] More effort was put into adapting grooved discs to synchronous replay, but the technology was far from perfect, and, surprisingly, few Hollywood studios were interested. Warner Brothers, looking hard for an advantage over the other studios, was willing to take a risk. They used the Vitaphone, a more reliable sound-on-disc system developed by Bell Telephone in 1925, to include a musical prelude to the movie *Don Juan* in 1926 and *The Jazz Singer*, the first "talkie," in 1927.[11]

Inspired by Edison's phonograph, American inventor Oberlin Smith conceived of using electromagnetism to record sound as early as 1878. Magnetic material exposed to a magnetic field retains some of this magnetism, which can be detected and played back as sound. "Smith's conceptual leap was to record sound by subjecting a recording medium to magnetic rather than physical vibrations," Manning points out. But Smith never developed this idea into a successful recording device. Independent of Smith's work, the Danish inventor Valdemar Poulsen developed the telegraphone, which he demonstrated at the Paris International Exhibition in 1900, but poor management at the company set up to handle its manufacture resulted in limited sales. Following this, little happened with magnetic tape until the 1920s, when the work of the German Kurt Stille led to a synchronized sound system for film using magnetized steel tape. The commercial versions that appeared in the late 1920s and 1930s, such as the Blattnerphone and the Marconi Company's Marconi-Stille recorder, were not very well-received: steel tape meant that it was necessary to weld pieces of tape together, and the machines, loaded with heavy tape, were "liable to sheer dangerously when [the tape was] spooled at high speed."[12] Nevertheless, in 1933 the Canadian Radio Broadcasting Commission purchased several machines for their Ottawa operation; these remained in service for about a decade.

A far lighter and promising alternative came from the work of Fritz Pfleumer, an Austrian chemist working in Berlin. In the 1920s, he developed a method to coat paper with magnetic powder. The paper, which was then cut into strips, was much cheaper and lighter than the steel tape. In the late 1930s, scientists at I.G. Farben adapted this process to plastic tape.[13] They collaborated with AEG on the development of a magnetic recording device and introduced the Magnetophon in 1935. It was the first in a flurry of tape recorders that were less cumbersome and more versatile than any yet seen.

Tape recording was ideal for an emerging group of sophisticates more interested in general concepts of sound than in traditional music. Cahill and Theremin had sought to make music; the next phase in electronic music would come from the heirs to the avant-garde, who were interested in sound itself. While some composers were already using grooved records to alter sound and disturb the still-new conventions of live and recorded music (John Cage, for example, used variable speed turntables combined with percussion and noise in *Imaginary Landscape No. 1* in 1939), the availability of magnetic tape encouraged musicians and engineers to start exploring the possibilities of manipulated and found sounds. Ambient music pioneer Brian Eno later remarked, "The move to tape was very important, because as soon as something's on tape, it becomes a substance which is malleable and mutable and cuttable in ways that discs aren't." Or, as Thom Holmes puts it, "Holding a strip of tape in your hand was like seeing and touching sound. You could manipulate this normally elusive phenomenon in ways that were previously unavailable to composers."[14] Christoph Cox and Daniel Warner point out that because the tape recorder made the collection of sounds relatively straightforward, it was critical to any acceptance of the removal of the distinction between

music and its "others"—noise, silence and all the other sonorities in which twentieth-century composers cultivated a serious interest.[15]

3.2 **Paris:** Musique concrète

In the period during and following World War II, France and Germany became major hubs for experiments with tape. In Paris, the school of *musique concrète* was established under the engineer (and later composer) Pierre Schaeffer, who spent his first several years working with discs rather than tape. Schaeffer, who was deeply influenced by the phenomenology of Edmund Husserl and Maurice Merleau-Ponty, as well as Futurism, had convinced Radiodiffusion Télévision Française (RTF) to support his research into acoustics and recording techniques. (This was especially impressive given that this was initiated in 1942, when the corporation was controlled by German occupying forces.) It would not be quite right to call him a composer in the traditional sense, although he spent his life creating new aural experiences with tape music. As Elliott Schwartz remarks, "It's difficult at any time to define this term and even more precarious with respect to tape music."[16] It is difficult even to call his work "music"—one book uses terms from mechanics ("shifting planes of sound," "sound masses"), emphasizing that this is at least as much about technique, process and the nature of sound as it is about any kind of final audience experience.[17] It implies that tape music belongs more to the laboratory than the concert hall. (A couple of decades later, Ralf Hutter of the German group Kraftwerk emphasized the same point about their clinically precise music: "We consider ourselves not so much entertainers as scientists. We work in our studio laboratory and when we discover something that is true, we put it on tape."[18])

Schaeffer saw himself as a collector of sounds; thus, rather than working with musical notation on paper, he worked with what he believed was the wellspring for any musical impulse. He called this *musique concrète* because, as Timothy Taylor puts it, "it is constituted from pre-existing elements taken from whatever sound material ... and then composed by working directly with the material."[19] Following Husserl's dictum to follow back to the thing itself, Schaeffer was interested in the apprehension of sound apart from all reference. But it is difficult to extract sound from association, and his early efforts, such as the *Étude aux chemins de fer*, which used disc-recorded sounds of locomotive whistles and train cars rumbling, did not satisfy his ambitions. In late 1948, RTF broadcast a series of études in the *Concert de bruits*, which used traditional instruments as sound sources in an effort to shake the association that machine sounds inevitably made. The concert sparked fierce debate in musical circles and the listening public, but RTF was supportive and hired the composer Pierre Henry as co-researcher and Jacques Poullin as sound engineer. Pierre Henry had trained as a composer, and so was a rarity among all the electronic engineers that dominated even serious electronic music.

Schaeffer was in search of the *objet sonore*, "a basic sound event, which is isolated from its original context and examined in terms of its innate characteristics outside its normal time continuum."[20] It was a radical reworking of the meaning of recording, as Schaeffer himself remarked: "*On a cru que les moyens d'enregistrement servaient avant tout à conserver, à graver, à pérenisser la 'haute fidélité'. L'importance réelle de l'électro-acoustique, c'est qu'elle permet de faire des sons, ou encore de fixer les sons naturels, de les répéter, de les perpétuer, de les transformer.*"[21] But his efforts to transform the recorded sounds in order to free them from all association were not yet bearing fruit. Varying the speed of the recorded disc affected the pitch, duration and amplitude envelope—the characteristic pattern of attack-body-decay—of the sound, but it had not yet purified the sound of the piano or the locomotive whistle of their contexts.

> His quest for an area of sound material that would prove sufficiently rich to sustain a major composition led him to select a source which in many respects offered connections with instrumental material and noises; the sounds of a man. His initial idea was to select sound material solely from noises that could be produced naturally by the man, for example breathing, walking, and whistling. These sources, however, proved too limiting and this selection was soon extended to include sounds drawn from the man's communication with the world via his actions, for example, the production of percussive sounds, or the playing of orchestral instruments.[22]

Ironically, the traditional piano was proving easier to snip from its associative framework than the noises that the Futurists had championed.[23]

In 1951, RTF gave Schaeffer a new studio equipped with several magnetic tape recorders. Schaeffer finally had a better means for collecting and manipulating sounds, although the methods he had developed for disc were by now established enough that it would be some time before he gave them up completely. But the group soon was exploiting the possibilities of tape with a number of devices that Poullin and Schaeffer constructed, including the phonogène, a variable-speed tape recorder, and the morphophone, which had twelve playback heads that could be exploited for reverberation effects.[24] Poullin used a five-track tape recorder to develop a four-channel playback system (recording on four of the five available tracks), a feat "quite remarkable for its time."[25] The new studio also became home to a growing number of researchers, including André Moles, whose work on the perception of acoustics would be of great help in Schaeffer's efforts to de-

velop a system for representing his music graphically—a necessity for performance. Schaeffer, for all his discouragement at the basic conservatism of the musicians who joined him and for all of his reliance on recording technologies, seems still to have yearned for the concert hall.

In common with much of the art of the high modernism of the mid-twentieth century, *musique concrète* demanded a fair bit of knowledge on the part of the appreciative listener. Without understanding its basis in Husserl and its attempts to initiate a new philosophy of music, a listener likely found the work of Schaeffer and Henry baffling. The reviews were often unkind: British critic Reginald Smith Brindle referred to Schaeffer and company as "technicians."[26] The sophistication of the techniques was certainly not obvious to an uninformed listener, and as reel-to-reel tape recorders became an increasingly common piece of home audio equipment, tape composition seemed not to require any particular training. Instructions on how to collect and alter sound, some written decades later, betray the ambivalence even serious scholars of electronic music feel about tape music: on the one hand, it's so simple that you, too, can create electronic music! You may not know a diminished seventh from a perfect cadence, but you can quickly learn to sample and splice. At the same time, these are the very books that take pains to stress the importance of the ideas and of Schaeffer's search for the *objet sonore*. The authors are in the difficult position of trying to foster appreciation for the form without forcing their readers to read Husserl and, at the same time, stave off the clichéd comment about all modern art: "My kid could do that."[27]

3.3 Cologne: Elektronische Musik

German work with tape proceeded from a sharply different philosophy than that in France. In 1948, Homer Dudley, a research physicist at Bell Labs in New Jersey, brought a Vocoder (Voice Operated reCOrDER) to Werner Meyer-Eppler, the director of the Department of Phonetics at Bonn University. The device was intended to synthesize speech, with the hopes that it would point the way toward compression techniques for transmitting the voice over phone lines. The Vocoder piqued Meyer-Eppler's interest in electronic sound more generally, so much so that he completely changed the direction of his research.[28] Together with composers like Bruno Maderna and Herbert Eimert, as well as a handful of other interested musicians and engineers, the German school of *elektronische Musik* that developed was interested in completely artificial sound. Beginning in 1951, the state broadcaster Nordwestdeutscher Rundfunk (NWDR) began sponsorship of a music studio in Cologne (Köln) to explore these ideas.

The Germans believed their efforts to be utterly different from those of the French, and the simmering resentment between the two groups occasionally led to public spats. The strength of the venom was largely due to French resentment of Germany in the aftermath of World War II: Schaeffer recalled, "We had driven back the German invasion but we hadn't driven back the invasion of Austrian music, 12-tone music. We had liberated ourselves politically, but music was still under an occupying foreign power, the music of the Vienna school."[29] Schaeffer referred here not to the Classical or Romantic periods (German music was equally determined to shake itself loose from the forms of Mozart and Beethoven) but to the purer twentieth-century idea of serialism, associated with the Austrian composers Arnold Schoenberg and Anton Webern.

Serialism began in the late nineteenth century as an effort to restore order to music in the wake of atonality and to purge music of the sentimentality of the late Romantic period. The idea was to arrange the twelve notes of the chromatic scale in a fixed order and to use this musical trope as a basic reference for the piece. In the 1950s, composer Pierre Boulez and *elektronische Musik* guru Karlheinz Stockhausen advocated "total serialism," which extended serial methods to rhythm, dynamics, even instrumentation—to all aspects of the piece. It was rigid and limiting, arguably wiping the piece clean of the composer's faintest fingerprint.[30] Electronic sounds were a means to achieve this level of control over the piece, and many of the early German works were developed through additive or subtractive synthesis of the basic sine wave. "Eimert likened his group to visual artists who had to first learn the traditional techniques of oil painting before breaking the rules."[31] (The analogy with twentieth-century visual art would be the many artists who tried to work purely with colour or form.) The composers used Harald Bode's Melochord, a five-octave, touch-sensitive keyboard, which generated fairly pure sine waves. In 1953 and 1954, Bode constructed special versions of the Melochord for the Cologne studio. These could be connected to external devices like reverberation units or white noise generators. The second version had a built-in ring modulator for supplementing the vibrato and filters. "These features make the studio model a precursor of the modular synthesizers introduced in the 1960s," notes Hugh Davies.[32]

Very quickly, the work of the Cologne musicians and the Paris musicians became difficult to distinguish in any clear-cut way. "While calling the music of the Cologne studio 'musique concrète' would have been blasphemous in 1954, there were actually great similarities in the structural and editing approaches used by both studios by that time," Holmes writes.[33] To some extent, this was thanks to Karlheinz Stockhausen, who forged the link between French *musique concrète* and German *elektronische Musik*. He began visiting Schaeffer's studio in the early 1950s while studying in Paris. He was deeply impressed by the possibilities tape composition offered for exploring the structure of sound at its most basic

levels. When he returned to Germany, Stockhausen became associated with the Cologne studio. He continued to work on tape compositions but also scored works for live performance that mixed electronic with traditional acoustic instruments. In *Hymnen* (1966–67), one of his best-known works, he used electronic techniques to transform the recordings of several national anthems. The result is an impressive mixture of found and generated sounds that took up four album sides in its original release. "The work had the unpredictable atmosphere of a collage," as Holmes describes it, "but moved in precise, well-planned stages that unfolded musically through changing sounds and textures."[34]

By the 1970s, several prominent rock groups were using similar techniques for a variety of effects. Perhaps the best-known practitioners were British prog-rockers Pink Floyd, although critic Paul Stump rejects their claim to any philosophical sophistication. He says of "Alan's Psychedelic Breakfast" from *Atom Heart Mother* (1970), "What we are hearing is nothing more than a reportage of events, and their integration into the piece's musical language is somewhat meaningless." He goes on, "It's a very uncharitable view, perhaps, and one that can be taken with hindsight, but the work of Morton Subotnick, Cage, and Stockhausen, exploring the character of noise as music, had been there long before."[35] German groups such as Can, Kraftwerk, and Tangerine Dream were more deliberate in their tribute to Stockhausen and used his ideas in a pop style that is often called Krautrock.[36] In the 1990s, as the ideas of 1950s experimental music began to circulate more widely, Stockhausen was cited by everyone from house and techno producers to Sonic Youth—even if most of the purchasers of their recordings were unaware of this.

3.4 Canada and the United States

North America never developed definitive centres for experimental music in the way that France and Germany did. However, there were pockets of activity comparable to Paris or Cologne, thanks largely to the institutional support of public organizations like the National Film Board (NFB) and National Research Council (NRC) in Canada, and universities in both Canada and the United States. Overall, however, institutional support was considerably weaker than in Europe, even for some of the best-known people in twentieth-century music. John Cage, for instance, a towering figure in experimental music, became acquainted with tape techniques at the home studio of Louis and Bebe Barron, which they had set up in their New York apartment in 1948. The underlying ideas were different, too. Peter Manning says of these collaborations:

> These compositions explored many of the techniques associated with *musique concrète* and to a certain extent *elektronische Musik*, but musically they were motivated by rather different aims. Cage in particular was concerned with exploring principles of indeterminacy: *Williams Mix* and *Imaginary Landscape No. 5* were based on "I Ching" chance operations, involving an elaborate series of tape-splicing and looping routines.[37]

Cage, like Schaeffer, had begun experimenting with transforming recorded music prior to the development of magnetic tape. *Imaginary Landscape No. 1* (1939) used records. He shared some goals in common with the European serialists, but rather than adopting a formal pattern, he used random numbers to determine the characteristics of each tone in his compositions. As a result, the composer had less control over the music than even the strictest serialist—all personal choice and taste were absent from the composition process. This meant that, in some cases, although the work was composed according to exacting rules, it would not sound the same twice. *Imaginary Landscape No. 4* (1951), for instance, called for the performers to tune twelve radios to different frequencies. The chance sound that resulted was in stark contrast to the specifications of the prescribed frequencies.

The efforts of so many twentieth-century composers to do away with the performer was very much at odds with the budding culture of celebrity and may have been, to some extent, a reaction to it. The recording industry had made stars out of Maria Callas and Arturo Toscanini, and they were admired in part because of their artistic temperaments, a testament to their individuality. This individuality was admired not only for its own sake; it supported the very existence of the classical repertoire. The audience for concert-hall music was split into the small, knowledgeable group who appreciated the innovations of composers like Cage, and the vastly larger group of classical music fans for whom the repertoire had stopped growing around the turn of the century. Classical music had become primarily an art of interpretation for the musician in performing and the producer in recording—there were no new compositional ideas to present. Classical music idealized the concert hall, treating the performance as authentic and a recording as exactly that—an imitation, a fungible commodity to be bought and sold in the crass world of commerce. The classical music world was therefore shocked when Canadian pianist Glenn Gould exchanged performance for the studio in 1964. Gould was unusual among classical musicians in championing the unique capacities of recording. The studio, he insisted, was itself a kind of instrument.[38] Electronic music straddled a peculiar balance here: the aesthetics had more in common with high art and serious music than with anything popular or listenable in the usual sense of the term, and even experienced music listeners often found it difficult and obscure. Unlike classical music, however, it was emphatically not about interpretation. Electronic composers used recording technology to set down the definitive and final versions of their work. Everything was in the hands of the composer—there was nothing for a musician to interpret,

nor was there any of the variation that came along with natural sound sources, unless that variation was part of a deliberate effect, as in Cage's music. In the most extreme instances of this, composers actually inscribed the music directly onto the soundtrack.

In 1932, the German inventor Rudolf Pfenninger realized that the timbre of the sound recorded on optical film could be altered. A sound engineer could create a variety of timbres simply by drawing on the medium. In Leningrad, Yevgeny Sholpo invented the Variophone, a device for representing sound graphically, and in Ottawa, the pioneering filmaker Norman McClaren made a series of films with hand drawn soundtracks. An animator with the National Film Board, McLaren called his hand-drawn soundtracks "animated sound." In 1952, he combined hand-drawn sound with the recorded sounds of other instruments in *A Phantasy* and *Two Bagatelles*. In *Blinkety Blank* (1954), the percussive sounds were added by drawing on the film soundtrack. In all, McLaren produced 13 films and a documentary using this technique.[39]

Beginning in 1948, Osmond Kendall, an engineer with the National Film Board, developed the Composer-tron, which used drawn sound techniques. In her biography of Hugh Le Caine, Gayle Young recounts that Kendall then worked with composer Louis Applebaum to explore the possibilities the Composer-tron had for playing exactly what the composer wrote with a grease pencil on the cathode-ray-tube input device—no musician could intervene between composer and audience. Kendall left the NFB to work on a commercial version of the machine but was not successful. In the late 1950s, Hugh Le Caine invented a device that converted drawn patterns on a paper tape to music signals. This Spectrogram was perhaps the last major effort at optical techniques. It was similar in principle to the Hamograph, which used patterns of black tape applied to 35 mm film as the basis for voltage control of the sound envelope.[40] However, none of these saw much influence. Canadian composer David Keane thinks it is "a great misfortune" that drawn patterns were not pursued further:

> Not only does the idea still have merit for the purposes of experienced composers, but it has great potential for music education. The economy and the clear, simple relationship between the graphic notation and the musical outcome would be invaluable to teaching musical principles and for early instruction in composition.

Peter Manning agrees: an "important recording technique, of considerable interest to electronic sound synthesis, lost the support of commercial development."[41]

Magnetic tape was dominant. In the U.S., composers Vladimir Ussachevsky and Otto Luening at Columbia University believed that tape music was a "means for extending

Figure 8: Hugh Le Caine playing the fifth and final version of his Multi-Track or Special Purpose Tape Recorder (1967). (Library and Archives Canada)

traditional ideas of tonality and instrumentation, rather than … a tool for creating a totally new sound."[42] Having recovered from its experience with the theremin, RCA had produced a commercial synthesizer, the Mark I. Ussachevsky, Luening, and Milton Babbitt at Princeton succeeded in securing space at Princeton to experiment with the new machine. Their input was valuable in the design of the Mark II synthesizer, and its installation at Columbia in 1959 marked the inauguration of the music studio there. In the absence of state broadcaster support, this university support was critical to earning respect in the U.S.: "Acceptance of the medium as a credible art form within the broader music community proved very much harder for those who worked outside these important spheres of influence."[43] Edgard Varèse, for example, was not associated with any university and never managed to convince anyone to provide him with studio facilities. He worked mainly from his home in Greenwich, New York. By the 1950s, he had given a name to his philosophy of music: "organized sound."

The organizers of the Philips Pavilion for the World's Fair in Brussels in 1958, after much convincing from the architect Le Corbusier, were willing to take a chance on this technophilic and futuristic style. Varèse composed the music for *Poème électronique*, a multimedia installation that integrated the architecture of the building with light, colour and sound. A rhythmic and repetitive piece was looped to play continuously through 425 speakers, which were activated at different intervals so that the listening experience varied with location. The installation remained in place throughout the fair, and by its close, a large number of ordinary people had been introduced to a new kind of music. Iannis Xenakis, who began the project as Le Corbusier's assistant, turned to electronic music composition following its completion.[44] Studios continued to be established. In 1958, Gordon Mumma and Robert Ashley opened a private studio in Ann Arbor, Michigan, and Lejaren Hiller began directing the music studio

Figure 9: Le Caine's Serial Sound Structure Generator, designed in consultation with Gustav Ciamaga for the University of Toronto (1965–1970). (CSTM 1991.0222)

Figure 10: The Sonde could generate 200 sine waves simultaneously. This prototype was later installed at Queen's University. (Tom Alföldi / CSTM 1986.0154)

at the University of Illinois. The San Francisco Tape Music Center, whose founders included Ramon Sender, Morton Subotnick and Pauline Oliveros, was originally independent but became part of Mills College in 1966.[45] It later became the birthplace of the Buchla synthesizer.

Canada was perhaps more fortunate in having public institutions that could support experimental music, although, according to Peter Manning, electronic music in Canada "remained strangely isolated from developments in America and Europe at this time."[46] Physicist Hugh Le Caine was by now a major figure in electronic music in Canada. Arnold Walter of the Faculty of Music at the University of Toronto had sought his advice on the establishment of an electronic music studio at the university, and the NRC agreed to support this plan by building the specialized equipment necessary for composition. Walter also negotiated support from the CBC and the NFB. The University of Toronto Electronic Music Studio opened in June of 1959. Le Caine had also been in touch with the Montreal-based composer István Anhalt, who hoped to establish European-style studios in Canada to take advantage of the native talent pool. After a few years of working with Le Caine's instruments, Anhalt persuaded McGill University to establish a studio, which opened its doors in 1964. Simon Fraser University in Burnaby, British Columbia, opened the doors of an electronic music studio in 1967, where Murray Schafer established the World Soundscape Project to explore the sounds in which we are immersed.[47] The relationship between the studios and the NRC was sometimes lopsided, due in no small part to the vastly different areas of expertise of the

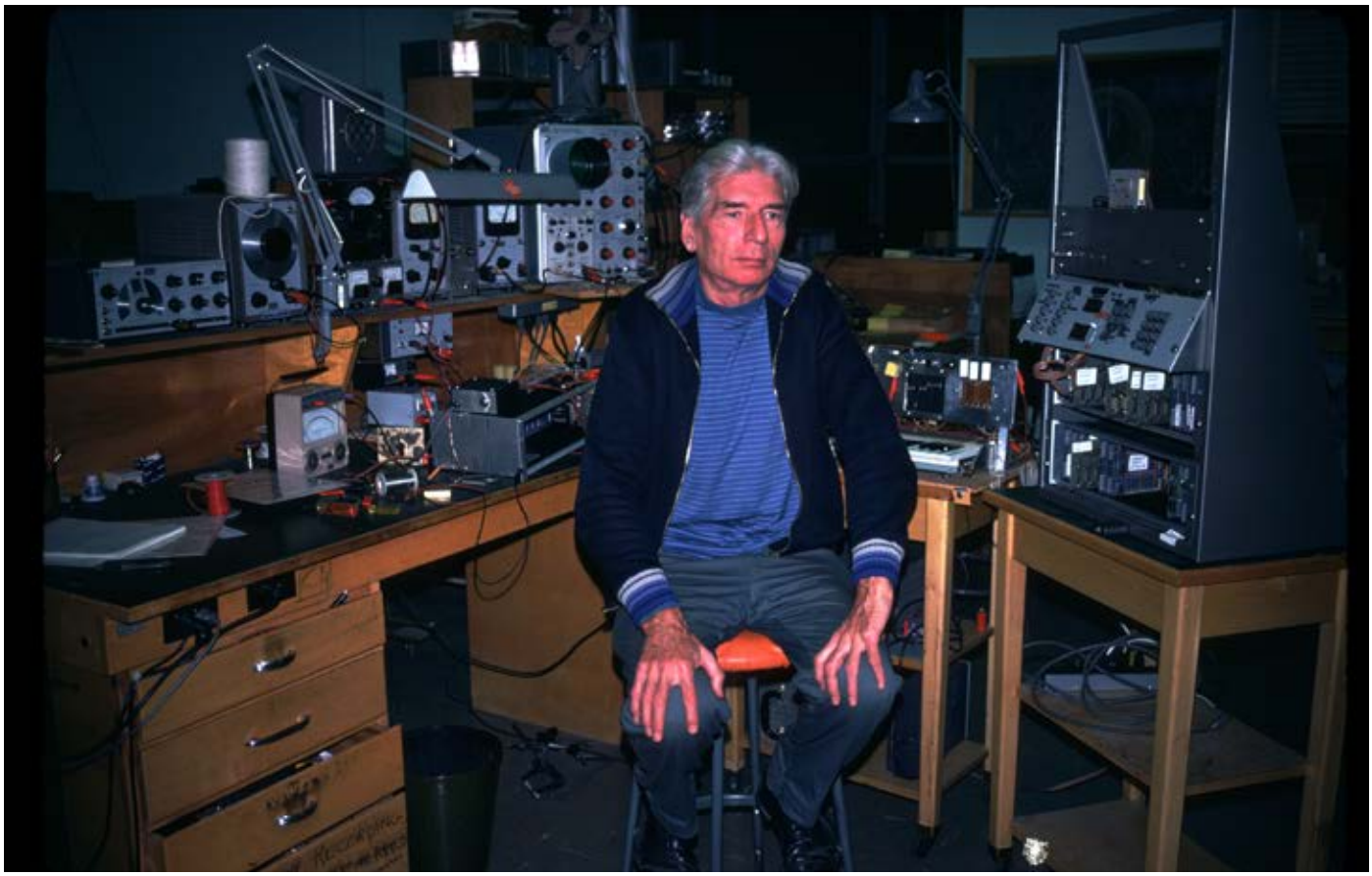

Figure 11: Hugh Le Caine in his National Research Council lab (1974). (Paul Pedersen)

people involved. As Gayle Young comments,

> From the point of view of the NRC lab, the ideal relationship with the university studios would have been a close collaboration between Le Caine and the composers…. There would have been a complete cycle of idea and feedback followed by further refinement. However, there was little detailed discussion of alternatives or improvements. The studios were grateful for the equipment they received and may have hesitated to respond critically.[48]

Among the instruments they now had access to was Le Caine's Multi-Track or Special Purpose Tape Recorder, which Le Caine had used in 1955 to compose a short piece to demonstrate the device's possibilities for recording and mixing. That piece, based on the sound of the fall of a single drop of water, was called "Dripsody" and became the best-known example of *musique concrète*, used (as Elliot Schwartz wryly remarks) "in nine out of every ten classroom lectures on electronic music ever given." The Multi-Track was much in demand, and the NRC received requests from institutions as far away as Hebrew University in Jerusalem.[49]

Le Caine was a busy man in the 1950s and 1960s. In addition to the Multi-Track and the Spectrogram, Le Caine had developed a key-controlled oscillator bank to generate electronic sounds, various devices to give the composer finer control over the sound envelope and the Serial Sound Structure Generator, which automated control of the characteristics of sound and anticipated some of the features of the first sequencers that appeared on analog synthesizers. He also produced the Sonde, which could generate up to 200 sine waves at the same time. "The Sonde simplifies the work for a composer wishing to generate complex sine-tone mixtures. Here no tuning of individual oscillators is necessary. The volume of each of the 200 tones was controlled by a single slider in twenty amplitude volumes." The advantage for the composer was minimal re-recording—no trivial thing, since each act of re-recording added to the background hiss of the final tape.[50]

Le Caine was an enormous influence on the next generation of electronic music composers in Canada, both because of his instruments and because of the institutional support he was able to secure for them. However, none of his instruments was ever manufactured on a commercial scale. Although his Polyphone synthesizer, designed in 1970 for the McGill studio, was one of the best polyphonic analog

synthesizers of the era, it remained in the hands of musicians fortunate enough to work in university music studios. Nor did the music that was composed in these studios gain much of an audience: Canadians had no more to be ashamed of on this count than their American and even European counterparts—outside of musically sophisticated circles (admittedly more common in Europe), most people found the music obscure at best. Meanwhile, electric instruments and electronic techniques—including many of the techniques pioneered in these studios—were enjoying popularity and diffusion on a grand scale through the innovative recordings of rock and pop musicians.

Notes

1 Jonathan Sterne, *The Audible Past* (Duke Univ. Press, 2003) 293. Philips is best known for his military marches. By the time Meredith Wilson wrote the hit Broadway musical *The Music Man* in 1957, John Philips Sousa marches were the cartoonish antidote to an even more cartoonish idea of juvenile delinquency. Kimberly Fairbrother Canton calls this Wilson's defense of the superiority of a middlebrow aesthetic that included barbershop quartets and similarly nostalgic ideas of an ideal American past. "'Who's Selling Here?': Sounds Like the Music Man is Selling and We're Buying" *Modern Drama* 51, no. 1 (Spring 2008) 42-59.

2 Garry Joel August, "In Defense of Canned Music," *The Musical Quarterly* 17 No. 1 (Jan., 1931) 148.

3 "On the Fetish Character of Music and the Regression of Listening," (1938) *Essays on Music* , Richard Leppert ed. (University of California Press, 2002) 296, 298.

4 On the development of the role of the recording engineer, see Susan Schmidt-Horning, "Engineering the Performance: Recording Engineers, Tacit Knowledge, and the Art of Controlling Sound," *Social Studies of Science* vol. 34, no. 5 (2004) 703-731.

5 Jonathan Sterne, *The Auditory Past* (Duke Univ. Press, 2003) 160.

6 On reading and private life, see, for example, Michelle Perrot, ed., *A History of Private Life* vol. IV: *From the Fires of Revolution to the Great War* trans. Arthur Goldhammer (Harvard Univ. Press, 1990) and Cecile M. Joagdzinski, *Privacy and Print: Reading and Writing in Seventeenth Century England* (University of Virginia Press, 1999).

7 Eisenberg, *The Recording Angel: Music, Records, and Culture from Aristotle to Zappa* 2nd edn. (Yale Univ. Press, 2005) 132, 143.

8 Ibid., 204.

9 Robert Philip, *Performing Music in the Age of Recording* (New Haven: Yale University Press, 2004) 137.

10 Norman McLaren is still the only filmmaker of any note to have experimented with drawing a soundtrack onto film, and probably because of his achievements, there was a brief flurry of interest in Canada. Other centres for this activity were in Leningrad and Germany in the 1930s – see Dunn, "History of Electronic Music Pioneers," 27. Several devices that used photoelectric means to sample and play back sounds were developed during this period, however, including the Hardy-Goldthwaite Organ and telephone speaking clocks. See Davies, "A History of Sampling," *Organised Sound* Vol. 1, No. 1 (1996) 7. Michael Chanan covers the major developments in the history of recording technology in *Repeated Takes.*

11 Talkies soon had the effect of putting theatre musicians out of work in a way that Thaddeus Cahill could not have imagined. Douglas Gomery, "The Coming of Sound: Technological Change in the American Film Industry" *Technology and Culture – The Film Reader*, Andrew Utterson, ed. (New York: Routledge, 2005) 53-67; Preston J. Hubbard, "Synchronized Sound and Movie-House Musicians, 1926-29," *American Music* vol. 3, no. 4 (Winter 1985) 429-441; James P. Kraft, "The 'Pit' Musicians: Mechanization in the Movie Theaters," *Labor History* 35 (1994) 66-89; Donald Crafton, *The Talkies: American Cinema's Transition to Sound, 1926-1931* (New York: Scribner, 1997). On recording more generally, see André Millard, *America on Record: A History of Recorded Sound* (New York: Cambridge University Press, 1995) and Mark Katz, *Capturing Sound: How Technology Has Changed Music* (Berkeley: University of California Press, 2004). Katz's book has an accompanying disc. For an overview of some of the patents taken out on various recording techniques, see Davies, "A History of Sampling," pp. 3-7.

12 Manning, *Electronic and Computer Music*, 13.

13 Mark Clark, "Suppressing Innovation: Bell Laboratories and Magnetic Recording," *Technology and Culture* 34 (July 1993) 517-520. See also Matthew Malsky, "Stretched from Manhattan's Back Alley to the MOMA: A Social History of Magnetic Tape and Recording," in René T.A. Lysloff and Leslie C. Gay, Jr., eds., *Music and Technoculture* (Middletown CT: Wesleyan Univ. Press, 2003) 233-263.

14 Brian Eno in *Audio Culture: Readings in Modern Music*, Christoph Cox and Daniel Warner, eds. (New York: Continuum, 2004) 128; Holmes, *Electronic and Experimental Music*, 78.

15 Cox and Warner, *Audio Culture* 5. John Cage set down his ideas in "Experimental Music: Doctrine," *Silence* (Middletown: Wesleyan University Press, 1961.)

16 *Listener's Guide*, 278. Schaeffer described his philosophy in *La musique concrète* (Paris: Presses Universitaires de France, 1967). For recent assessments, see Jean-François Augoyard, et al., *Ouïr, entendre, écouter, comprendre après Schaeffer* (Paris: INA-GRM/Buchet-Chastel, 1999); Robert Martial, *Communication et musique en France entre 1936 et 1986: Des transmissions Orphée* (Paris: L'Harmattan, 1999) and *Pierre Schaeffer: de mac luhan au fantôme de gutenberg* (Paris: L'Harmattan, 2002).

17 *Audio Culture*, 17.

18 Rule, "Kraftwerk: Architects of the Trans-Global Express," in Rule, *Electro-shock!* 184.

19 Taylor, *Strange Sounds*, 45. Davies, "A History of Sampling," p. 7, lists several other people doing similar work with discs, though none of them had "Schaeffer's sustained and developing compositional activity:" Tristram Cary in London, Paul Boisselet in Paris, Raymond Chevreuille in Brussels, and Maurico Kegel in Buenos Aires.

20 Manning, *Electronic and Computer* Music, 23. See also Trevor Wishart, *On Sonic Art* (The Netherlands: Harwood, 1996).

21 Cited Dominique and Jean-Yves Bosseur, *Révolutions Musicales* (Minerve, 1999) 25.

22 Manning, *Electronic and Computer* Music, 23-24.

23 Schaeffer developed a system of musical notation for the performance of these pieces. See Manning, *Electronic and Computer Music*, 25, 28-36. A good close musical analysis of Schaeffer's music, as well as Karlheinz Stockhausen and Varèse's *Poème Électronique* is David Ernst, *The Evolution of Electronic Music* (New York: Schirmer, 1977).

24 Manning gives the impression that these recorders were part of the equipment furnished by RTF; every other source indicates that Poullin and Schaeffer were responsible for building them. Davies says that Schaeffer took out a patent on the phonogène in "A History of Sampling," but most authors credit Poullin with the design and building of the phonogène and morphophone. See, for example, Joel Chadabe, "The Great Opening Up of Music," www.arts-electric.org/articles/060205.grm.html.

25 Manning, *Electronic and Computer Music*, 26.

26 Taylor, *Strange Sounds,* 45.

27 DIY instructions are in Schwartz, *Electronic Music: A Listener's Guide*, pp. 263-283, Deutsch, *Electroacoustic Music*, 64, and in greater detail, with accompanying discography, in Barry Schrader, *Introduction to Electro-Acoustic Music* (Englewood Cliffs, NJ: Prentice Hall, 1982). A more professional take on things is Samuel Pellman, *An Introduction to the Creation of Electro-Acoustic Music* (Belmont CA: Wadsworth Publishing, 1994), a useful starting point for any would-be electronic musician. A more recent (listenable!) example of *concrète* is the innovative 1998 house album *Around the House*, which includes a variety of found domestic sounds. It was reissued in 2002: Herbert, *Around the House* (!K7, 2002).

28 The vocoder would later be used by German synth band Kraftwerk.

29 Cited in Holmes, *Electronic and Experimental Music*, 100, note 25.

30 Paul Griffiths, "Serialism," in Denis Arnold, ed., *The New Oxford Companion to Music*, (New York: Oxford University Press, 1983) 1668-1670; Robin Maconie, *Other Planets: The Music of Karlheinz Stockhausen* (London: Oxford University Press, 2005); Jonathan Harvey, *The Music of Stockhausen: An Introduction* (Berkeley: University of California Press, 1975); Karlheinz Essl, "Algorithmic Composition," Nick Collins and Julio d'Escriván *The Cambridge Companion to Electronic Music* (Cambridge Univ. Press, 2007)107-125.

31 Holmes, *Electronic and Experimental* Music, 103.

32 Davies, "Melochord," *The New Grove Dictionary of Musical Instruments*, 641.

33 Holmes, *Electronic and Experimental Music*, 104.

34 Holmes, *Electronic and Experimental* Music, 142. See also Herbert Eimert, "How Electronic Music Began," *The Musical Times* Vol. 113, no. 1550 (April 1972) 347-349. For the influence of American experimental music on the Germans in the context of the Cold War, see Amy C. Beale, "Negotiating Cultural Allies: American Music in Darmstadt, 1946-1956," *Journal of the American Musicological Society* 53 (Spring 2000): 105-139.

35 Paul Stump, *The Music's All That Matters: A History of Progressive Rock* (London: Quartet Books, 1997) 67.

36 See Simon Reynolds, "Kosmik Dance: Krautrock and Its Legacy," in Peter Shapiro, ed. *Modulations – A History of Electronic Music: Throbbing Words on Sound* (New York: Caipirinha Productions, 2000) 26-37, and Manning, *Electronic and Computer* Music, 174-175.

37 Manning, *Electronic and Computer* Music, 75.

38 Glenn Gould, "The Prospects of Recording" and "Music and Technology" in *The Glenn Gould Reader* (New York: Knopf, 1984). Gould's ideas on the studio, while not specifically on electronic music, are fascinating reading, and make an interesting supplement to the various uses that electronic musicians were making of multi-track recording and mixing. See also Symes, *Setting the Record Straight*. On the effects of recording more generally (and some speculation about where it is headed), see Eisenberg, *The Recording Angel*, and David Kusek and Gerd Leonhard, *The Future of Music: Manifesto for the Digital Music Revolution* (Boston MA: Berkelee Press, 2005).

39 Keane, "History of Electro-Acoustic Music in Canada," and Young, *The Sackbut Blues*, 57. On Norman McLaren more generally, including his animated sound innovation, see William E. Jordan, *Norman McLaren: His Career and Techniques* (Montreal: National Film Board, 197-); Maynard Collins, *Norman McLaren* (Ottawa: Canadian Film Institute, 1976); Valliere T. Richard, *Norman McLaren, Manipulator of Movement: The National Film Board Years, 1947-1967* (Newark, NJ: University of Delaware Press, 1982); and Alfio Bastiancich, *McLaren, précurseur des nouvelles images*, Traduit de l'italien par Marlène di Stefano (Paris: Dreamland, 1997).

40 Young, *The Sackbut Blues*, 200-201, 123.

41 Keane, "Electro-Acoustic Music in Canada." Good secondary material on the Composer-tron is almost non-existent, and the brief acknowledgements that are available are inconsistent with each other. Elaine Keillor, in a review excoriating Walter Pitman for his many errors in his biography of Canadian composer Louis Applebaum, refers to the inventor as *Ken* Kendall: "Louis Applebaum: A Passion for Culture," (book review) *CAML Review/Revue de l'ACBM vol.* 31 no. 1(April 2003) 28-30. David Keane spells the name of the instrument *Compositron* in his "History of Electro-Acoustic Music in Canada." *The Sackbut Blues*, 57; Hugh Davies, "Composertron," *New Grove Dictionary of Musical Instruments*, 450; Manning, *Electronic and Computer Music*, 14.

42 Manning, *Electronic and Computer Music*, 76.

43 Ibid., 77.

44 Mark Treib, *Space Calculated in Seconds: The Philips Pavilion, Le Corbusier, Edgard Varèse* (Princeton, N.J.: Princeton University Press, 1996). Brian Eno would later develop a similar-sounding music that he called Environmental Ambient.

45 On Ashley and Mumma, see Holmes, *Electronic and Experimental* Music, chapter 9. On Oliveros, see Heidi Von Dunden, *Music of Pauline Oliveros* (Metuchen, N.J.: Scarecrow Press, 1983). The San Francisco Tape Music Center first got funding in 1964, but it began when Sender and Subotnick pooled their audio equipment in 1961. In 1966, it moved to Mills College in Oakland, California, and was renamed the Center for Contemporary Music. Holmes, *Electronic and Experimental* Music, 207-208.

46 Manning, *Electronic and Computer* Music, 156. One notable exception was the Pauline Oliveros's visit to the Toronto studio in 1966, which resulted in several compositions. Perhaps the reason for Canada's isolation was the very institutional support that gave rise to its studios: people at the National Research Council moved in scientific circles, rather than artistic ones.

47 Manning reports that there were also studios founded in Vancouver (1964), and at Laval, QC (1968), but gives no other details – *Electronic and Computer Music*, 156. On the World Soundscape Project, see http://www.sfu.ca/~truax/wsp.html and R. Murray Schafer, *The Tuning of the World* (New York: Knopf, 1977).

48 Young, *The Sackbut Blues*, 137.

49 Schwartz, *Listener's Guide*, 131.

50 Young, *The Sackbut Blues*, 217.

4. The Beginnings of a Mass Market

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4.1 Electric Pianos

The market for the piano was more mature than for most other instruments. Although the handcraft tradition never disappeared, Théberge points out that the "mechanical character of its design" meant that it was "well suited to modern factory manufacturing processes," and its versatility as well as its signification of a certain level of material achievement made it part of a buoyant market in the early twentieth century.[1] An electric piano would have to compete directly with acoustic pianos, since most consumers would see them as substitutes. There is some evidence, however, that companies threw their allegiance behind the electric piano after World War I in the hopes of reviving a flagging market. Tom Darter reports that sales of pianos slumped in the years following World War I, a phenomenon attributed to the availability of the phonograph and the radio.[2]

Early attempts to electrify the piano were in the form of amplification.[3] In the mid-1920s, a Chickering player piano in Atlantic City was amplified by microphone. Fred W. Roehm and Frank W. Adsit developed the Radiano microphone specifically for the piano, in order to improve its fidelity in radio broadcasts. Simon Cooper's Crea-Tone (1930) used electromagnets to prolong the vibrations of the strings, a principle that had been experimented with nearly four decades earlier, first with a bowed piano (the bow was pressed to the strings using electromagnets) in 1892, and later with the Choralcelo.[4] The Variachord (1937) had strings that were activated and amplified electrostatically. Lloyd Loar, best known for his early electric guitars, also invented an electric piano, the Clavier (1934). Like Selmer's Pianotron (1938) and Hohner's Pianet (1962), it used plucked reeds, rather than hammers and strings, as its sound source. Richard R. Smith reports that "a prototype electric piano sat in [Loar's company] front office for years."[5]

Where electricity promised real improvement over the acoustic version of the instrument, however, was in portability. The acoustic piano (like the guitar) has a soundboard, which is a large, thin piece of wood that spreads the vibrations of the strings throughout the body of the instrument, so that the entire instrument acts as an amplifier. Inventors experimenting with electricity found that they could eliminate the soundboard since the vibrations of the strings were converted via electromagnetic pickups (as in the Neo-Bechstein Flügel and Radiopiano) or by electrostatic transducers (as in Benjamin Miessner's Electronic Piano). Eliminating the soundboard also made it possible to use shorter, thinner strings and a lighter framework, making the instrument itself lighter and, therefore, its inventors hoped, more portable. In the course of developing the Neo-Bechstein Flügel, Walter Nernst and Oskar Vierling found that this gave their instrument too light a touch in comparison to a conventional piano. They solved this by using heavy hammers to strike a rail that drove a smaller hammer into the lighter, thinner string. The result was an "unusually pure" tone with an increased sustain. In fact, they found they had to use dampers to make sure that the sustain was like that of a conventional piano—without a soundboard to absorb energy, the strings could resonate for up to a minute.[6] The final commercial version included a radio and phonograph in the speaker cabinet. "This was a typical arrangement on electric pianos well into the Forties," Tom Darter writes.[7]

Benjamin Miessner began by experimenting in radio, later selling his patents to RCA and using the funds to set up a lab in Millburn, New Jersey, in 1930. Based on his brother Otto's experiences as a music teacher, Miessner hoped to develop a piano that was lighter and cheaper, and would not easily go out of tune. He tried reeds, tuning forks, rods and bars, and finally settled on strings with pickups at several points along each "to select and mix various partials to produce various tone colours." The instrument was demonstrated to the American Institute of Electrical Engineers in 1932 (along with the Rangertone organ and the theremin) and was well received. Miessner licensed his inventions, and they were used in the Minipiano (Hardman, Peck & Co.), the Electone (Krakauer Bros., 1938), the Dynatone (Ansley Radio Corporation, 1945), and the Storytone (Story and Clark). Bernhardt's Furniture in Windsor, Ontario, produced the Miessner pianos in Canada.[8] Miessner then developed a Stringless Piano, which attempted to reduce a muddiness in the sound of his original invention, the result of the low damping rate of the strings. In 1955, he developed the instrument that was the basis for Wurlitzer's electric piano, which used thin, steel reeds struck by hammers at the third partial. The pickups were arranged to negate the second partial of each reed. The design gave the piano a more piano-like sound.[9]

The idea of producing a teaching instrument was also the force behind the Rhodes Electric piano, whose inventor began in World War II with small, 2.5-octave instruments cobbled together from spare parts salvaged from disabled planes. Harold Rhodes had built these to teach piano to patients in an army hospital, a humanitarian project for which he was later decorated. After the war, he began experimenting

with electrostatic pickups and entered into a partnership with Leo Fender. This resulted in the Fender-Rhodes and the Piano Bass, a 32-note instrument that debuted in 1960. However, Rhodes was never really happy with Fender ("too many cooks in the kitchen," he said) and took advantage of the chance to work more independently following the CBS buyout of Fender in 1965.[10] Rhodes soon saw the Suitcase 73, a full electric piano, come to market. The result was an enduringly popular instrument, whose sound continues to be sampled for synthesizers today. Miles Davis insisted that his keyboardists use it. Ray Charles, Stevie Wonder, and (later) Billy Joel adopted it. Charles is reported to have called it "an atom bomb that changed the musical landscape. Everything was changed forever."[11]

The German electrical engineer and instrument designer Harald Bode was responsible for the polyphonic Warbo Formant Orgel (1937)—often referred to as an organ— and the Melodium, a touch-sensitive keyboard instrument (1938). These were not actually organs but keyboard instruments with timbre and envelope control. However, it was on the basis of these successful instruments that Bode went on to design electronic organs for several companies, including a tone-wheel instrument for the Estey Organ Company. Estey brought him to the United States in 1954, and Bode eventually took a position with Wurlitzer. The manufacture of electronic organs expanded enormously during this period, and talented designers like Bode were very much in demand. He recognized early on the revolutionary potential of transistors for electronic instruments, and his work on transistorized instrument design was critical to the achievements of synthesizer pioneers Robert Moog and Donald Buchla.[12]

4.2 Electronic Organs

Another promising market for electric and electronic instruments was among those who wanted something with the voicing versatility of a pipe organ, but smaller (perhaps even portable) and cheaper. The electronic organs of the late 1920s and 1930s, like Richard Ranger's Rangertone and the Hammond Organ, used motor-driven alternators with rotational speeds corresponding to particular electrical frequencies to produce the standard 12-note chromatic scale—exactly the principle behind the Telharmonium. But these instruments were far smaller; they were similar in size to a conventional upright piano. Although they used tone wheels, the power, sound-mixing and amplification were vacuum-tube based. The Rangertone, developed and sold in the late 1920s and early 1930s, saw little commercial success (although Ranger went on to develop successful portable lip-synchronous recorders for the film industry).[13] The Hammond Organ, on the other hand, was very successful, possibly because inventor and businessman Laurens Hammond had a flair for bringing inventions to market. Hammond first demonstrated his organ to the public in 1935, and it went into commercial production almost immediately after. He benefited from a little luck—the Cahill family likely had grounds for contesting Hammond's 1934 patent on tone wheel sound generation, had they been so inclined. The instruments were still limited in their timbral quality: as Hugh Davies points out, the electronically generated frequencies are all perfectly in phase, meaning the instruments do not have the richness that comes from the natural variations of sound generated by a pipe organ. In 1937, Hammond introduced a second tone wheel to produce sound very slightly out of tune with the main wheel. The 1954 B-3 model is the best-known of the Hammond organs. When used with Don Leslie's rotating speakers, it had a distinctive "tremulant effect" that ensured its passage from African-American churches into jazz, rhythm and blues and rock music. The vacuum-tube components of these organs were also, Théberge notes, characteristic of the "transition from mechanical technologies to purely electronic devices."[14]

Figure 12: Hammond's polyphonic Novachord was technically ambitious but too unstable for commercial success. (Tom Alföldi / CSTM 1977.0258)

In the late 1930s, the Hammond Organ Company unveiled the polyphonic Novachord and the monophonic Solovox, which used vacuum tubes to generate a purely electronic sound. The Novachord was a particularly ambitious instrument, with a wide range of controls for expressivity that brought it much closer to the voices of various orchestral instruments. Composer Ferde Grofé conducted an "orchestra" of four Novachords and a Hammond A for the 1939 World's Fair in New York[15] However, the Novachord's workings were too complicated and its circuitry components were not reliable. The Hammond company stopped manufacturing it within a few years. The Solovox, designed by John Hanert, was part of the family of piano attachments—small instruments with their own tone cabinets intended to be attached to a piano or organ. Several other similar but shorter-lived

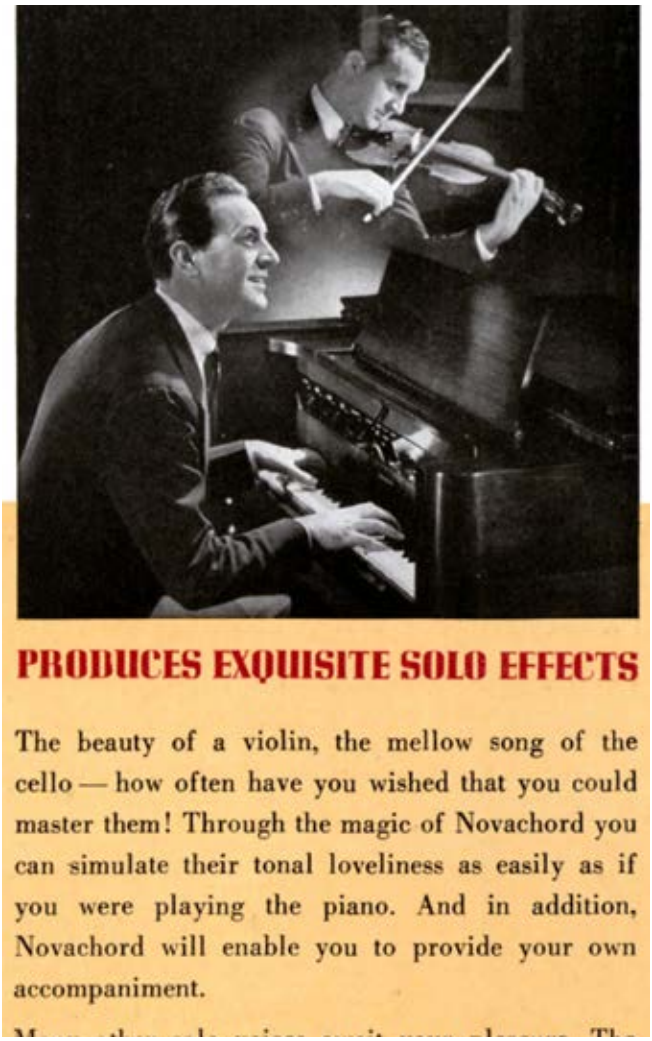


Figure 13: Detail from a brochure for the Hammond Novachord (1939). (CSTM L44521)

Figure 14: Hammond Solovox keyboard attached to piano (right) and tone chamber (left). This keyboard's brass legs were custom-made to obviate screwing the keyboard to the piano. (Tom Alföldi / CSTM 2002.0406)

Figure 15: Detail of Solovox keyboard and voice tabs. (Tom Alföldi / CSTM 2002.0406)

attempts at an entirely vacuum-tube organ were made during this time: Edouard Coupleaux and Armand Givelet's organ, which used punched paper rolls to control the quality of its sound; Constant Martin's Clavioline (licensed to both the Gibson and Selmer companies); and John Compton's Electrone. "In addition, various instruments appeared using techniques such as vibrating reeds combined with electromagnetic pickups (including the Orgatron, invented by F.A. Hoschke in 1935 and later sold by Wurlitzer) and photoelectric means (such as the Photona of Ivan Eremeef, 1935)."[16]

Of these, the Clavioline saw the most popular success when it was used by the UK band the Tornados on *Telstar,* a record produced by Joe Meek. "The finished result," Mark Brend writes, "was … the most radical British rock 'n' roll record yet recorded…. It is the sound of the record that grabs attention right from the bubbly, fizzing electronic trickery that the listener hears." The Musitron on the instrument break in Del Shannon's monster hit "Runaway" (1961) was a modified Gibson Clavioline. Keyboardist Max Crook modified it with "some resisters—it was too early for transistors—tubes from television sets, parts from appliances and other such household items." He added controls for timbre and vibrato and other tonal effects, and modified the circuits to increase the instrument's range.[17] The Jennings company brought out the very similar Univox to compete with the Clavioline. "Acting on pure faith that a small monophonic keyboard fitted with an amp and speaker would be something that people would want, [company head Tom] Jennings hired a technician named Derek Underdown to design the Univox." Despite a fierce advertising war, the Clavioline prevailed.[18] The Vox Continental organ, a transistor-based instrument, is preserved as the memorable vibrato on the Doors' "Light My Fire" and the Animals' "House of the Rising Sun." Iron Butterfly used it to great effect on "In-A–Gadda-Da-Vida." Its popularity soon waned—musicians preferred the Hammond and Leslie

Figure 16: Morse Robb (mid-1920s) with prototype tone wheels in phonograph cabinet. (CSTM 1981.0484 S.I.)

speaker combination, or the new, lighter electric pianos—but it was taken up later by Blondie and Elvis Costello & the Attractions. The sound also survived in synthesized form, in the music of Prince and the B-52s. Mark Vail mentions that the rival Farfisa organ became popular with up-and-coming Manchester dance bands in the early 1990s.[19]

Canadian Morse Robb also invented an electronic organ and experimented with touch-sensitive keyboards, beginning in 1926. According to Canadian composer David Keane, Robb "was the first inventor anywhere to succeed in developing an electronic organ." Like the Hammond organ and the Telharmonium, the Robb Wave Organ used tone wheels, but each of these "was edged in the shape of sound waves photographed from a cathode-ray oscillograph," making it an early version of a sampler—albeit via a cumbersome route. Despite the musicality that this design gave the instrument, Robb had difficulty finding a manufacturer, particularly after the onset of the Depression. In 1934, he found enough wealthy backers to see the Robb Wave Organ Company incorporated. One investor was Lady Flora Eaton, who saw to it that the Eaton's department stores in Toronto and Montreal had Robb Wave Organs. (Since Eaton's sold the instruments, this was also good business sense.) Hugh Le Caine heard a Wave Organ demonstrated at Queen's University in 1937 and visited the factory. But the instrument never succeeded in gathering the momentum that the Hammond or the non-electronic Wurlitzer did, and it ceased to be available

Figure 17: Robb Wave Organ, prototype tone wheels. (Tom Alföldi / CSTM 1991.0484)

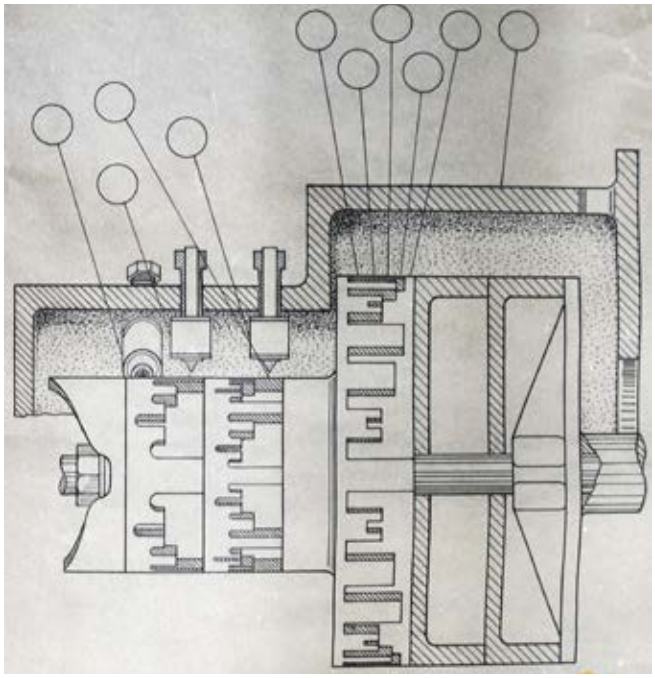


Figure 18: Technical drawing showing Robb Wave Organ tone wheel and pickups. (CSTM L31046)

shortly thereafter.[20] Possibly the Canadian market was simply too small to nurture instruments all on its own.

4.3 Mixed Success: Hugh Le Caine, Raymond Scott and Harry Chamberlin

Certainly Canadian physicist Hugh Le Caine, despite developing the first voltage-controlled synthesizer in the late 1940s, never saw much commercial success. It is no easy thing to assess Le Caine's role in the general history of electronic music. Partly by virtue of his citizenship, there is a substantial body of archival material in Canada

Figure 19: Hugh Le Caine's Electronic Sackbut, completed in 1948, was the world's first voltage-controlled synthesizer. (CSTM 1975.0336)

Figure 20: Hugh Le Caine demonstrates the Electronic Sackbut for His Royal Highness, Prince Philip (1954). (Library and Archives Canada, PA-167153)

and an exhaustive biography.[21] But it is far from clear that his instruments had any direct effect on the development of musical technology, even though many of the features of the Electronic Sackbut became popular decades later.[22] Holmes notes that Le Caine was a frequent contributor to the engineering literature and had a significant influence on Robert Moog and composer Pauline Oliveros. However, Le Caine's overall effect on the history of electronic music was less than the ingenuity of his inventions—particularly the voltage-controlled synthesizer—would suggest. Holmes concludes that Le Caine was content to remain "behind the scenes, allowing the spotlight to fall on the musicians with whom he worked." Le Caine was not inclined to pursue recognition or commercial success, and as a result his influence is often overlooked.[23]

Like Theremin, Le Caine came to instrument invention via the exact sciences. Although he showed an aptitude for music from a young age, he was always more interested in the technical aspects of tone creation. Biographer Gayle Young cites the notes he made on his piano lessons at the Royal Conservatory in Toronto following his first year in engineering at Queen's, which begin: "The key while descending approximately 0.35 inches activates a train of levers which imparts a velocity to the hammer."[24] Le Caine was trying to analyze his way to a more musical keyboard touch, and while he would not succeed with this on the conventional piano, touch-sensitive keys would be among the most significant aspects of his electronic instruments. In 1937, inspired by a Hammond organ that belonged to Chalmers Church in Kingston, Ontario, and further buoyed by the demonstration of the Robb Wave Organ on the Queen's University campus, Le Caine began work on his own electronic organ. The professor he was working for was supportive, since it would give Le Caine extensive experience in circuit design. The result was the free reed organ, which never saw an existence beyond experimental prototype but—much as Le Caine's professor had hoped—resulted in a new kind of galvanometer that the department's atomic physicists found very useful. Le Caine's professors and co-workers would support any future lab time he devoted to musical instruments—one never knew when a device practical for their own work might emerge.[25]

Le Caine went on to join the National Research Council in Ottawa but continued to work on instruments in his spare time. Between 1945 and 1948, he developed the first voltage-controlled synthesizer, the Electronic Sackbut. (He built three versions in total, occupying him off and on throughout his life.) The original instrument was rough looking, and Le Caine never saw any need even to remove the staples in the boards that made up the stand. True to the aims of the experimental physicist, his goal was to perfect volume, pitch and timbre control, rather than produce anything a consumer might find attractive. As with a piano, a player could produce a louder note just by striking the key harder, since the displacement of the key was converted to voltage through a pair of condensers at each end of the keyboard. The technique anticipated the voltage-controlled Moog synthesizers of the 1960s. "The sum of the pressures exerted on both condensers was equal to the downward pressure on the key regardless of which key was being depressed, so the response was uniform across the keyboard," biographer Gayle Young notes.[26] The keys also allowed a glide between consecutive notes simply by pressing the key sideways towards the next key. Timbre control was equally sophisticated: a touch-sensitive pad for the left hand controlled the waveform. Public demonstrations convinced the NRC to allow Le Caine to work full time on electronic instruments beginning in 1954. Thom Holmes remarks, "This was a privileged position seldom afforded to an engineer of music technology in any country."[27]

Ironically, this may be why none of Le Caine's instruments was marketed successfully, despite the fact that the purpose

Figure 21: Le Caine's Polyphone: "One of the most powerful and least-known analog synthesizers of all time." (Tom Alföldi / CSTM 1986.0004)

of the NRC Music Laboratory was "to develop new electronic instruments to a point where they could be manufactured by Canadian companies." Unlike Cahill or Theremin, neither Le Caine nor the NRC had any need to see any of these projects through to a stage where they might have produced an income. The commercial potential of the Electronic Sackbut, for instance, was not recognized until nearly two decades later, after small synthesizers had already become available on the market.[28] Even when the synthesizer became an instrument that every hopeful musical group wanted to acquire, Le Caine never saw any mass commercial success, which severely limited his potential to influence the music world. Take Thom Holmes's description of Le Caine's 1970 Polyphone synthesizer, an instrument that gave each touch-sensitive key its own sound source, as well as pitch and waveform controls: "At the height of the monophonic Moog craze, Le Caine sat down to design what would become one of the most powerful and least-known analog synthesizers of all time." Paul Théberge blames the very institution that encouraged Le Caine's eclecticism. The NRC's inexperience with the

Figure 22: Mellotron Mk II (1964). (Don Kennedy/ Cantos Music Foundation)

demands of commercial development and manufacture was possibly "one of the greatest roadblocks in the passage of his instruments from the status of 'invention' to 'innovation.'" Théberge reminds us that the path from invention to accepted musical instrument is a difficult one at the best of times: "Every step of the innovation process—from conception to financing, research and development, testing, marketing, production engineering, manufacturing, promotion, distribution, and finally, public acceptance—requires careful planning, coordination, and execution." A lack of Canadian manufacturing experience, probably in combination with a pervasive academic naïveté at the university music studios and the NRC, meant that the instrument never made it to market.[29]

But Le Caine had always been interested in building instruments intended for live performance, whereas avant-garde musicians were interested in recorded music. Therefore Le Caine's influence on electronic music came not through his instruments, but in his work in establishing and supporting experimental music studios for the University of Toronto (in 1959) and McGill University (in 1964). The devices that were used in these studios, such as his Multi-track or Special Purpose Tape Recorder, did have a lasting effect on the development of studio-based electronic music in Canada.

American Raymond Scott was active at the same time as Le Caine, and his inventions also went unmarketed. But in Scott's case it had little to do with academic idealism and everything to do with business. Scott wanted to keep his edge

Figure 23: Chamberlin eight-track stereo tape replay keyboard (1968). (Don Kennedy/Cantos Music Foundation)

in the field of advertising and was paranoid about others stealing his ideas. "As a result, [he] had minimal influence on the field of music technology," concludes Holmes. But the Scott revival of the early 90s revealed the talent of this sought-after composer of advertising jingles and background music, notably for Warner Brothers cartoons. (The animated series *Ren and Stimpy* and *The Simpsons* have both helped to remind people of his work.) Scott invented a variety of musical devices at Manhattan Research, Inc., the company and studio he established in Farmingdale, New York, in 1946. He produced a multi-track tape recorder in 1953 (likely the first, and two years prior to Le Caine's). Scott's version was more sophisticated than Le Caine's 1955 Multi-track Special Purpose Recorder, since it could record seven tracks on a single reel where Le Caine's could record six. Scott also developed the Clavivox in 1959, a photoelectric keyboard instrument that he was willing to see go to market, although it didn't meet with much success.[30] Perhaps the most interesting of his instruments was the Electronium (1959–1972), which aimed to use the random generation of tones, rhythms and timbres to synchronize entire compositions. It was a step beyond the attempts of other inventors and composers merely to do away with the performer. Like some of the experimental music of John Cage, this prototype super-sequencer aimed to do away with the personality of the composer altogether. But Scott wanted to do this for practical rather than artistic reasons: "He envisioned it as a cost-saving innovation for the production of television and motion picture music," writes Holmes. Composer Herb Deutsch points out, "the concept of what he was trying to do was in effect what is now a MIDI-composition studio," and it was with analog technology to boot. [31]

There was an important exception to all these non-commercial developments. In 1946, Harry Chamberlin began to build a machine that could play back single-note tape recordings on demand. By 1952, he had produced a sampler for the home market: the Model 100 Rhythmate, with 14 loops of drum patterns. Like Hugh Le Caine's Multi-track completed three years later, Chamberlin's instrument used a keyboard to activate the tape loops. Chamberlin set up a small manufacturing shop in the town of Ontario, California. One of his salesmen, Bill Fransen, took two of the instruments to the British recording equipment engineers at Bradmatic, run by the Bradley family, to see if they could improve the reliability of the tape heads. Bradmatic was very impressed with the idea and soon built their own version of the machine, the Mellotron. According to Frank Samagaio's book on the Mellotron, Bradmatic had no idea that the concept belonged to Chamberlin; they thought they were acting on Fransen's idea and with Fransen's permission.[32] Chamberlin reportedly sold the rights to the Bradleys in 1966; the Bradleys then formed a new company, Mellotronics, which produced the Mellotron and a later version, the Novatron. These were rapidly taken up by pop musicians, notably the Beatles in "Strawberry Fields Forever."[33] Chamberlin went back to California to continue developing commercial versions of his eponymous instrument until shortly before his death in 1981.

The Chamberlin and the Mellotron or Novatron are not always easy to distinguish. Steve Howell, a sound library developer, has commented on this:

> Many claim that the Chamberlin had a better sound—clearer and more "direct" … which is strange because the Mellotron was (allegedly) better engineered than the Chamberlin. But there is a lot of confusion between the two instruments not helped by the fact that some Chamberlin tapes were used on the Mellotron and vice versa … so even though the two companies were in direct competition with each other, they shared their sounds … weird!

Howell believes that many musicians probably mistakenly credited Mellotrons rather than Chamberlins. This seems quite possible, since Mellotron seems to have bestowed its name to the tape sampler more generally. "To be honest, the whole story is shrouded in hearsay and music history mythology and we may never know the truth," Howell concludes. Both instruments were temperamental: the tape heads (one for each key) needed regular cleaning, demagnetizing and alignment. Howell, who owned a Mellotron in the mid-70s, reports that "it literally had to be serviced every time I wanted to use it for recording and if I took it out live, it would have to undergo a thorough check before the gig."[34] Frank

Figure 24: A 1971 Mellotron in transparent acrylic, revealing tape strips under the keyboard. (Don Kennedy/ Cantos Music Foundation)

Samagaio agrees that problems with the technology rendered the Mellotron obsolete:

> The factors that eventually sank the legendary Mellotron were manifold: its unwieldy weight and bulk, its comparative unreliability once it was subjected to the rigors of gigging (particularly in having to withstand changes of temperature and humidity in being loaded and unloaded at venues), and its inability to manipulate sounds as a sampler could.[35]

Reading between the lines of the ownership disputes and bankruptcies, however, it seems likely that the Mellotron was also prone to the problems of production that afflicted so many electronic instruments.

Digital sampling made tape instruments obsolete, but like many old electronics, they have enjoyed a revival. Mark Brend writes, "Although tape replay instruments were killed by digital sampling, which could do the same job in a package about a tenth the size, they began to enjoy a revival in the mid-1990s." Bands like the Flaming Lips and Crowded House have taken advantage of the graininess and abruptness of some of the Mellotron sounds. In the early 1990s, California (later Calgary) based collector David Kean bought the Mellotron and Chamberlin assets and inventory, remastered the original tapes and, in association with Markus Resch , began producing again with the Mellotron Mk VI in 1998. One of their noteworthy sales was to Noel Gallagher of the British superstars Oasis.[36]

Notes

1 Théberge, *Any Sound,* 23-27.

2 Tom Darter, *The Art of Electronic Music* (New York: Quill, 1984) 16.

3 There is a tantalizing reference to a very early electric piano, the Tonophone (1894), is in Charles B. Fowler's "The Museum of Music: A History of Mechanical Instruments," *Music Educator's Journal* 54 (October 1967) 48. Fowler says that the museum was "temporarily" housed in Scarsdale, New York (45). *Grove Music Online* reports that the Wurlitzer Tonophone (1899) was a coin-operated, electrically powered player piano, which could play from a range of ten tunes printed on perforated rolls. Cynthia Adams Hoover, "Wurlitzer, History of the Company."

4 Hugh Davies, "Sostenente Piano: Electric and Electronic Principles," *Grove Music Online*.

5 Richard Orton and Hugh Davies, "Electric Piano," *Grove Music Online*; Richard R. Smith, *The History of Rickenbacker Guitars*, 13.

6 Richard Orton and Hugh Davies, "Electric Piano," *New Grove Dictionary of Music and Musicians*, 58.

7 Samuel S. Holland, "Electronic Pianos," in Robert Palmieri, *Piano: An Encyclopedia* (New York: Routledge, 2003), 119; Tom Darter, *The Art of Electronic Music*, 18.

8 Both Tom Darter and Hugh Davies mention the Canadian Bernhardt but there are no accompanying references. *The Encyclopedia of Music in Canada* lists Bernhardt among the piano manufacturers, and states that they were produced around 1957. "Piano Building in Canada," www.thecanadianencyclopedia.ca.

9 Darter, *The Art of Electronic Music*, 22.

10 Cited Darter, 23.

11 http://www.rhodespiano.com/history_1.htm. Rhodes reacquired the rights to his name in the late 1997. Joseph A. Brandstetter acquired them soon after, and established the current incarnation of the Rhodes Music Corporation.

12 Deutsch, *Electroacoustic Music*, 17-18. The major commercially available organs are detailed – including circuit diagrams – in Richard H. Dorf, *Electronic Musical Instruments* (New York: Radiofile, 1968).

13 www.keyboardmuseum.org/pre1960/1930/rangertone2html; Holmes, *Electronic and Experimental* Music, 74.

14 Hugh Davies, "Electronic Music," and Alyn Shipton, "The Electronic Organ," *Grove Music Online*. Holmes, *Electronic and Experimental* Music, 74; Mark Vail, *The Hammond Organ: Beauty in the B* (San Francisco: Backbeat Books, 2002). Vail also covers the history of the Leslie speaker, which was paired with the Hammond B-3 to produce its distinctive sound. Théberge, *Any Sound,* 46.

15 Hugh Davies, "Electronic Instruments," *The New Grove Dictionary of Musical Instruments*, 673; *The Hammond Organ*, chapter 8. Footage of Grofé's New World Ensemble is available on the video-sharing site youtube: http://www.youtube.com/watch?v=2puK4Z967kU

16 Holmes, *Electronic and Experimental Music*, 75.

17 Brend, *Strange Sounds: Offbeat Instruments and Sonic Experiments in Pop* (San Francisco: Backbeat, 2005) 37; Brian Young, "Classic Tracks: Del Shannon's 'Runaway'" (originally published October 1, 2008) http://mixonline.com/recording/tracking/classic-tracks-del-shannon-runaway/

18 Art Thompson, "British Invasion: Celebrating 50 Years of Vox," *Guitar Player* (October 2007) 89, 95. See also Jim Elyea, voxguidebook.com.

19 Mark Vail, "Vox Continental: Original Doors Combo Organ," and Barry Carson, "Combo Organs of the '60s," in Mark Vail, *Vintage Synthesizers* (San Francisco: Miller Freeman, 1993) 223-226 and 227-239; http://pow-wowcentral.com/Farfisa/farfisa1.html; http://www.caffeinatedrecordings.com/web/farfisa/

20 It is not clear from the limited descriptions in the secondary sources what instrument provided the source sound waves, nor whether the tone wheels deviated from the source sound waves in order to provide a purer sound. Keane, "Electroacoustic Music in Canada"; Helmut Kallmann and Betty Nygaard King, "Robb, Morse," *Encyclopedia of Music in Canada*, www.canadianencyclopedia.ca. Keane published more than one overview of the Canadian picture; the encyclopedia article cites the similar "The Birth of Electronic Music in Canada," *Studies in Music from the University of Western Ontario* 9 (1984). See also Hugh Davies, "Wave Organ," *The New Grove Dictionary of Musical Instruments*, 844 and J.J. Brown's characteristic lament in *Ideas in Exile: A History of Canadian Invention* (Toronto: McClelland and Stewart, 1967) 236-245. A useful technical resource is Stevens Irwin, *Dictionary of Electronic Organ Stops* (New York: Schirmer, 1968).

21 The archival material that is the basis for Gayle Young's biography *The Sackbut Blues* is at the Canada Science and Technology Museum and Library and Archives Canada.

22 See in particular Chapter 10 of Young's book. We can get some sense of Le Caine's overall ranking from the more general secondary sources: Thom Holmes devotes several pages to him in a brief overview of his career and the music labs he established at the University of Toronto and at McGill University, but Peter Manning allots him less than a paragraph. We must be cautious, then, not to overrate the existence of a complete volume devoted to him and to his work. Le Caine is a major figure in the history of electronic music in Canada, but occupies a somewhat lower rank in electronic music in general.

23 Thom Holmes, *Electronic and Experimental Music,* 3rd edn. (New York: Routledge, 2008), 168.

24 Cited in *The Sackbut Blues*, 18, note 3. Young's comments on this passage are highly restrained: Le Caine, she says, "was probably relying more on his conception of the physics and mechanics of the keyboard more than the intuitive 'feel' for the instrument that is usually developed by musicians" (18). She seems to have been reticent to say anything that might be taken as criticism of his musical skills, and later in the book, his business skills. This complicates any effort to use *The Sackbut Blues* to determine Le Caine's place among electronic musicians and inventors – one has the sense that there is another story masked by a habit of biographical politeness. Young has commented that she wanted to retain as much of the story as possible in the words of the original actors. See Young, "Hugh Le Caine: In Context, 2004," *eContact!* 6.3. Available online at cec.concordia.ca/econtact/Issues_in_ea/Le_Caine.html.

25 Young, *The Sackbut Blues*, 22-23.

26 Young, *The Sackbut Blues*, Appendix A: "Technical Descriptions of Instruments Designed by Hugh Le Caine," 171. Young goes into the technical aspects of touch-sensitive keys in her description of the Touch-Sensitive Organ, pp. 186-193. She also maintains a website that includes a complete list of his instruments, with descriptions and photographs of the important ones at hughlecaine.com. One must be cautious in using these lists; some of the devices listed are things that Le Caine built his own versions of, but he cannot be said to have pioneered their techniques: Young notes, for instance, that "ring modulators were a common component in radio technology for several decades before they were used in sound generation." She lists Le Caine's 1964 version; Harald Bade had designed ring modulators for sound generation in the Köln studio a decade earlier.

27 Holmes, *Electronic and Experimental Music*, 154.

28 Young, *The Sackbut Blues*, 69, 179.

29 Holmes, *Electronic and Experimental* Music, 159. See Young's account of the attempt to market the Polyphone, pp. 151-152 and Théberge, *Any Sound*, 41, 48-50.

30 Jeff Winner and Irwin Chusid, "Circle Machines and Sequencers," *Electronic Musician* (December, 2000), archived online at emusician.com/mag/emusic_circle_machines_sequencers/. A Clavivox survives in the collection of the Audities Foundation in Calgary, who maintain a variety of acoustic and electronic instruments. Their website is at www.audities.org.

31 Holmes, *Electronic and Experimental Music*, 150; Deutsch quoted in Irwin Chusid, "Raymond Scott: Biography," raymondscott.com/liner1.html. See also the entry on the Electronium on this website, raymondscott.com/Electron.html. Deutsch, *Electroacoustic Music* 30-31. Robert Moog worked for Scott for a while, doing the subassembly of Clavivox parts: Pinch and Trocco, *Analog Days*, note 8, p. 335.

32 Frank Samagaio, *The Mellotron Book* (Vallejo, CA: ProMusic Press, 2002) 3-4. Oddly, there is no mention in this book of any patent tangling. The legal settlement is mentioned in the brief overview, "A Mellotron History," www.mellotron.com/history.htm. Samagaio also mentions a Mellotron historian, Sarah Angliss, but her website indicates that she is a sound engineer and artist who has had training in history of science at the Science Museum in London. (www.spacedog.biz/biography/htm) – she does not seem to have published any work on the Mellotron. The BBC broadcast a radio documentary on the Mellotron in 2006, *Sampledelica: History of the Mellotron.*

33 There is a list of artists using Mellotrons or Novatrons and Chamberlins on www.planetmellotron.com/artists.htm., although it doesn't mention specific songs or recordings. *The Mellotron Book* has a list of albums in Appendix C, pp. 134-147, but it does not include the names of the record labels, nor does it always have the year pf release. It does not distinguish between Mellotrons, Novatrons, or Chamberlins. From Canada, there is April Wine's "Like a Lover, Like a Song," *Mahogany Rush IV*, the Québécois prog rock band Morse Code, among a handful of others. Samagaio does mention (p. 11) a 1993 compilation album, *The Rime of the Ancient Sampler – The Mellotron Album* (Voiceprint VP141CD), now out of print.

34 Steve Howell, "Chamberlin," hollowsun.com/vintage/chamberlin/index.htm. All ellipses and italics in original.

35 *The Mellotron Book*, 10.

36 Mark Brend, *Strange Sounds: Offbeat Instruments and Sonic Experiments in Pop* (San Francisco: Backbeat, 2005) 56-57; David Kean, "The Mellotron Mk VI," www.rlmusic.co.uk/mals_site/mellotron/overview.html. The company has a Calgary address – see www.mellotron.com. (Note that this is not the same person as David Keane, the Concordia music professor whose overview has been frequently cited. Kean is president and founder of the Audities Foundation, an organization dedicated to preserving electronic instruments.)

5. Electric Strings

5. Electric Strings

5.1 The Guitar Goes Electric, 1930–1955

If there is any instrument that could lay claim to being the most characteristic of the second half of the twentieth century, it is the electric guitar. Critical to the distinctive sound of rock, and part and parcel of the dominant youth and consumer culture in Canada and elsewhere, the electric guitar's many recordings were released into a mature consumer market that meant it would form an important part of the music that would shape lives and be associated with pivotal moments in millions of personal coming-of-age stories.

The guitar was not always a fixture in popular music. Up until the 1920s, the banjo was the stringed instrument in dance bands' rhythm sections because its distinctive sharp tone was loud enough to be heard over the drums and brass. Nevertheless, there was at least one very early attempt to electrify the guitar: in 1890, a U.S. naval officer, George Breed, patented an electrical string method that could be applied to either the guitar or the piano. In the case of the guitar, the player completed the circuit by pressing the string against the frets, driving a tone wheel that made the string vibrate a particular frequency. In their book on the guitar, Nick Freeth and Christopher Alexander comment, "Breed's cumbersome, impractical guitar can have had little appeal to players, who would have been obliged to adapt their technique to master it, as no picking or strumming was possible."[1] Breed's design never went beyond the patent application. A true electric guitar would come about only after a shift in musical tastes allowed the guitar to elbow the banjo out of the spotlight. As radio-listening dancers came to prefer jazz to folk and country music, the banjo came to seem unsophisticated. Philip Gura and James Bollman remark, "Virtually omnipresent in both popular and high culture at the turn of the century, the five-stringed banjo abruptly ended its reign as America's instrument with the rise of ragtime and jazz."[2] Not all manufacturers were quick enough to notice the banjo's fall from grace, and many found themselves with too many banjos and not enough customers.[3] But there were few instruments that could take its place and still be heard in the era's increasingly large dance bands.

For a while, the Hawaiian steel-stringed lap guitar looked like a contender. These guitars probably evolved from wooden guitars brought by Mexican cowboys to the Hawaiian islands in the 1830s. Steel strings came later, according to Tim Brookes, possibly with the Portuguese survivors of a whaling ship sunk by the Confederate Navy ship *Shenandoah* in early 1865.[4] "Anyone who has tried to play slide guitar on nylon or gut strings knows that you get little more than a dull whisper," Brookes says. "Steel strings, the legacy of the *Shenandoah*, gave volume and ringing sustain." But the Hawaiian islands supplied many whaling ships in the mid-nineteenth century, and there is little conclusive evidence that the steel strings came from the *Shenandoah*. Brookes's popular book is a mixture of memoir, history and outsized legend—he repeats the story of the Hawaiian player Joseph Kekuku, said to have invented slide-style playing on a sudden inspiration in 1885. The story is that Kekuku picked up a discarded railway bolt (or perhaps a comb or the back of a penknife) and started sliding it along the strings.[5] While it is unlikely that this is literally true (Indian slide-style instruments date from the nineteenth century, and it is possible that Hawaiians came across them at some point), Kekuku was a guitar virtuoso—the kind of player about whom legends soon develop. He performed in the United States and Europe, and was followed by a small flood of touring players after Hawaii became a U.S. territory at the turn of the century. Along with various other musical styles with a foreign or exotic flavour (such as the tango), Hawaiian music enjoyed a period of great popularity. The guitars became known as lap steels or steel guitars, not because the body or strings were steel, but because the cylindrical slide used to play it was called a steel. "The Hawaiian guitar boom lasted an astonishingly long time," Brookes writes, "starting to fade only in the fifties."[6] Brookes credits Hawaiian groups with establishing the pattern of lead and rhythm guitars, and the introduction of open or slack tuning. Open tuning and steel strings gave the guitar a great range of expressivity, which firmly established it as a solo instrument in popular music. Sol Hoopii, another Hawaiian virtuoso, was able to coax an enormous range of tone from the steel strings across his lap, moving one commentator to write: "'I Ain't Got Nobody' features biting, staccato, stinging lines, ethereal whispering, and very effective crying, descending phrases."[7]

In the mid-1920s, George Beauchamp (BEE-cham), who played steel guitar in the Los Angeles area, approached John Dopyera with a request. Dopyera, a Slovakian immigrant who ran a banjo manufacturing firm with his brothers, had already established a reputation for clever inventions "for improving the sound and playability of various stringed instruments."[8] Beauchamp wanted a louder guitar. Dance bands and the crowds they attracted were so large that it was impossible for an acoustic guitar to remain audible under its own power.

The steel guitar, which sat on the player's lap with the sound directed toward the ceiling, suffered particularly from the problem of audibility. Hawaiian musicians had begun making the guitars from bell brass coated with nickel silver (a copper-nickel alloy) to get a louder (and sharper) sound, but even this was no match for a crowded dance hall. Beauchamp asked Dopyera to put a phonograph horn on the guitar to amplify the sound, but the results (like those of other horn-plus-strings inventions of the period) were unsatisfactory. Dopyera then developed a metal instrument containing three aluminum resonators to amplify the vibrations of the steel strings, which were mounted on an aluminum-supported bridge. This had the desired result: the resonator guitar had "an exceptionally loud volume and distinctive tone," and gained a loyal following in country and blues music. Dopyera applied for a patent on the instrument in 1927. The next year, Beauchamp, Dopyera and Dopyera's brothers started the National String Instrument Corporation to manufacture and market resonator guitars. The company grew quickly, but the directors were almost immediately at odds with one another. Beauchamp pressed for a single-cone design, which would be cheaper and might, therefore, have greater sales. Dopyera responded with an idea for how this might work, but it was Beauchamp who filed the patent claim. An angry Dopyera left the company with two of his brothers to form a rival company, Dobro, although the brothers continued to hold a 50 per cent share of National's stock. Dobro produced a slightly different version of the single cone resonator. The companies merged in 1934, by which time Beachamp had been fired during another company upheaval.[9]

Others gamely adapted various technologies to the task, none of which had been intended for the guitar. "Channels of exchange and communication among musicians," Waksman remarks, "were at least as important as commercial channels in the success of the electric guitar."[10] Musicians used telephone pickups, phonograph needles and amplifiers, and radio amplifiers. Guitarist Les Paul recalled his early performances as a country player: "By the time 1931 came around I'd made up my mind not to play anything but the electric guitar so I needed an amplifier—I couldn't keep playing through my parents' radio!"[11] Of course, none of it was worth much if the club didn't have electricity, and many of the venues on the various circuits that criss-crossed the U.S. did not. Guitarist Luderin Darbone recalled using the engine of his car to power his sound, but—as he acknowledged ruefully—"that was hard on the automobile."[12]

Electrification had a crowd-pleasing novelty to it, even when it contributed nothing to amplification. In 1926, an Edmonton furniture manufacturer, W.G. Greenfield, built what he called the "Electrical Special," a steel guitar equipped with a light bulb. "Imagine the effect in a darkened theatre when the light bulb shone out of the sound-hole to light up the player," comments Lorene Ruymar of the Hawaiian

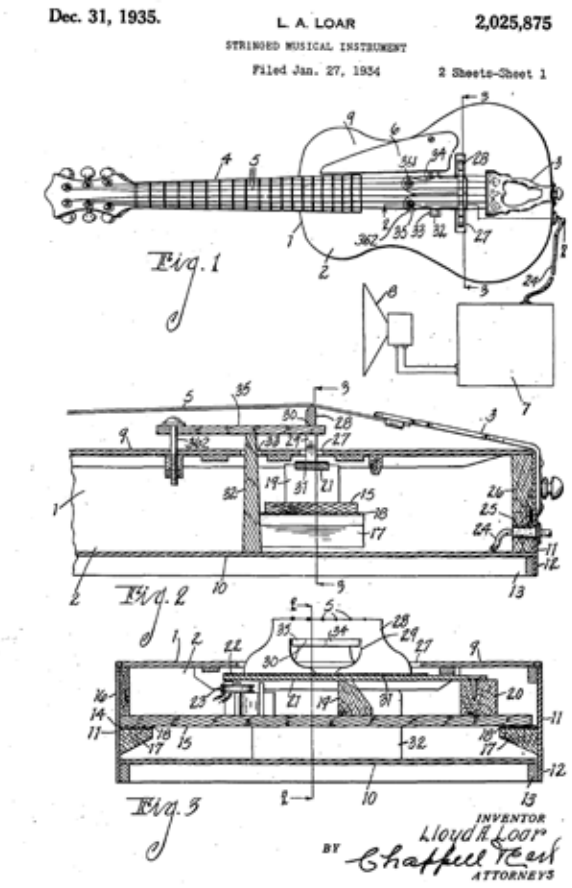


Figure 25: Lloyd Loar's electric guitar patent (1935). (U.S. Patent 2,025,875)

Steel Guitar Association. "The sound, of course, remained unchanged."[13] With efforts like these, it was only a matter of time before guitar manufacturers fell into step with purposefully designed instruments and pickups, although guitar giant Gibson was suspicious to begin with. In the 1920s, Lloyd Loar, in charge of production at Gibson's Kalamazoo factory, designed a prototype electric double bass and a solid-bodied electric violin that featured a coil-wound pickup, volume controls and an on-off switch. The company balked at further development of these experiments, despite Loar's urging. Loar left Gibson in 1933 to form his own company for the manufacture of electric instruments, Vivi-Tone. As Tom Wheeler points out, the design of Vivi-Tone guitars shows that Loar understood that electrification had far greater potential than mere amplification. His patent applications reveal the electric guitar as an entirely new kind of instrument. Vivi-Tone brought out two models: the first was essentially an acoustic guitar with a pickup inside, but the second was a purely electric guitar. It did not have the hollow chamber that all acoustic guitars have to amplify sound; since amplification was electric, the guitar could be solid-bodied, which meant

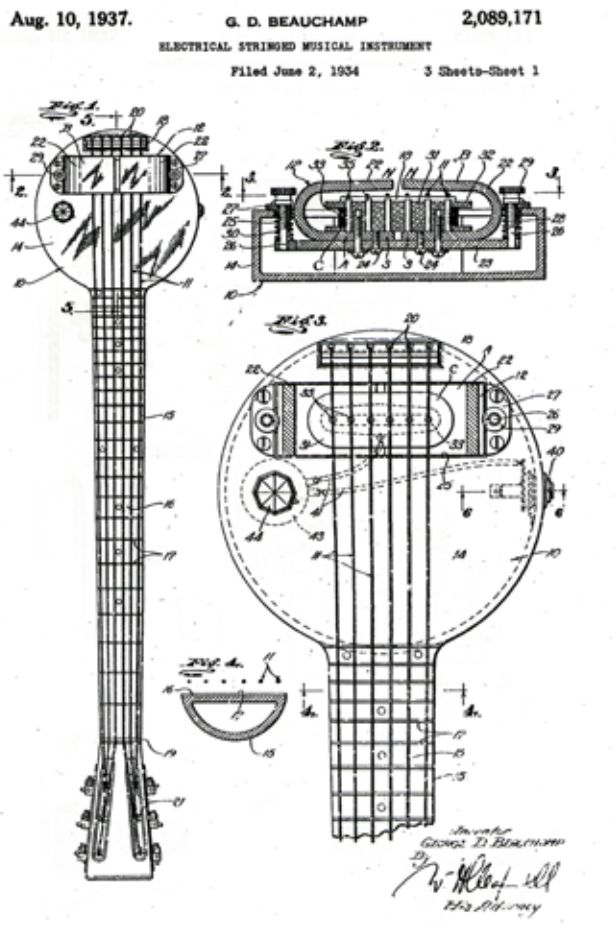

Aug. 10, 1937. G. D. BEAUCHAMP 2,089,171
ELECTRICAL STRINGED MUSICAL INSTRUMENT
Filed June 2, 1934 3 Sheets-Sheet 1

Figure 26: George Beauchamp's patent for the Rickenbacker "Frying Pan" lap steel (1937). (U.S. Patent 2,089,171)

that very little of the energy of the vibrating string was transferred to the body of the guitar. This gave the instrument the capacity for a much longer note—a greater sustain—than hollow-bodied instruments. Wheeler writes, "Instead of seeing electricity as a way to enhance a guitar's acoustic resonance, [Loar] sought to isolate its purely electric qualities so as to create something radically new."[14] But Vivi-Tone suffered the same fate as many fledgling instrument companies: it folded not long after it opened, and it is estimated that as few as two dozen guitars were ever produced.[15]

Tom and Mary Anne Evans reported in 1977 that none of Loar's actual pickups survived, although the drawings did. They show that the design consisted of a charged diaphragm stretched above a fixed anode. When the diaphragm vibrated, it induced a fluctuating current. It was not to be the standard approach. The electric guitars that followed shortly after tended to use electromagnetic pickups, which consisted of a coil wrapped around one or two magnets or around an iron pole piece in contact with the magnets. It was arranged on the guitar so that the (ferrous) guitar strings passed through its electromagnetic field. When the strings vibrated, they induced a current in the coil, which alternated at the same frequency as the movement of the string. It had distinct advantages over Loar's design: they were less susceptible to moisture and could produce a current that was stable over longer distances.[16]

The first electric guitars to gain any real notice used electromagnetic pickups. The Rickenbacker A-22 and A-25 lap steels (or "Frying Pans," after their inelegant shape) were designed by machinist Adolph Rickenbacher (who also worked for National) with George Beauchamp. Beauchamp, not deterred by his experiences at National, persuaded Rickenbacher to form the Electro String Company with him. Their "Rickenbacker Electro Instruments," which included electric violins as well as guitars, had an inauspicious inaugural year. "Timing could not have been worse," Richard R. Smith writes in his history of Rickenbacker. "1931 heralded the lowest depths of the Great Depression and few people had money to spend on guitars." Worse, "the Patent Office could not decide if the Frying Pan was an electrical device or a musical instrument. There were separate divisions for each category." The idea of the guitar pickup was not very different from the telephone pickup. "Using the logic of the patent process, these devices were the same if you substituted a string for the telephone's mouthpiece diaphragm."[17] The patent was denied. Beauchamp rewrote the patent application, but it was further delayed because (according to Smith) none of the examiners believed it would work. Electro String did not receive their patent until 1937, by which time several other guitars and amplifiers were on the market, and the company had wasted time, energy and money in a fruitless attempt to block them.[18] However, the Frying Pan survived, and versions were commercially available as late as 1958.[19] Rickenbacker also produced other electric stringed instruments, such as the electric mandolin that appeared in their 1957 catalogue. Both Rickenbacker and National developed electric Spanish-style guitars in the early 1930s. These soon became quite complex. Musician and inventor Clayton "Doc" Kauffman developed the Vibrola for Electro String, a heavy, Spanish-style guitar that came to market in 1937. "It had an extra thick body that housed a motor and pulleys. The pulleys attached to the motorized tailpiece which changed the pitch of the strings as the player strummed. It sounds like an underwater sound effect today, but it was marvellous in the 1930s."[20]

None of these early electric guitars were especially quick to gain a toehold in the marketplace. According to Electro String's lawyer, by 1936 some 20 electric guitars were on the market in addition to the Rickenbacker models, including as many as eight that were distributed nationally. But musicians were hesitant, perhaps because the style of play didn't fit well with the kinetic feel of jazz dance bands, or perhaps because the instruments just looked too different. Electro String certainly had not catered to musicians' conservative attitude with

their materials, which included the plastic Bakelite. Plastic had the advantage of being less responsive to heat than metal, so the guitar was less likely to go out of tune in a cold dance hall. It was also small, to avoid being too heavy. One of Rickenbacker's later models, the Electro Spanish Model B, was a Bakelite Spanish guitar with a semi-solid body—semi-solid because solid would have made the moulded plastic instruments excessively heavy, even with their small size.[21] In his history of Gibson electric guitars, A.R. Duchossoir says that "pre-war solid bodies all failed to generate a durable impact because of their size and shape which made them difficult to hold and play in a conventional manner."[22] For the electric guitar to gain wide acceptance, it would need a number of technical improvements. It would also need a skilled and innovative musician to lead the way.

Journalist Frederic Grunfeld believes that jazz guitarist Charlie Christian was that musician: "There is the guitar before Christian and the guitar after Christian, and they sound virtually like two different instruments." As Waksman points out, this is because they were, in fact, two different instruments—Christian was the first to begin to exploit the potential of the electric guitar to make a totally different sound from the acoustic guitar.[23] While there are other musicians with a claim to helping to launch the electric guitar—including bluesman T-Bone Walker, country musician Merle Travis, and pioneering rock 'n' rollers Chuck Berry and Buddy Holly—Christian's style of play stands out. Influenced by Lester Young's highly expressive tenor sax solos, Christian gave the electric guitar a voice. Musicologist Graeme M. Boone describes Christian's work on the 1939 recording "Breakfast Feud": "Christian's comping here consists only of simple beats, but the rhythm section is so tight and Christian's time so perfect that the accompaniment glows with energy." In a later solo, Christian exploits the electric guitar's capacity for very long phrasing: he "takes advantage of that fact by stringing ideas together unpredictably, sometimes drawing them out beyond one's expectation in a string of swinging eighth, sometimes breaking them into fragments."[24] In 1939, Christian successfully auditioned for Benny Goodman's Sextet. Waksman points out that Christian probably would have had even greater influence had he been invited to play in Goodman's better known big band:

> While he had a prominent role in the Sextet, he rarely performed with the more popular large orchestra, a situation he shared with the other black musicians hired by Goodman during the 1930s, like pianist Teddy Wilson and vibraphonist Lionel Hampton…. The parity that Charlie Christian's guitar gained with respect to other solo instruments was not equaled by his own parity with respect to white musicians.[25]

Still, Christian's distinctive style and status as a pioneer of bop and cool jazz (the styles that replaced the ragtime-influenced hot jazz style characteristic of the 1920s and 1930s) ensured that his superb musicianship, both as a soloist and accompanist, continues to be recognized today. Christian typically played a Gibson ES-150, a guitar that became so associated with him that it was known as the "Charlie Christian model."[26]

Gibson appears to have been cautious in bringing an electric guitar to market. The ES-150 didn't come to market until the mid-1930s. Lloyd Loar's failed Vivi-Tone venture and the state of the economy served to reinforce the company's basically conservative nature. They survived the worst of the Depression not through innovation, but by manufacturing low-budget acoustic guitars and cheap wooden toys.[27] But they did recognize a growing demand from musicians for a louder guitar. The first Gibson electric guitar went to market in 1936: the Electric Hawaiian-150 (EH-150) and an accompanying 15-watt amplifier. That same year, a cheaper Electric Hawaiian, the EH-100, made its debut, followed by the company's first Electric Spanish guitar, the ES-150. Tom Wheeler suggests that "Gibson was so big, so esteemed, and so traditional that it helped legitimize any field it entered."[28] Gibson ensured that the electric guitar passed from peculiar novelty to acceptable instrument. Several other models and versions followed through to the end of the war. Though late to the game and arguably less innovative than Rickenbacker or Vivi-Tone, Gibson was critical to the establishment of a stable market for the new instruments.

Gibson was also comparatively slow to bring a solid-body electric to market, likely because by that time their factories and workers were involved in the war effort. But there was a burgeoning market, as evidenced by all the musicians who "often stuffed rags and newspapers" into their hollow-bodied electrics to prevent feedback.[29] Guitarist Les Paul, who began his career playing country and bluegrass under the names Red Hot Red and Rhubarb Red, was also a radio hobbyist. With his facility for electronics, he began building his own guitars to achieve the sound he wanted. The best-known of these was "The Log," built in 1941, which was little more than a fencepost with pickups and an Epiphone neck attached. Paul sawed a Spanish hollow body in half and glued the halves to each side of the maple 4x4, a gesture that now seems to indicate what Paul thought of acoustics, even if he merely meant to improve his instrument's acceptability at the time.[30]

Country guitarist Merle Travis also wanted a solid body, and he sketched a design for California engineer Paul Bigsby, who produced a guitar for him in 1948. Just down the road, Leo Fender had turned from building and repairing amplifiers and public address systems to musical instruments and technologies. He collaborated with Doc Kauffman for a period, but in 1946 they dissolved their business venture, K&F Manufacturing Corporation, over differences about

the company's possible expansion—Fender believed there was great potential for growth and gambled on lap steels and amplifiers "at a time when musicians were deprived of new musical instruments because established manufacturers (like Gibson) had been diverted into war production work."[31] Where Bigsby was not interested in the mass market—his instruments were all made to order—Fender had his eye on the vast numbers of musicians and the full life cycle of the guitar. He wanted an instrument that was easy and inexpensive to repair. He said, "When I was in the repair business, dealing with other men's problems, I could see the shortcomings in the design completely disregarding the need for service. If a thing is easy to service, it is easy to build."[32] Fender's instrument had a detachable neck, both to simplify production (the necks could be made separately) and to facilitate shipping.[33] Nick Freeth and Charles Alexander comment on the significance of the Esquire, introduced in 1950:

> Unlike previous solid wood "electric Spanish" models, the guitar that Fender began to develop in 1949 was specifically conceived as a factory-made instrument, and intended to be as cheap and easy as possible to manufacture and repair. It had a basic, single-cutaway body shape and a bolted-on detachable neck, as well as two important innovations: a new pickup with individual pole-pieces for each string, and an adjustable bridge to ensure better intonation.[34]

Leo Fender looked like he had made a good bet, although he was still tinkering with the design. Late in the developmental stage, he added a second pickup on the neck. This didn't please the sales force, which had been promoting a single-pickup guitar to instrument retailers. The two-pickup model was renamed the Broadcaster, although they were essentially the same instrument.[35] Fender changed the name to Telecaster in 1951, after the Gretsch Company complained that "Broadcaster" was too close to their trademarked "Broadkaster" drumkits and banjos. That same year, Fender came out with the first electric bass guitar to rack up noticeable sales, the Precision Bass. "Back in the 1950s," Tony Bacon remarks, "other makers at first merely continued to mock Fender's unique solidbody guitars. But soon Gibson had joined in with its Les Paul, Gretsch with the Duo Jet, Kay with a K-125 model."[36] Gibson acted in spite of its reservations. Fender's designed-for-cheap-mass-production instruments seemed to betray craftsmanship, and Paul's Log looked like an especially bad omen for traditional luthiery. But it was hard to argue with success.[37]

Paul had a hard time convincing manufacturers that the crude-looking Log was worth a look. He first approached Larson Brothers in Chicago. "They thought I was crazy. They told me it wouldn't vibrate. I told them I didn't want it to vibrate, because I was going to put two pickups on it." Paul, as Waksman points out, had begun to think of the electric guitar as a new kind of instrument, something that was designed to produce its own unique sound qualities, rather than simply a louder version of the traditional guitar. "Strange though its appearance may have been, the Log was a perfectly functional instrument with a rich tone and greater sustain than other available guitars of the period."[38] Paul took it to Gibson, but at the time they weren't interested. "They laughed at me for 10 years…. They called me 'the guy with the broomsticks with the pickups on it.'"[39] However, when Gibson introduced a solid body in 1952, they asked Paul to endorse it. In part, this was because Paul had become a star, but it was also because he was responsible for the design, to an extent—exactly what extent is a matter of debate. Popular sources give Paul near total credit for the guitar that bears his name, something that Paul himself did not discourage.

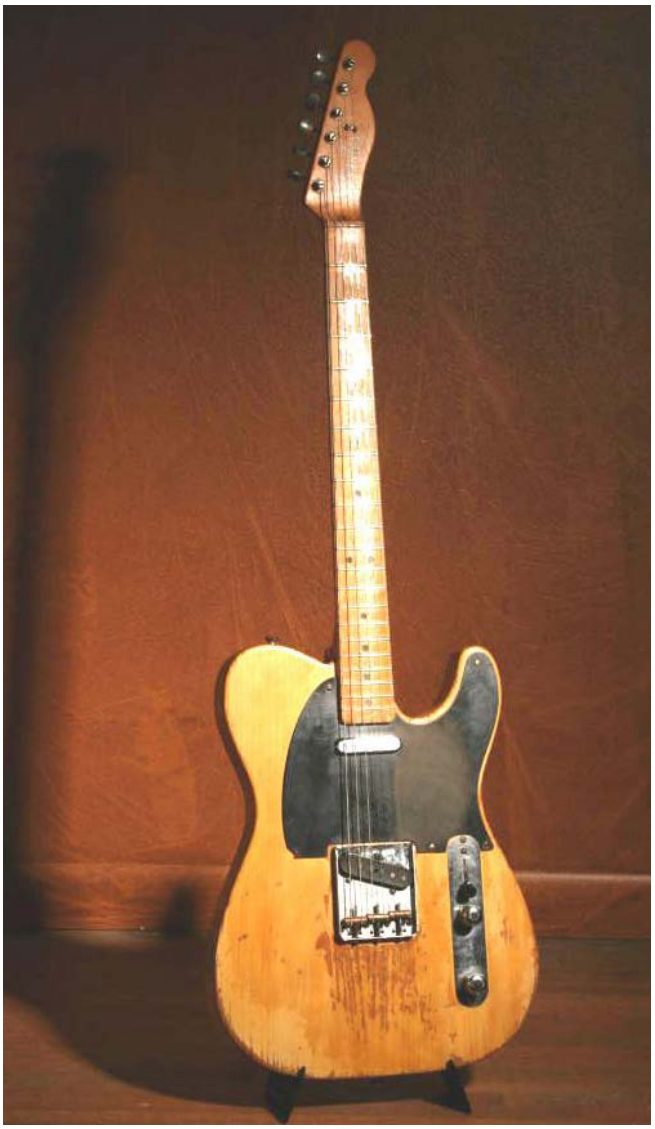


Figure 27: Fender Broadcaster. (Dana Woods / Encore Music)

Figure 28: Gibson Les Paul Gold Top (1954). (Elderly Instruments)

The United States Patent and Trademark Office Museum inducted Paul into their National Inventors Hall of Fame in 2005, and the accompanying bio states that he "transformed popular music by inventing the modern solid-body electric guitar." The Rock and Roll Hall of Fame was more cautious when it inducted Paul in 1988, citing his many innovations, but primarily those that involved recording techniques. In the 1940s, Paul used the recording studio to produce the new Les Paul sound, characterized by massive overdubbings."[40] Gibson president Ted McCarty maintained that a team of employees had put together a prototype before even approaching Paul.[41] Gibson employees, however, did credit Paul with the development of the tailpiece, "which was a solid bar that became both bridge and tailpiece at the same time," and allowed for a greater sustain. However, it suffered from production problems:

> The factory got it wrong when it came to installing the tailpiece on production guitars. Whereas the patent shows that the strings should (logically) pass over the bridge, the first guitars were built with strings running under it. And a shallow neck-to-body angle prevented any reversing of the strings' mounting, lest it would dramatically raise the action and make the guitar unplayable. Four decades later, such a mistake remains incomprehensible on the part of a company like Gibson. But it did not prove a major predicament to Les Paul himself whose personal guitars were modified with either a vibrola or a conventional trapeze tailpiece.[42]

Meanwhile, the endorsement agreement between Gibson and Paul remained in place. Paul continued to take popular credit for the design, even as that design began to change.

The most significant design change came in 1957, when Gibson added the "humbucking" twin-coil pickup, the result of a year's work on the part of engineer Seth Lover. As the recording studio and broadcasting became more and more important to musical careers, the noise that the single-coil pickups made became more and more of an annoyance: "Players liked to keep their amplifiers close to them for easy adjustment, but the single-coil pickups of the day were sensitive to radio frequency hum from a power source, and hum was critical in the quiet atmosphere of the studio," Tom and Mary Anne Evans point out.[43] Lover connected the two coils out of phase, and wound them around magnets oriented to have opposing polarities, which had the effect of cancelling out the hum. The Evanses continue, "The humbucking pickup gave a marvelously gutsy sound which was ideal for the solid-body guitar, and Gibson's design has been widely copied since the expiry of the original patent."[44] It was the humbucker that gave the Les Paul guitar its distinctive tone.

It may be this distinctive tone—combined with Paul's successful promotion of his "new sound"—that explains why Paul continues to get more credit than he probably deserves for the solid-body electric. The Les Paul guitar had a thicker, heavier sound (in contrast to the bright clarity of the Telecaster and Stratocaster), which, along with the electronic organ, gave much 1960s rock and pop its character. According to historian André Millard, 1970s heavy metal guitarists preferred the fat sound of the Les Paul, and it is possible that they and their many fans bestowed on Paul an honour that was not entirely his to take. This is perhaps understandable with respect to the design of the guitar that bears his name. But when Paul gets credit for the solid-body electric, despite the designs of Lloyd Loar or Rickenbacker, we can only speculate that the desire for mythically proportioned heroes that animates rock 'n' roll fandom (especially heavy metal fandom) may have been extended to the origins of the electric guitar, too.[45]

Fender, meanwhile, had seen great success with its strategy of inexpensive guitars and amps. Their success made them ambitious: could they compete on Gibson's higher-end turf? Don Randall, who headed the Fender sales department from 1953, recalled, "The decision to introduce a new guitar came from the sales department. The principal need was to have something to fill a market slot with—to have a better-looking product, which looked more sophisticated than the Telecaster."[46] Beginning in 1953, Leo Fender began to solicit advice from musicians Freddie Tavares and Bill Carson, as well as his sales staff. They added a vibrato unit to the instrument, as they were impressed with the similar unit that machinist and instrument builder Paul Bigsby had added to the guitar he built for country guitarist Merle Travis. Bigsby's device was a spring-loaded arm attached to the bridge. When Travis pushed down on the arm, it pulled the guitar strings so that they were looser, lowering the pitch. As he released the arm, the strings returned to the original tension and pitch. By 1949, Bigsby had made guitars with vibrato tailpieces for several musicians who had been impressed by Travis's guitar. Each of these was a custom order. "It is said that by 1949 several had been made and sold for five hundred dollars apiece."[47] Although Rickenbacker, Gibson and Gretsch had all produced vibrato units prior to Fender's entry into the market, it was Fender's new instrument that got under Travis's skin. He insisted—based on the sketch he had initially given Bigsby—that Fender had stolen his ideas. Tom Wheeler believes that it is unlikely there was any direct rip-off, even if (as Travis claimed was true) Leo Fender had borrowed a Bigsby guitar. Others, including one of Fender's general managers, Forrest White, recall that Fender did borrow the guitar and was quite likely influenced by it.[48] But the influence was neither in Fender's solid-body construction (by this time used by a number of manufacturers) nor in the vibrato unit itself, which was very different from Bigsby's by the time anything got to market. The vibrato unit (which was incorrectly called a tremolo unit) ended up going through a costly redesign process when it became apparent that the original version inhibited the guitar's sustain.[49] As a result, the unit bore little resemblance to Bigsby's design. Where the new Fender Stratocaster guitar bore a striking resemblance to Bigsby's guitar (and Travis's sketch) was in the headstock design, which put all six tuning pegs to one side. "At the very least," Wheeler concludes, "Merle Travis sketched the headstock silhouette that became a world-famous Fender hallmark five or six years before it appeared on any Fender."[50]

None of this controversy ever became so heated as to affect the reception of the Fender Stratocaster, launched in 1954. Its features included three pickups and an angled bridge, which allowed it to maintain the treble without giving up any of the bass, as well as the tremolo unit. They also gave the guitar a great deal of longevity: Ray Minhinnett and Bob Young conclude that the instrument was so advanced that "it would take guitarists over a decade to catch up with it and

Figure 29: Catalogue for Kay Musical Instrument Co. (ca. 1959) featuring its Gold K line of professional guitars, endorsed by jazz great Barney Kessel. (CSTM L46904)

appreciate its qualities."[51] Fender's guitars were also beginning to look quite distinct from their acoustic predecessors, with shapes that suggested speed. This appealed to the buyers that the company had in mind: as *The Art of the Guitar* notes, "The electric guitar has mainly been associated with males, so it is no surprise that beginning in the postwar era, designers of electric guitars have frequently drawn inspiration from cars for both shape and finish." By the early 1960s, under the guidance of Don Randall and photographer and graphic designer Robert Perine, "Fender literature surged with vitality, youth, and splashy colors."[52] The choice of colours expanded to include shades that would have been unthinkable in the traditional luthier's studio: Lake Placid Blue, Foam Green, Fiesta Red.[53]

Fender and Gibson were not the only companies active during this period, although they were the most important. Others included New York-based Epiphone, an acoustic manufacturer who brought out their Electar line of electric guitars, banjos and mandolins in 1935. Their amplifiers were designed by Nathan Daniel, an electronics whiz who came up with an amp that would work for both AC and DC, since lower Manhattan was still on DC in the 1930s. The company moved to Philadelphia in the 1950s—apparently to avoid the

Figure 30: Gretsch Chet Atkins guitar. This example belonged to Randy Bachman, guitarist for the Guess Who and Bachman-Turner Overdrive. (Canadian Museum of Civilization)

unionization of its workers—and never recovered. Gibson bought them out in 1957.[54] Vega, another company founded in the late nineteenth century, launched Electrovox guitars in 1936. The next year, the company introduced the Vibra electric foot pedal, which controlled volume, and began manufacturing an electric violin in 1939. Throughout the 1940s and 1950s, Vega was a wholesaler as well as a manufacturer and manufactured some of its guitars with parts from other companies. In 1970, Martin bought Vega and soon after used the name for an imported line. Martin sold Vega to Korea's Sun Pyo Hong in 1980.[55]

More influential was Gretsch, founded in Brooklyn, New York, in 1883. Perhaps inspired by the success of Gibson's Les Paul, Gretsch turned to country musician Chet Atkins to endorse one of their 1955 models. The Chet Atkins guitars made Gretsch a force to be reckoned with, especially in the American south and west. Atkins's distinctive picking style was influenced by Merle Travis's playing and had made him well known as a soloist.[56] Like Les Paul, another influence, Atkins was not wedded to any particular genre of music, and his recordings—which included traditional country and mainstream pop on the same albums—were indicative of a long-lasting shift in country music. Steve Waksman writes, "During the 1950s and into the 1960s, when country music moved ever closer to the pop mainstream, the electric guitar was a key vehicle for the changes that the music was undergoing and the willingness of musicians like Chet Atkins to broaden the music's range." In this way, country music moved away from its rural roots to become a pop radio phenomenon headquartered in the city of Nashville, Tennessee—and remains so today.[57]

5.2 Basses, Amps and Electronic Effects

It was not just guitars that were going electric. Acoustic bass instruments had exactly the same problem as the acoustic guitar—it was difficult to achieve the volume necessary to be heard over the other instruments in the orchestra—and some of the proposed solutions were similar. The German inventor Augustus Stroh added an amplifying horn. Others just kept making the instrument bigger: Regal's Bassoguitar was more than five feet tall (the company promoted it as "The Biggest Guitar in the World!").[58] As for the guitar, however, the route to greater volume would be through electrification. Rickenbacker and Dobro both produced a fretless electric bass in the mid-1940s that was played upright, like an acoustic bass. At Fender, however, they recognized that electrification meant that the bass could be completely reimagined and, in 1951, they introduced the Precision Bass, a smaller electric bass with frets that was played horizontally, like an electric guitar. It had the advantage of easy portability and allowed musicians to switch easily from guitar to bass while on stage. It also meant that the bass player could move around more freely and therefore take a more central role in the band, particularly if he was a singer. (It was nearly always "he"—new portability notwithstanding, a history of heavy lifting and the association of very low notes with masculinity meant that the bass remained a man's instrument for some years to come. Carol Kaye, a very successful studio bass player in Los Angeles in the early 1960s, was a notable exception.[59]) The firm V.C. Squier, which supplied strings to Fender, didn't make strings that were beefy enough for the Precision Bass, so, to begin with, Leo Fender wrapped iron wire around gut string—a laborious and tedious job. But once the instrument saw some commercial success, Fender's orders were large enough to have V.C. Squier manufacture heavier strings. Forrest White, who was a key figure in the Precision Bass's development, remarked in 1994,

> Today the Precision Bass is the most widely used electric bass throughout the world. I personally think this was Leo's greatest overall contribution to music, and I believe he, too, thought it was his greatest accomplishment. It is almost impossible now to find someone who

Figure 31: Fender Precision Bass. (Elderly Instruments)

is still playing the old "dog house" upright bass.[60]

Like the electric guitar, it took a while before the new instrument was wholeheartedly accepted: jazz bassist Monk Montgomery recalls that in the early 1950s, "The electric bass was considered a bastard instrument."[61] Certainly Gibson's efforts in the bass guitar market were not immediately successful. They produced electric upright bass models in the late 1930s (although not in large numbers) and introduced the violin-shaped Electric Bass in 1953, which was also played upright. In 1958, they brought out the EB-2, "essentially a guitar body with a bass neck attached." Jim Roberts, the founding editor of *Bass Player* magazine suggests that the half-hearted design indicates that Gibson was not really interested in the electric bass. But Gibson did create a winner in 1963 with the Thunderbird, which "blasted out a powerful, biting tone" that continues to find adherents in the heavy metal crowd.[62]

The Precision Bass was sold with the Bassman amp, which was deliberately constructed to handle the instrument's low frequencies. It proved a winning combination, especially among jazz musicians, who appreciated its "deep, booming quality." John Teagle and John Sprung remark that today the Bassman "is considered by many to be the ultimate guitar amp."[63] Amplifier design, as shown by the success of Fender's pairing, was extremely important to the eventual acceptance of the instrument. An electric guitar without an amplifier is only half an instrument—it can only whisper. Few of the electric guitar companies had much experience in building amplifiers, and Fender was able to exploit a natural advantage. But possibly because the guitarist may not interact with it in any obvious way, amplifier history does not tend to generate the same interest as guitar history. In *Amps! The Other Half of Rock'n'Roll,* Ritchie Fliegler writes, "A player can choose from a library full of guitar books that specialize in history, serial numbers, idiosyncrasies of specific companies, pickup design, and so on. But comparatively little has been written about the other 50% of the electric guitar—the amp." There are obvious exceptions—the 1960s saw the emergence of walls of amplifiers behind the guitarist, and Jimi Hendrix humped his amplifiers just as he humped his guitar. Fliegler encourages his readers to look at the amp more thoughtfully: "What I hope you come away with is a newfound respect for these heavy black and brown boxes that make us throw our heads back and smile while moms, dads and neighbors call the cops—an appreciation that amps are as alive and as 'organic' as any guitar."[64]

The amps that accompanied the early electric guitars had to meet a number of demanding specifications: not only did they need to generate the particular tone and volume that the company believed musicians wanted, they had to be robust enough to withstand the rigours of touring. Teagle and Sprung report that, through the 1940s, Fender's "tweed-covered, chrome-chassis amps gained the reputation of being nearly indestructible on the road, as well as being the most powerful on the market."[65] K&F (Fender's initial venture with Doc Kauffman) made their amps individually, by hand—it was still a small company and a small market. However, they did not offer any customization: musicians could choose between an eight-inch speaker with one input and volume control, or a ten-inch speaker, with two inputs and a volume control. Teagle and Sprung say the cabinet finish was rumoured to have been baked on in Fender's home oven. When Fender began manufacturing under his own name, the market was sufficiently developed to justify a line of amps with hardwood cabinets, protective metalwork that added "flash and brilliance" and coloured grille cloth. Fender brought out the Dual Professional amp in 1947, which had a cloth-covered cabinet (a heavy linen that the company later called "tweed"), an on-off switch and a pilot light. Later models, including the Bassman and the Twin Amp, continued to improve in appearance and had greater precision and flexibility in controlling the tone, without necessarily being innovative. The 1955 Tremolux amp, for instance, included a tremolo feature, something Danelectro, Premier and Gibson had been

making since the late 1940s. The high point in Fender's amp design came with the reworking of the Twin in 1958, which produced an amp that was "very loud with minimal distortion." The Twin's price tag, $399, shows that there were customers willing to pay dearly for good amps: "The Twin cost over 20% more than Fender's most expensive guitar of the time, the blonde-finished Stratocaster with gold hardware!"[66] Many professionals thought it was worth it, however: in his history of the guitar in country music, Gordon Ross calls it "possibly the most popular of all the guitar amps available."[67]

In the early 1960s, Fender began to change the construction of their amps so that the amplifier chassis and the speaker were housed in different cabinets. This "piggyback" style of construction was not only easier to transport, it protected the speaker from the heat of the tubes and the amplifier from the vibrations of the speaker. It also meant that the music could be a lot louder: "Having a cabinet devoted solely to speakers," Donald Brosnac writes, "meant an enclosure could be designed to maximize speaker efficiency." Most high-power tube amps are now piggyback amps and lower-output power amps are "combo" amps, with everything housed in a single cabinet.[68] Leo Fender designed the piggyback Showman amp and speaker combination for the "King of the Surf Guitar," Dick Dale, in order to handle the loud volumes that Dale used to evoke "the sounds of the native dancers in the jungles along with the roar of mother nature's creature's [sic] and the roar of the ocean." Dale also asked Fender to make him a reverb unit based on one he had pulled from a Hammond B-3 organ. The result was the Fender Tank Reverb, which Dale used for vocals.[69] But guitarists liked it, and it soon "set the standard for guitar-oriented reverb."[70]

As transistors made audio gear cheaper, less finicky and more portable than tubes, the market began bursting with components to shape tone in a variety of ways—"clipping, filtering, phase shifting, flanging, and amplitude and frequency modulation." Sometimes this was done with a separate effects box (or "stompbox"), and sometimes as part of the amplifier.[71] These enabled the distinctive fuzz sound of a lot of 1960s rock, although its genesis dates back a little further to when, as electrical engineer and radio producer Joseph A. Paradiso puts it, "some musicians (such as Chet Atkins, Roy Buchanan, and others) occasionally employed distortion from overdriven inputs, malfunctioning amplifiers, or damaged amplifiers or speakers in their recordings."[72] Les Paul had experimented with achieving various distortion effects, and Link Wray "achieved a crunching effect by poking a hole through his amplifier with a pencil" on his 1958 hit "Rumble." Perhaps the response of manufacturers—who continued to bring out tone-shaping components—encouraged musicians in turn to explore distortion further, since few musicians used it extensively before the 1960s. Do-it-yourself effects didn't disappear even then—the Kinks' gritty "You Really Got Me" (1964) used an amplifier whose speaker cones had been slashed with a razor blade.[73] Then Gibson got into the game with the Maestro Fuzz Tone, which Keith Richards famously used in the Rolling Stones' 1965 hit, "I Can't Get No Satisfaction." Sales took off. Robert Walser reports that as musicians became interested in the thicker sounds of the distorted guitar, they "horrified" the audio engineers, who had always worked to minimize distortion, by requesting amplifiers and effects for precisely that: "For despite its previous status as noise, at this historical moment, such distortion was becoming a desirable sign in an emerging musical discourse."[74]

British company Vox, which had already developed popular amplifiers, a tape echo unit and the Vox Tone Bender Fuzz (around 1966), partnered with the American firm Thomas Organ to come up with one of the most famous of the effects. While trying to find a way to reduce the cost of the three-position switch on the MRB (mid-range boost) function of the Vox Super Beatle Amp, engineer Brad Plunkett found that a cheaper potentiometer resulted in a distinctive sound that was quickly dubbed "wah-wah." Tim Brookes describes its introduction in 1966: "The innovative pedal could hardly have been better timed for adoption by the two biggest guitar stars of the era—Eric Clapton and Jimi Hendrix—and later bearing the name Cry-Baby, the pedal was a huge hit for the Thomas Organ side of Vox."[75] As Brookes points out, the guitar was now not one instrument, but many. Effects like the "fuzztone, the 'sitarmatic' bridge, pre-amps to boost the signal and overdrive the amplifier, the Vibratone, the Cry-Baby Wah-Wah and the Uni-Vibe phase shifter…gave the guitar an open-endedness no other instrument could offer."[76] As Dick Dale's vocal reverb shows, these effects were not necessarily confined to the guitar but they did become strongly associated with it. And the guitar's star was ascendant: Art Thompson believes that many of the effects "likely would have been squandered on the home organ had it not been for the electric guitar craze that was ignited by the British Invasion."[77] Thompson's swipe at the organ is not really fair: it was far from dead, and its popularity at the time should not be underestimated. 1960s rock 'n' roll would not have sounded the same without it. Vox actually tried out a guitar-organ hybrid that would allow guitarists to create an organ-like sound. They got orders for it after displaying it at a trade show, and one was given to the Beatles, but it did not sell well and soon went out of production.[78] The guitar was what rock 'n' roll's young audiences were interested in.

In 1965, Leo Fender sold his company to CBS, but over the next decade CBS proved to be inept managers. In 1985, CBS sold Fender's names and patents to a group led by William Schultz. Leo Fender himself continued to build guitars for the Music Man corporation (notably the StingRay) and then for another company he co-founded, G&L.[79] Amp designer Blackie Pagano commented, "Leo Fender wasn't a guy who just built guitars and amplifiers. He changed cultures."[80]

Certainly Fender assisted in the passage of the guitar and the bass from their anonymous roles in the rhythm section. By the late 1950s, the electric guitar had arrived. It had become, if not exactly respectable, tremendously popular—something that any instrument maker would include in its product line. The electric guitar was also beginning to show signs of becoming a powerful symbol in American culture.

Even when rock 'n' roll first began to get popular in the 1950s, it had not been obvious that the guitar would be its icon. The new sound drew on "blues, jazz, gospel, rhythm and blues, folk, country, and pop" to produce something new and inescapably catchy.[81] But it was not necessarily associated with the guitar or the electric guitar: Fats Domino ("Blueberry Hill,"1956) was a pianist, as were Little Richard ("Tutti Frutti," 1955) and Jerry Lee Lewis ("Great Balls of Fire," 1957); Big Joe Turner's recording of "Shake, Rattle and Roll" (1954) features a saxophone solo, as did the sanitized cover version by Bill Haley and the Comets (1954); and the top string instrument in terms of sales was still the violin. The guitar's future was far from assured. Brookes reminds us to be cautious about history written from the perspective of the victor:

> At the time, the guitar was fighting for daylight along with a number of emerging musical forces. When interviewed about the music that first fired his enthusiasm for rock and roll, Alan Freed, the white deejay said to have invented the term, spoke of the tenor sax of Red Prysock and Big Al Sears and the blues singing and piano of Ivory Joe Hunter. Guitarists didn't feature.[82]

Indeed, a large part of the reason that Elvis Presley's 1956 performance on *The Milton Berle Show* was so sensational and aroused accusations of obscenity was that he appeared *without* a guitar, which allowed him to move more freely and meant his motions were completely undisguised. Presley's response to Scotty Moore's guitar resulted in a display that Waksman says was "heightened almost to the point of self-parody."[83] Waksman does, however, credit Elvis and Chuck Berry for igniting the guitar's popularity. Even as rock 'n' roll went into a mild decline at the end of the 1950s, rock instrumentals by West Coast bands like the Ventures solidified the guitar's status. It was the arrival on American shores of British bands like the Beatles, the Kinks, the Yardbirds and the Rolling Stones (among others)—a phenomenon so striking that it was quickly labelled the British Invasion—that really forged the guitar into a powerful symbol of rock 'n' roll and youth culture. These bands, their musical sense shaped by American blues and early rock 'n' roll, all relied on guitars. As Tim Brookes notes, they ensured that the electric guitar lost all vestiges of its rural folkiness: "The guitar group was now an English phenomenon, even if most of the guitars the lads were playing were American instruments making a kind of triumphant homecoming, and it was perfectly okay for

Figure 32: A tape echo unit (mid-1970s). (CSTM 2005.0102)

middle-class white American kids to bug their parents to buy 'em one."[84] Electric guitars and good amps were still expensive, however, and most kids of any background with musical ambitions tended to buy a pickup and a cheap amp, "and you'd put your pickup on your acoustic," as Paul McCartney recalled of his early days with the Quarrymen.[85]

As rock 'n' roll and the electric guitar were catapulted into mainstream consciousness, many new companies formed to capitalize on their popularity. Some were very successful: Jim Marshall, a drummer, began building powerful amps in his London garage in 1960. Pete Townshend and John Entwistle of The Who were impressed by the sound of Marshall's overdriven tubes, but they wanted a sound that was even louder, darker and perhaps dangerous. Townshend and Entwistle asked for a 100-watt amp. (The Fender Bassman checked in at 50 watts.) Marshall's first attempt was to Townshend's specifications—against his better judgement, Marshall put all eight 12-inch speakers in a single cabinet. It was too heavy for the roadies, as Marshall had warned. He then built the stack of amps he originally had in mind. "In late 1965, production versions of this 'stack' followed in the Marshall 1960A (angled-front top 4x12 cabinet) and 1960B (base; flat-front 4x12 cabinet), the instantly recognizable Marshall 'stack' of today." The stack became a defining image of rock music and, by the 1980s, it had reached "comic levels as walls of Marshall cabs— nine times out of ten they're empty dummies—[were] used as backdrops for concert stages, photos [sic] shoots, and video sets." [86] The spoof rock documentary *This is Spinal Tap* (1984) featured a 20-foot-high stack with a volume dial that went to 11.

The desire to transform the electrical signal of the guitar or bass through deliberate distortion is not so different from the impulse behind *musique concrète* and other forms of tape music. In the studio, producers and rock musicians added sound effects like reverberation and echo with devices like the

Copycat, which was very similar to Schaeffer's morphophone:

> [The Copycat was] a compact tape loop delay system, providing, normally, between three and five playback heads, suitably spaced to provide an irregular pattern of delays. Careful regulation of the component playback levels and the degree of feedback supplied to the record head allowed an acceptably smooth prolongation of all but the most percussive of guitar sounds. Thus it was that pioneering techniques such as those developed by Stockhausen at Cologne were to be quickly replicated within the commercial sector, albeit for somewhat different ends.[87]

The Beatles made extensive use of various technological effects in the recording studio:

> The psychedelic "Tomorrow Never Knows" routed Lennon's voice through a Leslie organ speaker to create a whirling effect, accompanied by reverse-playing tapes and tape loops (achieved by removing the erase head of the tape machine, then recording many times over the same piece of tape).[88]

Spooling the continuous loop of tape through the altered machine allowed them to overdub indefinitely. The processing techniques were "to prove highly influential on the creative evolution of the electronic medium as a whole," and were in fact influenced by Stockhausen—McCartney had been listening to his work and had attended his concerts.[89] In the case of "Tomorrow Never Knows," the process was done manually, but the majority of doubletracked vocals on the *Revolver* album were done using automatic double tracking (ADT) or flanging, a technique developed to make the process less labour-intensive by the team at the Beatles' Abbey Road Studios under the direction of EMI engineer Ken Townsend. An audio engineering text describes it as "taking the vocal signal from the sync head of a multi-track, recording it to another loop of tape which is speed varied with a slow oscillation and recording it back onto the multi-track about a fifth of a second after the original." Music journalist David N. Howard explains the resulting effect: "Like photographic slides, the system enabled two sound images to overlap, and by varying the distance between the two images, the previously identical frequencies could be subtly altered to achieve greater acoustical depth."[90] The Beatles were far from alone among rock musicians exploring new sounds. The world of recorded sound offered a variety of aural experiences that left many listeners and musicians with an appetite for more—not only the transformation and manipulation of electric signals, but also the exciting (and arguably orientalist and self-consciously "exotic") use of instruments like the sitar to achieve a psychedelic or mystical effect, or the changes of meter borrowed from Indian music and from the highly influential Ravi Shankar. Danelectro briefly offered an electric sitar, a "'short-cut' instrument" that allowed the musician to "play the sitar and then amplify it without having to really learn to play the sitar," which can be heard in extended solo on the Steely Dan track "Do It Again."[91]

Still, in the popular imagination, the Beatles were associated first with guitars—all else sprang from there—and as guitars became more and more popular, more companies began to jump in. Wurlitzer, for instance, best known for its electronic organs, brought out its Stereo Guitar.[92] New companies were formed, too. Among them were several Canadian manufacturers.

5.3 Canadian Guitars and Equipment

Pete Traynor, then working in the repair shop at the Long & McQuade music store in Toronto, wanted an amp that was tough enough to take the abuse dished out by the store's rental customers. Traynor was the son of an electrical engineer and was quite comfortable with electronics. "High-calibre audio/video repairmen were around back then, but few knew or cared enough about instrument amps to work any wonders. By comparison, Pete Traynor seemed like Merlin with a soldering iron."[93] Traynor reportedly tested his designs by throwing them from the roof of the building. Owner Jack Long spun the business off under the name Yorkville Sound in 1963. Traynor designed a bass amp called the DynaBass. In 1967, the company expanded into Vancouver, British Columbia, and Buffalo, New York, and Traynor continued to design a number of innovative products. Yorkville Sound suspended production of Traynor amps in the solid-state years (after Traynor left the company in 1976 due to health problems) and concentrated on the international expansion of their Audiopro line of speakers, mixing consoles and amplifiers.[94] In 2000, they brought out the tube-based Traynor again, emphasizing the product's sturdiness and affordability: "At Traynor, our goal has always been to provide affordable and dependable professional audio products…. The affordable excellence of Yorkville Sound!" Naturally, it can be difficult to pack a premium product into a bargain price, and Traynors have not gone without criticism. Geddy Lee, the bassist for Canadian rock group Rush, said that he had the same Traynor amp for years because "in those days we couldn't afford very much."[95]

Winnipegger Garnet "Gar" Gillies, like Fender, began in radio repair. He was also a trombonist and he began installing P.A. systems in the clubs he played. His sound equipment business continued to evolve, and in the mid-1960s, he and his sons formed the Garnet Amplifier Company. Garnet supplied the amplifying equipment to struggling local band Chad Allan and the Expressions, who soon changed their name to the Guess Who. Gar built a pre-amp for their guitarist, Randy Bachman. The result, named "Herzog," became

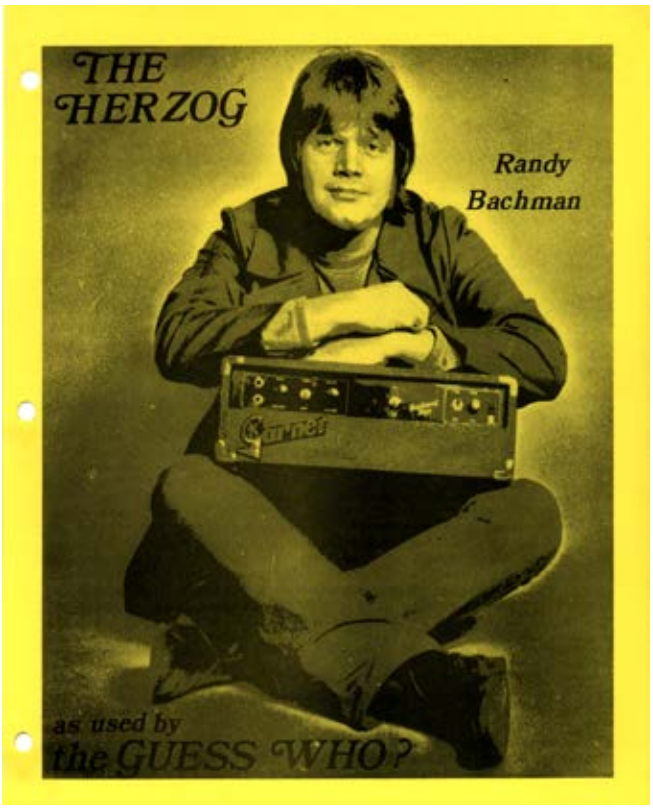


Figure 33: Advertisement for Garnet Herzog pre-amplifier featuring Randy Bachman (ca. 1970). Together they produced the "American Woman sound." (Garnet Amplifiers/Pete Thiessen)

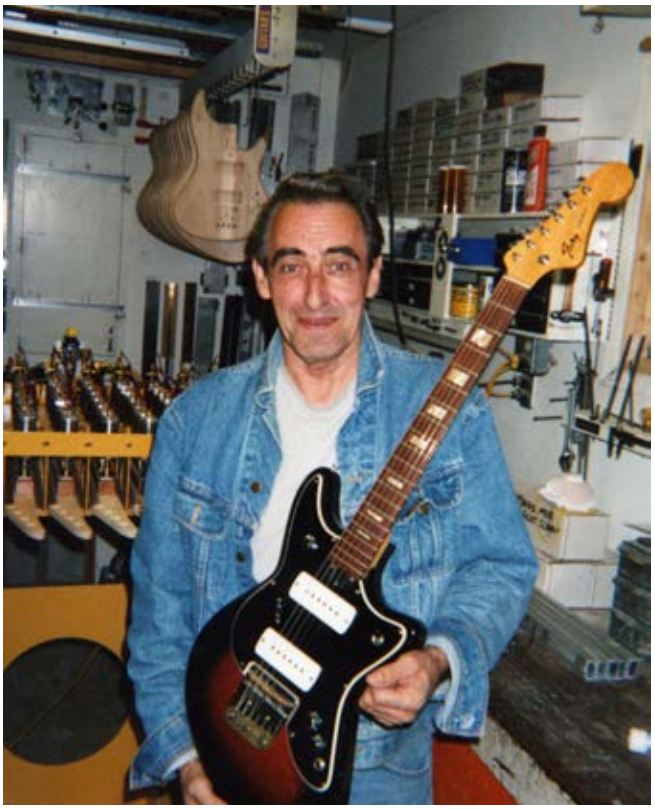


Figure 34: Glenn McDougall in his Saskatoon workshop (2003) holding the forty-year-old prototype of his Fury Fireball. (Bryan Dewalt / CSTM)

Bachman's signature sound on hits like "American Woman." By the early 1970s, Garnet had begun to make inroads into the American market. Their success indicates that an audio business needs more than just good equipment—it needs a relationship with professional musicians. These are necessary but not sufficient conditions: like many companies, Garnet tried to expand too aggressively in the 1980s and was forced to shut their doors in 1989. Gar Gillies continued to design and build custom amps. He died in 2006.[96]

Several Canadian guitar manufacturers started up as well. Although poorly documented, for a time in the 1950s and 1960s a company in Galt (now Cambridge) Ontario appears to have made lap steels and amplifiers under the "Mason" brand name.[97] Glenn McDougall founded Fury Guitars in Saskatoon in 1962. He believed he could put his own stamp on high-quality sound and performance, and so manufactured all of his own instrument components. All the pioneering firms had done this as a matter of necessity, but by 1962, it was a way to stand out in the marketplace. While his guitars were not typically custom-built, the size of the company and its high standards reassured customers that they were purchasing craftsmanship, which seemed increasingly rare among all the mass-manufactured instruments made for a rapidly maturing market. Fury did not stray from its founding ideals and remains a family company today. Fury's Space Bass, a shiny, black, bat-shaped bass produced in small numbers between 1983 and 1988, has proved popular among collectors of heavy metal instruments. The company also had a breakthrough in the 1980s with their patented ZP pickups, used on their BBM guitar (which competed for customers with instruments like the Fender Strat). The ZP is a combination of two single-coil pickups and a humbucker, which work together to "increase string motion by concentrating the magnetic force on the outer rim of the magnet poles." [98]This gives the strings a lively feeling, lengthens the sustain and produces a "monstrous sound." Saskatoon became a guitar-building hub thanks to McDougall. In 1999, he began designing instruments for Deakon Roads Guitars (also in Saskatoon), and helped fellow Saskatooners Dingwall Designer Guitars get back on their feet after a devastating fire in 1996.

Currently based in Lindsay, Ontario, Lado Musical Inc. is another high-quality builder of electric guitars and basses. Founder Joe Kovacic (also known as Joe Lado, from an archaic Croatian word meaning "lovable" or "dear") trained with Croatian and Viennese instrument makers before immigrating to Canada in 1971 and founding his company in 1973. In 2003, he started a lutherie school to pass on the

Figure 35: Jazz-rock fusion virtuoso John McLaughlin playing a Godin Freeway SA. (Godin Guitars)

art of repairing and building acoustic and electric guitars, and to foster a new generation of fine-instrument builders in Canada. On the school's website, Joe Lado promises, "A legacy is being passed along. If you have the dream to become a master guitar builder, we have the ability to help you fulfill your dreams."[99]

In 1982, Robert Godin formed a company to manufacture acoustic guitars and electric guitar parts in La Patrie, Quebec. When the company later set out to design and build its own guitars, they found that this experience had been highly instructive. "The great thing about this is the tremendous experience that we gained building all these instruments to their various specifications," the company's website states. The company now makes several lines of guitars (mostly acoustic) in six factories in four different locations: three in Quebec and one in New Hampshire. The necks and bodies for the electric Godins are made in La Patrie, and the guitars are assembled in New Hampshire. The company has produced innovative products, such as the 11-string, fretless, acoustic-electric hybrid Glissentar, which incorporates elements of the mandolin's Mediterranean ancestry. Because it is fretless, it "opens the door to microtonal playing as well as some incredible and unique sounds for adventurous guitar players." [100]

Less well-known Canadian guitar manufacturers include North Vancouver's Odyssey, which was active from 1976 to 1981. One of the company founders, Attila Balogh, also did a short custom run for Paul Dean of Loverboy. Signature Guitars was active in Aurora, Ontario, from 1987 to 1990. Roy Custom Guitars continues to produce instruments in Chelmsford, Ontario.[101] F Bass in Hamilton, Ontario, produces high-quality electric basses. Founder George Furlanetto comments, "I will probably have a chisel in my hands until I can no longer hold one."[102] There continues to be a level of activity around the guitar and bass guitar that early-twentieth-century inventors could never have imagined. Even much later in the century, the choice of the guitar struck George Harrison as entirely arbitrary. Reflecting on his first guitar, a gift from his father, he said, "It's funny how little things can change your whole life. Don't ask me why he chose a guitar instead of a mouth organ or something. They certainly weren't popular at the time."[103]

5.4 Break: The Electric Violin and the Unusual Case of the Harp

The attempt to electrify bowed string instruments goes back as early as 1912, when the company J.J. Corner produced a violin with an internal pickup.[104] In the 1930s, there seemed to be as much energy devoted to an electric violin as to the electric guitar. This is hardly surprising: the violin far outpaced the guitar in sales, not least because of its use in popular orchestras. Taking up the violin would appear to have been a more sensible choice for any musician who hoped for steady employment.[105] Lloyd Loar's Acousti-Lectric Company in Kalamazoo, Michigan, and Electro String in Los Angeles developed a slew of electric instruments, as did Rickenbacker. In addition to the violins, which included a bakelite solid-body violin designed by Doc Kauffman for Rickenbacker, there were mandolins, violas, cellos and bass viols. Rickenbacker was also associated with two electric orchestras. Mark Allen and his Orchestra, a Southern California group, were the first to perform with George Beauchamp's electric violins, and in San Francisco, the Bert Lynn All Electric Orchestra used everything available from the Rickenbacker catalogue, plus a few quirky instruments that Lynn made himself. "Photos show that he conducted his orchestra with one hand while adjusting volume controls on a mixer and amplifier board with the other."[106] Another all-electric orchestra mentioned in the literature is the Cracraft All Electric Orchestra from the late 1930s and early 1940s, which had electric strings, a Krakauer Electone, a Hammond Novachord, electric guitars "and even *kettledrums*."[107] The future of the electric string looked bright in this energetic orchestral context. But the activity in electric bowed strings declined noticeably after World War II. This was not because the violin was any less popular (it would still be a couple of decades before electric guitars would appear on Christmas wish lists),

but "because the improved quality of amplification systems and special pickups meant that acoustic systems could now be very effectively electrified."[108] Nevertheless, Fender made an attempt at an electric solid-body violin in 1958. It may have been an attempt to diversify their offerings—they had recently seen success with an electric solid-body mandolin. But sales of the violin were not satisfactory, and it was withdrawn from the market after less than a year. According to Forrest White, it was just too heavy. The Nashville musicians who tested the prototype "all liked the sound and the way it played, but their only objection was to the weight. This was the reason the Fender Electric Violin died almost before it became alive." The company reintroduced an altered, semi-hollow-body version in 1969, which ceased production in 1975.[109]

Other companies and instruments soon stepped into the breach. Jazz-rock soloists Jean-Luc Ponty and Michael Urbaniak played the Violectra—an electric violin tuned one octave lower than usual. Montrealer Marc Bélanger plays the vitar, "a sort of electronic violin which combines the tone colours of the upper bowed strings with those of the guitar."[110] Electric bowed strings tended to have this experimental flavour no matter the musical genre, perhaps because the story of twentieth-century music can be told as a reversal of the fortunes of the guitar and the violin. Jimmy Page is better known for having sometimes played his electric guitar with a bow than is any electric violinist. The problem may be in part the violin's strong association with classical music. As with most electric instruments, classical musicians seem to have found the electric violin distasteful. The pop-star sexiness and jazz-classical-techno fusion of players like Vanessa-Mae have done little to sway them from that position.[111] Within more straight-up pop music, the violin can have a slight air of having become lost on its way to the concert hall, unless it is used for passages that are clearly rooted in folk (as in the violin solo at the end of The Who's "Baba O'Riley," played by Dave Arbus). David LaFlamme, who played electric violin with It's a Beautiful Day, the San Francisco psychedelic band he founded, was originally a concert violinist. Although the band saw some success with songs like "White Bird" (1969; covered by Vanessa-Mae in 2001), it seems now to be part of the 1970s prog-rock fascination with classical music. Bands like the Electric Light Orchestra also made use of electronic strings. Perhaps the electric violin needed a genre that was less grandiose. It certainly seemed less ambiguous in the folk and folk-based pop of Canadian fiddlers Natalie MacMaster and Ashley MacIsaac.[112]

Canadian pop duo Myles and Lenny used Lenny Solomon's electric violin to musical advantage in the 1974 hit "Can You Give It All to Me," but after an unsuccessful album in 1975, the two dissolved their partnership. Solomon went on the form the jazz quintet Quintessence as well as the Lenny Solomon Trio.[113] He is also a founder and artis-

Figure 36: Nova Scotia-made Vector Omega 3 electric violin with a Traynor AM-50T amplifier (2010). (Tom Alföldi / CSTM 2007.00090, 2008.0108)

tic director of Bowfire, a travelling stage production similar to Riverdance, but with more attention on the musicians.[114] Stéphane Allard, who performs with Bowfire, has received a number of Canada Council grants to do work on the electric cello and violin, as well as electronic processing of the recorded sounds of stringed instruments.[115] The world of contemporary staged Celtic music, with its combination of music and dance, aggressive advertising and slick production values, seems to have provided electronic bowed strings with their only large-scale stable home. However, it is probably not going to earn them much respect among other musicians.

Contemporary composers have also used bowed instruments in combination with electronic technology to explore musical ideas. In Peter Sculthorpe's *Hambledon Hill*, a string quartet is surrounded by a ring of loudspeakers, a visual clue to the symmetry of the melodic and rhythmic structure of a piece that is sensitive to the relationship between acoustic and recorded sound. George Crumb wrote *Black Angels* (1970) for a quartet of electronic bowed string instruments developed by Max Mathews.[116] It is the cello, however, more than the violin, that has been of particular interest in these kinds of compositions, such as Lukas Foss's taped cello-plus-effects *Cello Concert* (1966), and Tod Machover's computers-plus-cello "hypercello," which is used in "Electric Etudes" and "Begin again again …." Musicologist Frances-Marie Uitti observes, "The cello, by its very nature, is well suited to such electronic experiments, on account of its rich overtones, the colouristic potential of its long strings and its naturally deep resonance."[117] It was a Canadian cellist, Richard Armin, who developed the RAAD family of electric bowed strings in the 1970s and 1980s:

> Narrower and thinner than typical stringed instruments, the RAADs are each shaped like vertically paired diamonds. Their tops are the traditional auburn, but these are isolated sonically from the rest of the fid-

dle (which is jet black) and instead amplified directly. Thus these instruments are truly electronic, though played normally, and facing the audience from behind were two sets of stacked speakers, and a couple of console boxes that winked Christmas colors.[118]

The instruments, which also have a sampling capacity, are played by the Armin Electric Strings, an ensemble which has usually included Armin's sister and two brothers. Canadian composer John Rea wrote *Some Time Later* (1986) for RAAD instruments to showcase the way the "live" instrument could play different rhythmic patterns on top of a looped sample. The RAAD instruments are also used by Toronto jazz-rock violinist Hugh Marsh, the Arditti Quartet and in various theatrical productions. The hypercello in Machover's "Begin again again …" (which premiered with Yo-Yo Ma in 1991) is comprised of RAAD, Zeta and acoustic cellos, in addition to various processing effects. Robin Stowell calls the RAAD "kit-like," and comments on its stylistic versatility:

> By allowing the instrument's signal to be amplified, modified or altered through changes in frequency response, rapid changes in amplitude, harmonic alteration (of overtones), echo and reverberation effects, and distortion, it has served a wide range of classical and popular musical styles.[119]

Another instrument that occupies this musical fusion territory is the electric harp, which is mentioned less frequently in the literature than the violin (which is, itself, not mentioned much). Efforts to amplify the harp in the late 1940s used contact microphones or pickups, and later connected these to electronic amplifiers with a variety of sound-modifying effects. In the 1980s, Salvi Harps brought out the first fully electric harp. In 1988, Dean Rubine and Paul McAvinney unveiled the VideoHarp—a synthesizer controller that uses optical sensors to detect the parameters of the movements of the harpist's fingers, which are then converted to synthesized sounds. It may be played as if it were a harp, but also with any other kind of gesture; it need not be classified as a harp at all, other than in some of its guiding inspiration. Recent developments in electronic harps have taken full advantage of the potential of computerized electronics.[120]

Notes

1 Nick Freeth and Charles Alexander, *The Guitar* (Philadelphia: Running Press, 2002) 156.

2 Philip F. Gura and James F. Bollman, *America's Instrument: The Banjo in the Nineteenth Century* (Chapel Hill: University of North Carolina Press, 1999) 3. This was not the first time that changing musical tastes had affected stringed-instrument preferences. At the turn of the century, the banjo gave way to the mandolin. Instrument makers responded with banjos that sounded more delicate or exotic - just in time for Americans to become infatuated with tango music around 1910. Michael Holmes, "Tangos and Tenors: Revenge of the Banjo Makers," Walter Carter, ed., *Gibson Guitars: 100 Years of an American Icon* (Gibson Guitar, 1994) 76. See also Karen Linn, *That Half-Barbaric Twang: the Banjo in American Popular Culture* (Urbana: University of Illinois Press, 1991).

3 Walter Carter, "The Miniature Orchestra: Enter the Guitar" *Gibson Guitars*, 127.

4 Although the U.S. Civil War had ended, there was no fast way to relay the news to ship at sea. The *Shenandoah* continued pursuing Yankee whalers until August 2, 1865. See "CSS *Shenandoah*," http://www.history.navy.mil/photos/sh-us-cs/csa-sh/csash-sz/shendoah.htm.

5 Brookes, 54. The legend is also in Lorene Ruymar, *The Hawaiian Steel Guitar and Its Great Hawaiian Musicians* (Anaheim Hills, CA: Centerstream, 1996) 2, and Hugh Davies, "Hawaiian Guitar," Stanley Sadie, ed. *The New Grove Dictionary of Music and Musicians* 2nd Edn. (London: Macmillan, 2001). The only book to mention the role of the *Shenandoah* seems to be Brookes, and he does not cite a source.

6 Note that in Hawaii, "Hawaiian guitar" refers to slack-keyed instruments only. Note also that "slide guitar" is a method of playing the Spanish guitar with a slide, rather than another term for steel guitar. See Ruymar, *The Hawaiian Steel Guitar.*

7 Brookes, 54; Richard Chapman, *Guitar: Music, History, Players* (London: Dorling Kindersley, 2000) 224.

8 Freeth and Alexander, 116.

9 Tom and Mary Anne Evans, *Guitars: Music, History, Construction and Players from Renaissance to Rock*, (New York: Paddington Press, 1977) 255-6, Freeth and Alexander, 118., nationalguitars.com and rickenbacker.com. The various mergers and acquisitions can be difficult to track. Gibson now owns the rights to the name Dobro, and manufactures guitars under that name. In the late 1980s, two fans of the National resonator formed National Reso-Phonic Guitars, which manufactures resonators faithful to the original style. See nationalguitars.com. There is also a history of the original instruments: Bob Brozman's *The History and Artistry of National Resonator Instruments* (Fullerton, CA: Centerstream, 1993).

10 Steve Waksman, *Instruments of Desire* (Harvard U.P., 1999) 22.

11 Paul Trynka, "Guitar Pioneers," *The Electric Guitar*, 10.

12 Brookes, 146.

13 The Electrical Special is reported by Ruymar in her book, *The Hawaiian Steel Guitar*, 119. This was not the only instrument equipped with a light bulb. Among the twentieth-century additions to the bass drum was a "small trap door for the reception of an electric-light bulb to give added lustre during the halcyon 'twenties." James Blades, *Percussion Instruments and Their History* Revd. Edn. (Westport CT: Bold Strummer, 2005) 473. This light bulb could also be used to illuminate a scene painted on the front drumhead. See http://www.pas.org/Museum/tour/0898.cfm.

14 Tom Wheeler, "Visionaries: The Inventors of the Electric Guitar," *The Electric Guitar* (London: Virgin Books, 1993) 19. See also Roger H. Siminoff, "A Man Before His Time: Lloyd Allayre Loar," Walter Carter, ed., *Gibson Guitars: 100 Years of an American Icon* (Gibson, 1994), 92-95. See also Tom Wheeler, "Vivi-Tone," *American Guitars: An Illustrated History* Revd. Edn. (Harper Perennial, 1992) 356-358.

15 "Guitar Gallery Timeline," Experience Music Project website; follow link from http://www.empsfm.org/exhibitions/index.asp?articleID=663 to lauch timeline (complete with sampled sounds).

16 Evans, *Guitars: Music, History, Construction, and Players*, 340.

17 Richard R. Smith, *The History of Rickenbacker Guitars* (Fullerton, CA: Centerstream Publishing, 1987) 17, 18; "The Earliest Days of the Electric Guitar," www.rickenbacker.com/history_early.asp. Steve Waksman mentions in his text that the Frying Pan came out in 1931, but the accompanying photo says that it was "issued to the market in 1932." Waksman, 18, 19. Rickenbacker originally spelled his name 'Rickenbacher,' but changed it in the 1940s. Tony Bacon and Paul Day, *The Rickenbacker Book: A Complete History of Rickenbacker Electric Guitars* (London, 1994).

18 "The Electric Guitar," www.npr.org/programs/morning/features/patc/electricguitar/, posted August 12, 2002. André Millard's book mentions that Rickenbacker's business card identified him as 'the father of the electric guitar,' and identifies Beauchamp as "a musician and tinkerer." Given

that Smith credits Beauchamp with the work of writing and rewriting the patent applications, it is obvious he was more than that. Millard later states that Beauchamp may well have been responsible for much of the technical development. Millard, "Inventing the Electric Guitar," *The Electric Guitar* (Smithsonian Institution, 2004) 44, 58.

19 Darcy Kuronen, *Dangerous Curves: The Art of the Guitar* (Boston: MFA Publications, 2000) 116. This book accompanied an exhibit at the Boston Museum of Fine Arts, 2000-2001.

20 Smith, *History of Rickenbacker Guitars*, 48.

21 Ibid., 31 and *The Art of the Guitar*, 119.

22 Trynka, "Guitar Pioneers," 10; Duchossoir, *Gibson Electrics: The Classic Years*, (Milwaukee, WI: Hal Leonard, 1994) 40.

23 Waksman, *Instruments of Desire*, 34.

24 Graeme M. Boone, "The Guitar in Jazz," *The Cambridge Companion to the Guitar*, Victor Anand Coelho, ed. (Cambridge U.P., 2003) 73.

25 Waksman, *Instruments of* Desire, 30.

26 Graeme M. Boone, "The Guitar in Jazz," 73. Wheeler mentions that it was the ES-150's pickup that became known as the Charlie Christian (*American Guitars*, 132). Christian, of course, played other guitars, including models from Vega and Epiphone.

27 Walter Carter, "The Kalamazoo Playthings Company," *Gibson Electrics*, 132-133; Wheeler, *American Guitars*, 101.

28 Wheeler, *American Guitars*, 132. See also Adrian Ingram, *The Gibson ES-175: Its History and Players* (Ely, UK: Music Maker Books, 1994) 1-7.

29 "The Electric Guitar," www.npr.org/programs/morning/features/patc/electricguitar/

30 Paul's name comes up frequently in histories of the electric guitar - in no small part because of the famous Gibson model that bore his name, but less often in histories of jazz or the guitar more generally. Paul seems to be spot on in describing his music as "commercial" - pleasant, appealing to a broad listenership, but somehow more technologically than musically innovative. Waksman, *Instruments of Desire*, 68, 42.

31 A. R. Duchossoir, *The Fender Telecaster: The Detailed Story of America's Senior Solid Body Electric Guitar* (Milwaukee: Hal Leonard, 1991) 7.

32 Ibid., 7.

33 Rickenbacker had used detachable necks, too, but perhaps not with Fender's keen eye for the market.

34 Freeth and Alexander, 172.

35 Freeth and Alexander mention that by the time this happened, "a number of" two-pickup Esquires had also been sold," 172.

36 Tony Bacon, *Six Decades of the Fender Telecaster* (San Fransisco: Backbeat, 2005) 32. Bacon also details the changes made to the Esquire and the Telecaster during this period, pp. 29, 32.

37 Waksman, *Instruments of Desire*, 48.

38 Ibid., 43.

39 Guy Gugliotta, "'The Log' Puts Paul in Top Rank of Inventors," *The Washington Post* (Monday, May 16, 2005) A07, archived online, http://www.washingtonpost.com/wp-dyn/content/article/2005/05/15/AR2005051500649_pf.html

40 Duchossoir, *Gibson Electrics*, 41. This music shared many traits with other studio-based music of the time: "Lover," released in 1947, was the culmination of two years' worth of garage-based experimentation with multitrack recording on discs. *Instruments of Desire*, 57-59.

41 The Rock and Roll Hall of Fame puts it this way: "…Paul built his first solid-body electric guitar…." http://www.rockhall.com/inductee/les-paul. The National Inventors Hall of Fame entry on Paul is at http://www.invent.org/hall_of_fame/225.html. McCarty is from Duchoissoir, *Gibson Electrics*, 42.

42 Duchossoir, *Gibson Electrics*, 43.

43 Tom and Mary Anne Evans, *Guitar: Music, History, Construction, and Players from the Renaissance to Rock*, 342.

44 Ibid. See also pp. 379-384. Carter, "Enter the Guitar," mentions that Vega brought out a double-coil humbucker in the late 1930s, though none of the other sources corroborate this, 127.

45 On the sound of the Les Paul versus the Stratocaster, see http://www.onlinerock.com/virtual/ vm_guitar.shtml

46 Cited in Ray Minhinnett and Bob Young, *The Story of the Fender Stratocaster* (Toronto: Stoddart, 1995) 21.

47 Millard, 57; bigsbyguitars.com/history.html, Deke Dickerson, "Bigsby Vibrato Prototype," *Guitar Player* (October 2007) 60.

48 Forrest White, *Fender: The Inside Story* (San Francisco: Backbeat, 1994) 81.

49 Vibrato is a back-and-forth difference in pitch; tremolo is a back-and-forth difference in volume. Fender's misuse of these terms has stuck, with the result that electric guitarists do not necessarily use these words the way other musicians do. They are also called whammy or wang bars.

50 Freeth and Alexander, *American Guitars*, 11.

51 Minhinnett and Young, *The Story of the Fender Strat,* 24.

52 *Dangerous Curves: The Art of the Guitar*, 123; Tom Wheeler, "Sunshine, Surf, Girls, Hot Rods, and Guitars!" *Guitar Player* (January 2007) 90.

53 http://www.kellyindustries.com/guitars/fender_stratocaster.html

54 *American Guitars* 29-39; Jim Fisch and L.B. Fred, *Epiphone: The House of Strathopoulo* (New York: Amsco Publications, 1996).

55 Ibid., 353-4.

56 Millard, *The Electric Guitar*, 53. See also Tony Bacon, *50 Years of Gretsch Electrics* (San Francisco: Backbeat, 2005).

57 Freeth and Alexander, *American Guitars*, 199-215; Waksman, *Instruments of Desire*, 110. Waksman includes an entire chapter on Chet Atkins - chapter 3.

58 Jim Roberts, *How the Fender Bass Changed the World* (San Francisco: Backbeat, 2001) 21-22.

59 See *How the Fender Bass Changed the World*, pp. 60-63. Kaye played bass on a number of Beach Boys hits, including the song that featured the electro-theremin, "Good Vibrations." See http://abbeyrd.best. vwh.net/carolkay.htm and www.carolkaye.com.

60 *Fender: The Inside Story* 53.

61 *How the Fender Bass Changed the World*, 37.

62 Ibid., 108-110.

63 *How the Fender Bass Changed the World*, 37; John Teagle and John Sprung, *Fender Amps: The First Fifty Years* (Milwaukee: Hal Leonard, 1995) 30.

64 Ritchie Fliegler, *Amps! The Other Half of Rock'n'Roll* (Milwaukee: Hal Leonard, 1993) 7. Circuit diagrams for many amps, as well as for some effects units, may be found in Dave Hunter, *The Guitar Amp Handbook* (San Francisco: Backbeat, 2005). For more background, see "Loudspeaker History," history.sandiego.edu/GEN/recording/loudspeaker.html.

65 *Fender Amps: The First Fifty Years*, 18. See also "Fender Amplifier History," musicguidebook.com/ articles/fender-amplifier-history.

66 Ibid., 28, 29. For more detail on the history of the amp with built in tremolo, see the unpublished paper by Ted Poulos, "All I Have To Do Is Dream: The Development and Use of Tremolo in Guitar Amplifiers," presented at the Popular Culture Association/American Culture Association Joint Meeting in Montreal in 1987.

67 Gordon Ross, "The Guitar in Country Music," *Cambridge Companion to the Guitar*, 145. Encouraged by their success, Fender began to manufacture acoustic guitars in 1963 - an inversion of Gibson's company history. (*Fender Amps*, 19.)

68 Donald Brosnac, *The Amp Book: An Introductory Guide to Tube Amplifiers* (Westport CT: Bold Strummer, 1987) 7.

69 dickdale.com/history.htm.

70 Art Thompson, *The Stompbox* (San Francisco: Backbeat, 1997) 64. See also Thompson's "50 Stompboxes that Changed the World," Michael Molenda, ed. *The Guitar Player Book* (New York: Backbeat, 2007) 212-225. The 'changed the world' title seems to be pretty popular with Backbeat Press.

71 *The Stompbox*, 6. See also Joseph A. Paradiso, "Effects and Signal Processors," *New Music Box: The Web Magazine from the American Music Center* (October 1, 1999) http://newmusicbox.org/ page.nmbx?id=06tp04

72 Joseph A. Paradiso, "Effects and Signal Processors," *New Music Box: The Web Magazine from the American Music Center* (October 1, 1999), newmusicbox.org/page.nmbx?id=06tp04; Art Thompson, "Wah: The Pedal That Wouldn't Die," *Guitar Player Magazine* (May 1992).

73 Chris Smith, *The Greenwood Encyclopedia of Rock History: The Rise of Album Rock, 1967-1973* (Westport, CT: Greenwood Press) 31-32.

74 Robert Walser, *Running with the Devil*, 42. See Waksman, "The Turn to Noise," 109, 116. Deliberate distortion, for Waksman, is an example of the shifting and highly contested boudary between music and noise, an idea he draws from the French social theorist Jacques Attali. "Distortion" is a term with both a technical and a general meaning - in the technical sense, a distortion effect is the sound of an amplifier working close to its limits. Effects like fuzz, however, are also referred to as distortion - the term can refer to guitar effects more generally. Dominic Hilton, *The Bonehead's Guide to Effects* (Hal Leonard, 1999) 23.

75 Art Thompson, "Vox Keyboards and Effects," *Guitar Player* (October 2007) 95. *The Greenwood Encyclopedia of Rock* states that the fuzzed-out guitar on 'I Can't Get No Satisfaction' "may have simply been the result of a blown amplifier." Chris Smith, *Greenwood Encylopedia: The Rise of Album Rock, 1967-1973*, 35. See also Thompson's article in the May, 1992 issue of *Guitar Player*, "Wah - The Pedal That Wouldn't Die."

76 Brookes, 238, 239, 241. *The Bonehead's Guide to Effects* lists the stompboxes and other effects technologies in alphabetical order, and gives some recipes for stringing them together to achieve particular sounds. There is a book on vox amplifiers by Jim Elyea: *Vox Amplifiers: The JMI Years*. It is available through voxguidebook.com.

77 *The Stompbox*, 6.

78 Andy Babiuk, *Beatles Gear* (San Francisco: Backbeat, 2001) 153.

79 Matt Haig, *Brand Failures: The Truth about the 100 Biggest Branding Mistakes of All Time* (London: Kegan Page, 2003)142-145; Tony Bacon, *Fifty Years of Fender* (San Francisco: Backbeat, 2000) 42-96.

80 Quoted by Tom Wheeler, "The Genius of Practical Design," *Guitar Player* (January 2007) 85.

81 Lisa Scrivani-Tidd, *The Greenwood Encyclopedia of Rock History: The Early Years, 1951-59* (Greenwood, 2006) 169.

82 Brookes, 176.

83 Although his performance on the *Ed Sullivan Show* tends to be the one most people talk about, the *Milton Berle* performance came first. Waksman, "Rock Guitar from the 1950s to the 1970s," *The Cambridge Companion to the Guitar*, 111.

84 Brookes, 208. The Yardbirds included, at different times, three of 'rock guitars virtuosos: Eric Clapton (later of Cream), Jeff Beck, and Jimmy Page (who went on to lead Led Zeppelin).

85 Andy Babiuk, *Beatles Gear* (San Francisco: Backbeat, 2001) 20.

86 Accounts vary on whether the initial Townshend version was cut apart to make it easier to move. Marshall says no, but a piece on the Marshall Stack on www.thewho.net reports that it was. Rich Maloof, *Jim Marshall, Father of Loud* (San Francisco: Backbeat, 2004), 52-55; "The Marshall 'Stack," www.thewho.net/whotabs/marshallstack.htm. Mike Doyle, *The Sound of Rock: A History of Marshall Valve Amplifiers* (Westport, CT: Bold Strummer, 1990).

87 Manning, *Electronic and Computer Music*, 169.

88 *The Greenwood Encyclopedia of Rock: Folk, Pop, Mods, and Rockers, 1960-66*, 93

89 Manning, *Electronic and Computer Music*, 168, Bob Spitz, *The Beatles: The Biography* (New York: Little, Brown, and Co., 2005) 601-602; Walter Everett, *The Beatles as Musicians: Revolver through Anthology* (Oxford Univ. Press, 1999) 32. At McCartney's request, Stockhausen is among the figures pictured on the *Sgt. Pepper's Lonely Hearts Club Band* cover. Lennon would later famously marry into the avant-garde with Yoko Ono.

90 Richard Brice, *Music Engineering* 2nd edn. (Burlington MA: Newnes, 2001) 229; David N. Howard, *Sonic Alchemy: Visionary Music Producers and their Maverick Recordings* (Milwaukee WI: Hal Leonard, 2004) 22.

91 Rachel Rubin and Jeffrey Melnick, *Immigration and American Popular Culture* (New York Univ. Press, 2007) 160. See all of Chapter 4, "Monterey, 1967: The Hippies Meet Ravi Shankar."

92 Art Thompson, "Pawnshop, Prize: Wurlitzer Stereo Guitar," *Guitar Player* (August 1999) 22.

93 Mike Holman, "Yorkville Sound History, 1963-1991" http://yorkville.com/downloads/other/yorkvillehistory.pdf

94 "Velvet Black," informatik.uni-bremen.de/~dace/vb/history.html

95 "Corporate Overview" http:///www.traynoramps.com/default.asp?p1+6&p2=0&p_id=24; Holman, "Yorkville Sound History"; Tom Mulhern *Bass Heroes* (San Francisco: Backbeat, 1993) 111. See also Gerald Weber, *Tube Amp Talk for the Guitarist and Tech* (Hal Leonard, 1998) 462-463; www.yorkville.com and "Pete Traynor," www.lynx.net/~jc/torontoStar.html.

96 garnetamps.com/history.htm; garnetamps.com/herzog.htm. Gillies also produced a book, *The How and Why of Tube Guitar Amps as 'Gar' Sees It*, available on the garnet.com website.

97 Folkway Music, "Instrument Gallery," www.folkwaymusic.com/instruments/resogallery.html

98 Zachary R. Fjestad, *Blue Book of Electric Guitars* (Minneapolis: Blue Book Publications 2006) 416, 224, 258 Jim Roberts, *American Basses* (San Francisco: Backbeat, 2003) 70, 47-48; Mike Francis, "Fury BBM Guitar," *Canadian Musician* (September-October 1998) 22; Gerald Laurence, "Fury 'BBM' Electric 6-String: New Design Techniques (and Killer Pickups) Make the Fury a Winner," *Gear* (April 1998), http://www. furyguitar.com/bbmsix.htm; Joe Gore, "Alternative Jungle: Fury BBM 6- and 12-strings," *Guitar Player* (December 1998) 156+; furyguitar.com. The website includes an article by Stan Garchinski from *Vintage Guitar* magazine's January, 2000 issue: "Builder Profile: Fury Guitars," http://www.furyguitar.com /vintage.html.

99 There seems to be no information on Lado in the standard literature, merely entries in the price guides. http://www.lado-guitars.com/history.html, http://en.wikipedia.org/wiki/Lado_Guitars. See also "Lado Guitars," *Tempo* (September-October 1979) 14-16, 18.

100 http://www.godinguitars.com/aboutus.html; http://www.godinguitars.com/godinglissentarp.htm. You can see Robert Godin talk about the Glissentar on www.youtube.com/watch?v=UepwVg89u2k

101 *Blue Book of Electric Guitars*, 795, 891, 931.

102 *American Basses*, 51; fbass.com/html/george.html.

103 *Beatles Gear*, 17.

104 Hugh Davies, "Electronic Instruments," *Grove Music Online*.

105 See Brookes, 176.

106 Richard R. Smith, *The History of Rickenbacker Guitars*, 13.

107 Tom Darter, *The Art of Electronic Music*, 20, emphasis in original.

108 Hugh Davies, "Electronic Instruments," *Grove Music Online*.

109 White, *Fender: The Inside* Story, 109. White's memoir reports that the electric violin did not become available until 1970. Tony Bacon, *50 Years of Fender*, 26; Donald Brosnac, *Guitar History, vol 1: Guitars Made by the Fender Company* (Westport CT: Bold Strummer, 1983) 30.

110 Hugh Davies, "Electronic Instruments," *Grove Music Online*; Flora Matheson Goulden, et al., "Violin and Viola Playing and Teaching," *Encyclopedia of Music in Canada*, www. thecanadianencyclopedia.com.

111 For example, her album *The Violin Player* (1995) or *Choreography* (2004). She has also collaborated with the artist once again mostly known as Prince, on *Xpectation* (2004).

112 nataliemacmaster.com; ashleymacisaac.ca.

113 "Myles and Lenny," http://jam.canoe.ca/Music/Pop_Encyclopedia/M/Myles_And_Lenny.html

114 www.bowfire.com

115 http://www.hhecn.com/view_item_en.asp?id=51

116 Robin Stowell, "Extending the Technical and Expressive Frontiers," *The Cambridge Companion to the String Quartet* (Cambridge U.P., 2003) 150, 170, 172.

117 "The Frontiers of Technique," *The Cambridge Companion to the Cello*, Robin Stowell, ed. (Cambridge U.P., 1999) 221. See also David Neubert, "Electronic Bowed String Works: Some Observations on Trends and Developments in the Instrumental/Electronic Medium," *Perspectives of New Music* 21 (1982) 540-566, which lists several works and players from different musical genres.

118 Peter Mose, "Alex Pauk's score merits repeating," *The Toronto Star* (10 December 1986) B4, cited in Robert William Andrew Elliot, *The String Quartet in Canada*, chapter 3, "Innovation and Modernism," note 56. Ph.D. dissertation, University of Toronto (1990), posted online at http://www.utoronto.ca/icm/thesis3.html. Elliot also recommends Marilyn Emerson's "The Shock of the New," in the February, 1984 issue of *The Strad*.

119 Nancy McGregor and Durrell Bowman, "Armin, Richard," *Encyclopedia of Music in Canada*, www.thecanadianencyclopedia.com; Robin Stowell, "The Violin," *Grove Music Online*.

120 Sue Carole DeVale, "Electronic Harps," *Grove Music Online*; Rubine and McAvinney, "The VideoHarp," *ICMC 1988* (San Francisco: ICMA, 1988) 49-55; Eduardo R. Miranda and Marcelo M. Wanderley, *New Digital Musical Instruments: Control and Interaction Beyond the Keyboard* (Middletown WI: AR Editions, 2006) 28.

6. Coming of Age: The Synthesizer, 1955-1980

6. Coming of Age: The Synthesizer, 1955-1980

6.1 Beginnings

In 1955, RCA demonstrated a new instrument that Harry Olsen and Herbert Belar had developed at their labs in Princeton shortly before. The RCA Synthesizer Mark I was designed to generate the sounds of the instruments commonly used for popular recorded music. The model that followed, the Mark II, went to the Columbia-Princeton Electronic Music Center when it was founded in 1959, where several composers used it in various tape compositions, notably Milton Babbitt. Since it was operated using punched paper controlled via a keyboard, using it was more like programming than playing a conventional instrument. However, programming is not a radically different act from composition, and people seem to have thought of the Mark II as a composition aid.[1] They never went into mass production—RCA planned to use them to guide the way to successful speech synthesis, rather than manufacture and market them for the musicians' market. But they were the first instruments to bear the name "synthesizer," and their capacity to generate many different instrumental voices meant that the name stuck to the devices that followed.

The most famous of the synthesizers—and probably still the most widely known—is the Moog synthesizer. In the introduction to Trevor Pinch and Frank Trocco's *Analog Days*, a history of Moog's instruments, Robert Moog writes,

> Why have most early electronic instruments fallen into obscurity, while many recent developments such as the keyboard synthesizer, the phaser, and the fuzz box have become part of the growing electronic musical instrument industry? Rapidly evolving technology is only part of the answer. The complete answer must take into account the evolution of the cultural environment in which we are immersed.[2]

In the mid-1950s, Robert Moog was busy with his Melodia Kit theremins. Moog, while he had had piano lessons as a child, "was at heart an engineer" and was mostly unfamiliar with the ideas and people shaping the contemporary experimental music scene.[3] But selling theremins brought him to a convention where he met experimental composer Herbert Deutsch. Moog and Deutsch soon collaborated on a number of devices that would later become synthesizer components. When they demonstrated some of these to Myron Schaeffer at the University of Toronto Electronic Music Studio, Schaeffer "flipped," Moog recalled. "He was the first person from the electronic music establishment to give us encouragement. Word got around…" Moog's devices soon coalesced into a new instrument that he demonstrated at the Audio Engineering Society's convention in 1964. "We actually took two or three orders at the show, which kept us busy for about six months. And that's how it began."[4] There was some debate over what to call this new instrument, since "synthesizer" was associated with RCA. However, it was such an apt description of what the instrument did that it soon became the generic term for all such devices.

Like Le Caine before him, and Don Buchla and Paul Ketoff at the same time, Moog designed his synthesizer to be fully voltage-controlled. As Thom Holmes describes it,

> In a voltage-controlled device, a small amount of current is applied to the control input of a given component to modify the output signal. This voltage signal is preset, precise, and quick, and can be activated by such easy-to-use voltage-control components as the synthesizer keyboard…. What the keyboard was actually doing was sending a voltage signal of a particular amount to the sound-generating oscillator of the synthesizer.[5]

Voltage control allows the musician to shape and mould the sound prior to its actual sounding. Voltage-controlled amplifiers, for example, strengthen the incoming signal in a way that depends on the magnitude of one or more control voltages that are at the musician's disposal. The increase to the signal's strength (a quality known as the amplifier's "gain") may be linear or exponential. Exponential devices are particularly useful musically, since we hear sound intensity exponentially (the decibel scale is logarithmic), and—even more importantly for the synthesis of musical sound—the way that musical tones build up and decay is exponential. The oscillators in the Moog were also voltage-controlled and activated by a keyboard: the higher the key, the higher the voltage, and the higher the pitch. Simple acoustics shows that if the frequency of a sound wave is doubled, the tone will be an octave higher.[6] Moog is credited with introducing the "volt-per-octave" standard to synthesizer design: each one-volt increase in control voltage doubles the oscillator frequency. What really made the Moog distinctive though, was its voltage-controlled filters. A filter removes some of the frequencies from the signal, so that a deep bass, for example, sounds low and grumbly with no treble interference via a low-pass filter. By using the filter in real time—as the note is being played—the instrument has a great advantage in replicating the attack and decay pattern of particular instruments.

Moog's design laddered pairs of transistors connected by capacitors; when overdriven, the resulting distortion was the "fat" sound that made the Moog so popular with rock musicians in the 1960s and 1970s. "Its design was so unique that several other synthesizer manufacturers copied it until Moog's company forced them to cease and desist."[7]

Composers and musicians could purchase different modules, which meant they could customize the instrument according to their needs. "The use of discrete modules mimicked the way electronic composers like Deutsch worked and showed the power of thinking of the synthesizer as a 'portable electronic studio,'" Pinch and Trocco point out.[8] Each module had its own function (to generate, process or control sound in some way), and they had to be connected with patch cords in order to make the desired sound. But the advantages of modularity were not unique to the Moog, and the Moog's persistence in the music world cannot be explained merely by pointing to its technological characteristics. Another voltage-controlled and modular synthesizer was taking very different form on the American West Coast, but it would never see the widespread use that the Moog enjoyed.

6.2 The Buchla Box

Soon after they founded the San Francisco Tape Music Center in 1961, Ramon Sender and Morton Subotnick began searching for new instruments. They were encouraged by the popularity of the Center after they began staging "Sonics," and recognized that an instrument that could be played live would bring in audiences:

> Sender had introduced more visual elements and audience participation because he discovered that audiences did not like just listening to tapes. This was a problem endemic to electronic music before the synthesizer: without a performer, a concert was terminally boring to watch.[9]

Likely this helps explain why, even with the institutional momentum provided by the studios—which continued to be established through the 1960s—tape music as such was declining in significance. Live performance was still the sign that you had arrived musically.[10] Many electronic musicians were deeply interested in the possibilities of live performance, spurred on by John Cage's pioneering work: "Cage's growing interest in live electronics provided the catalyst for the birth of a number of live electronic ensembles in America that, with some justification, considered themselves pioneers of a new art form that embraced aspects of progressive jazz and even rock."[11] Live electronic music promised to open the listener to new mental experiences—which was just what the emerging counterculture wanted.

The San Francisco Tape Music Center commissioned Don Buchla, a member of this artistic circle, to produce "a kind of open-ended palette or black box for composing."[12] Like Le Caine, Buchla was more interested in purposeful electronic instruments than in adapting existing equipment to musical goals. Like both Le Caine and Moog, Buchla was trained in physics (although he left without completing his Ph.D.). Unlike Le Caine and Moog, Buchla was highly drawn to some of the more radical ideas that circulated in the late 60s. He wanted his instrument, dubbed the Buchla Box, to be a complete break with all previous design. For example, the early versions had no keyboard at all, just touch-sensitive pads. "It just never occurred to him that [a keyboard] was an appropriate way to control electronic sounds," Pinch and Trocco remark.[13] Subotnick was willing to invoke traditional instruments when it suited him, though: when it turned out Buchla and his associates had to compromise on some of the components in order to keep it affordable, Subotnick said,

> We felt that it was more important for the Buchla synth to have lots of things that were slightly less stable than to have it be so expensive you could only afford a few modules…. As I recall, the determination of how long the oscillators would stay in tune was how long a violin stayed in tune in a concert. I figured if you had to retune a violin halfway through, why not an oscillator?[14]

Buchla also developed three sequencers for the instrument, in order to automate some of the tedious work of splicing and reassembling taped pitches: "You could literally program a very complex rhythm over a long period of time."[15] In some ways, the development of sequencers was the culmination of everything the advocates of total serialism had hoped for. Certainly the Buchla Box was an instrument only the most eggheaded musicians could love. Morton Subotnick was among these, and he used the Buchla to compose and record *Silver Apples of the Moon* at the request of Nonesuch Records (1967, re-released in 1994 on the Wergo label). Music critic Christian Hertzog said of the piece, "There is a rich counterpoint of gestures, in marked contrast to the simple surfaces of much contemporary electronic music." Nonesuch's commission, Hertzog says, seems to have been "a conscious acknowledgement that the home stereo system constituted a present-day form of chamber music."[16] While recorded music had indeed turned the home stereo system into a form of chamber music to be enjoyed as one wished, commissions of electronic music remained unusual.

Vladimir Ussachevsky ordered three Buchlas for the Columbia-Princeton studios after hearing it, and for a moment, it looked like the Buchla Box was poised to go mainstream. But after an ill-fated episode with CBS, which was initially interested in a manufacturing venture, Don Buchla decided to retain ownership of the company and run things his own way: small and far from mainstream. Holmes comments that

Figure 37: Buchla "Electric Music Box," series 200 (1970). (Don Kennedy/ Cantos Music Foundation)

Buchla "is recognized today as a kind of musical engineering guru, manufacturing highly individualized and personal instruments that are dearly valued by their owners."[17] The Buchla never gained a solid footing in the mass market.

In 1966, The San Francisco Tape Music Center moved to Mills College in Oakland, California, becoming part of the college's Contemporary Music Center. The Buchla Box was stored there, unused until 1992 when Christopher Koenigsberg, then a student, pulled it out and began to use it. He described the difference between it and the digital synths that had succeeded it, emphasizing a tension between ideas of human and non-human that runs through the history of electronic instruments:

> This is more like taking a lump of clay and kneading it with your fingers on the knobs and touch-plates. You can interact with the sound in complex ways. The problem with most equipment nowadays is there's a lot of bandwidth coming out, they can make a lot of different sounds, and the signal-to-noise ratio is really great. But there are a lot of parameters to change using these awful little LCDs. You don't get the sense that you're getting any bandwidth from the performer—the bandwidth of a human making expressive motions.[18]

6.3 Switched-On Moogs

Moog was more practical than Buchla, and his instrument's keyboard is one obvious example of this.[19] "[Moog's] success as an innovator can be traced to one key factor: he listened to what his customers wanted and responded to their needs," say Pinch and Trocco. One of the things that those customers wanted was a familiar interface. Pinch and Trocco seem surprised that the most enduring physical forms of the synthesizer include a keyboard, indicating a basic conservatism at work among even the most rebellious of rock stars: "Here was a new instrument, the synthesizer, one of the few new instruments ever to come along, and people seemed obliged to perceive it in terms of instruments with which they were familiar, the piano and guitar. Escape from these shadows would be difficult." Théberge, as noted earlier, has suggested that musicians from any genre can be reluctant to learn entirely new techniques. He comments more mildly that Moog's successful theremin business left him with little reason to second-guess his customers. Buchla, on the other hand, "with his closer relationship to the avant-garde, was initially hesitant to take such a step."[20]

Even with a keyboard, the Moog was not without growing pains: "From the point of view of competence, we were never a business," Moog said later. "Never….We were always in the red. We had no capital. None. Zero! And yet, we managed to keep stumbling along."[21] But the Moog was about to become very well known, thanks to a former student of Ussachevsky's at the Columbia-Princeton studio. Wendy Carlos (born Walter Carlos), then working as a recording engineer for Gotham Recording, began ordering components from Moog. She found the academic "in-groupiness" of studio music unappealing, but she was deeply taken with the synthesizer. Drawing on her background in physics as well as music, she offered valuable advice to Moog on how to improve the instrument's design. "The fixed filter banks came from Wendy," Moog said. "Lots of other things, too; I've lost track."[22] Carlos wanted to use the synthesizer to record classical music: "I thought that if I offered people a little bit of traditional music, and they could clearly hear the melody, harmony, rhythm, and all the older values," she said, "they'd finally see that this was really a pretty neat new medium."[23] In 1968, CBS Records released her album *Switched-On Bach*. Much to almost everyone's surprise, it was a mainstream hit. Carlos, a shy person, had not bargained for this. Neither she nor the Moog system was well suited to live performance—Carlos was in the midst of her change from Walter to Wendy (a change not complete until her surgery in 1972), and the synthesizer was a roadie's nightmare of heavy, finicky equipment. It was still primarily a studio instrument, and even had Carlos wanted to perform Bach in the concert hall, the extensive

use she had made of dub tapes meant that it would not have sounded much like her record. But *Switched-On Bach* vaulted the Moog into the mainstream musical consciousness.

In the wake of its success, "'synthesizer' suddenly became a household name…. The Moog was very much in demand and every hip musician and commercial recording studio wanted one."[24] (Union musicians were alarmed: the American Federation of Musicians banned the synthesizer from commercial work until Walter Sear, who had worked with Moog since the Melodia Kit days, convinced them that synthesizers did not automate their jobs.)[25] The orders poured in to Moog's Trumansburg factory, but not, for the most part, from classical musicians. This was unexpected. Moog, like Carlos, had thought the synthesizer would be used for straightforward classical music. But just as they had with nearly all the electronic instruments that had preceded it, classical musicians mostly ignored the synthesizer. The more vigorous movement in classical music at about this time was not the new, but the old: period instrument ensembles such as Toronto's Tafelmusik (1979) were formed to perform music as it would have been heard when it was composed. New instruments are perhaps more likely to find a home in a genre in which the repertoire has not become particularly fixed. The very idea of a repertoire was mostly foreign to the world of funk and rock where the synth was adopted. (Jazz and, to some extent, pop had developed repertoires, but no one treated these as definitive, let alone complete.) The instrument found a more solid place in pop, rock, jazz and funk. Progressive rock ("prog rock") saw the synth as a vehicle for crossover: in *Pictures at an Exhibition* (1971), Emerson, Lake and Palmer used "unaltered quotations from the original Mussorgsky score and elaborate synthesized manipulations [to provide] the outer extremes of a carefully constructed framework of rock and classical styles." Brian Eno went even further in his attempt "to forge close links between rock and avant-garde styles of composition."[26] Eno coined the term "Environmental Ambient" to describe his compositions, which were intended to alter the listener's relationship with his or her environment in a minimalist, largely imperceptible way. It was a rarefied and intellectual version of the more common idea that music influences our actions and moods (also the basis for the far less hip Muzak Company's infamous "elevator music.") Eno's best-known composition in this style is probably *Music for Airports* (1978).

All the attention to the synthesizer was a mixed blessing for Carlos, who prefers even today to remain private. She declined to be interviewed for Pinch and Trocco's *Analog Days*—the only major figure in synthesizer history to do so. Pinch and Trocco were interested in the idea of gender and the synthesizer, and it is possible that they tipped their hand to Carlos; had they secured an interview with Carlos, they likely would have devoted more of the book to her. Even without her participation, they get a little giddy: "While some people used the transformative power of the synthesizer to escape from the prison of 'straight' society, to help them transcend to new states of consciousness, Wendy, we suggest, may have used it to help her transcend her former body and her former gender identity."[27] Carlos, who wants to be known primarily as a musician, can hardly be blamed for refusing their requests for interviews. Pinch and Trocco base most of their account of gender on a Buchla synthesist, Suzanne Ciani, a successful composer of advertising music. Pinch and Trocco invoke an essentialist feminism to explain that women and men approach the synthesizer differently: "Having a synthesizer in your bedroom (along with a PC) was in a way an extension of the male hobbyist tradition of ham radios into a new era…. The women's desire to explore the technology for what it 'can do for them' is a persistent theme with all the women synthesists we talked with."[28] The synthesizer was more like a recording studio than any traditional instrument, and women were more likely to be in front of the microphone than processing its results. Women may have approached the synthesizer more self-consciously simply because playing it was more like recording production—a male-dominated arena—than like performance, where it would not be unusual to find women. The synthesizer also demanded a high level of comfort with electronics, something that the hobbyist 1940s, 1950s and 1960s had encouraged in boys and men, but not girls and women. Holmes comments:

> The studio model of the Moog was not an easy instrument to learn. Using it required some fundamental knowledge of wave physics and the way in which voltage-controlled components behaved. Notating electronic music was itself impractical, and composers turned to patch-cord setups and diagrams of control-panel settings to document the often bewildering matrix of cable connections required to produce a set of sounds…. The safest bet for most composers … was to simply record everything that was happening on tape, then return later to assemble the finished work as a composite of prerecorded sounds.[29]

Nor did it help that the performers who embraced the synthesizer in the late 1960s—the Doors, the Byrds, the Beatles and Emerson, Lake and Palmer—were representative of the testosterone-charged world of psychedelic rock 'n' roll.[30]

All the patches and switches that made the synthesizer a natural for recording engineers were about to become obsolete. In 1969, Moog was asked to put on a synthesizer concert at the Museum of Modern Art's Sculpture Garden. It was a high-profile and flattering request. Moog, however, was very aware that the synthesizer had not been designed for live performance: the oscillators were sensitive to temperature and humidity changes, and there was no easy way to be sure that you could recreate a particular sound. "Even if you could recognize the sound, it was not humanly possible to remember

Figure 38: The Minimoog (1971). (Tom Alföldi / CSTM 2005.0095)

exactly how you had set up all the patch wires and adjusted the numerous knobs."[31] Musicians, too, had been asking for something more reliable and portable, something they could take on the road. And giving them what they asked for would keep Moog's company going—at least for a while.

The Minimoog was a totally self-contained and portable synthesizer. Over 12,000 were produced over 13 years. It had a smaller range of sounds that the original modular systems, but it was lighter, cheaper and had controls that musicians found intuitive (such as its pitch wheel to control vibrato). It produced a distinctive sound that was the result of some interaction in its circuitry that defied complete analysis: like the very best instruments, the Minimoog was greater than the sum of its parts. "The sound of the Minimoog is for many the definitive analog sound," Pinch and Trocco comment.[32] Unfortunately, the company was in increasingly difficult financial circumstances. It was a bitter irony for Moog, for whom the late 1960s synth fad must have seemed at first a blessing. He recalled:

> Right around then, three forces merged. The first was that the market became saturated. The guys who'd jumped on doing their Moog records hadn't had hits, so they'd dumped their synthesizers. The second was that now we had competition—ARP [Instruments, Inc.]—and their product had the appeal of stable oscillators and no patch cords. The third thing was a general recession that forced music producers to cut back.[33]

Robert Moog soon sold his firm to Bill Waytena, who specialized in buying distressed firms. R.A. Moog, Inc. became Moog/Musonics, and later Moog Music, and moved to Buffalo, New York. The success with the Minimoog belonged to Moog Music now, and was largely due to the efforts of salesman David Van Koevering in creating a successful sales and distribution network. The firm was later sold to the Norlin Corporation.[34]

Figure 39: EMS VCS3 MK 1 "Putney" synthesizer (1969), one of the growing number of commercial synths. (Don Kennedy/ Cantos Music Foundation)

6.4 Other Synths

Not everyone wanted to purchase a complete synthesizer—others were of the same experimental and possibly countercultural frame of mind as Buchla. Simeon Coxe of the group Silver Apples (from the Subotnick album title) performed with his own synth around 1968, and engineer Richard Durrett completed the Durrett Electronic Music Synthesizer for Joseph Byrd of the band The United States of America. Both these instruments were lost when the bands parted ways; it is likely that, like the Telharmonium, they were used for parts.[35] By the 1970s, there was less need for a custom instrument as manufacturers sprang up to take advantage of musicians' interest. The best-known of these manufacturers was the one Robert Moog mentioned above: ARP, named for its founding engineer, Alan Robert Pearlman. An ARP synthesizer provided the famous six-note theme in the movie *Close Encounters of the Third Kind* (1977). It also was the voice of the robot R2-D2 in *Star Wars* (1977). ARP failed in 1981 after pursuing a synthesizer with a guitar-based interface called the Avatar. Pearlman had been opposed to the project from the beginning because the technical difficulties would demand too much of their limited research and development resources, but like many technological start-ups, the company had reached a stage where it was no longer clear who was in charge. "Despite [Pearlman's] objections, he was overruled, and the $7,000,000 company sank $4,000,000 into an untested product." [36] Oberheim

Electronics (later Oberheim/ECC) ran into similar problems: despite the admirable design of their instruments, the company was ultimately underfinanced.

Other synthesizers from all over the world were coming to market, both from established instrument manufacturers and specialty firms: Crumar, EMS, Korg and Yamaha, to name a handful.[37] These mass-produced synthesizers had a profound effect on compositional style, Manning believes. Although the modular systems allowed a degree of customization, this was a very different era from a decade or two earlier when there had been a "continuous dialogue … between the engineers and the composers in centers such as Paris, Cologne, and Milan." [38] Rather than composers asking for an instrument to produce a particular effect, electronic music would now begin with the characteristics of a particular instrument that had been mass produced and purchased in the marketplace. When the German group Kraftwerk, after establishing their studio in 1970, found that the interfaces on commercially available products were too conventional (they seem to be kindred spirits to Buchla), they began building their own instruments. Deeply influenced by the particularly German strain of technophilia that found its apotheosis in the Bauhaus movement, Kraftwerk wanted a more mechanical sound. Most commercially available synthesizers and drum machines had been designed to sound warmer, a little more like their acoustic counterparts. Kraftwerk point out that the walnut cases on 1970s and 1980s synthesizers betray an unexamined ambivalence:

> People have all the latest state-of-the-art technology, and yet they put wood panels on the front to help them feel comfortable. Or they develop new plastics and try and imitate the appearance of wood. They use modern technology to try to recreate the Middle Ages. This is stupid…. We go for the more minimalist or direct approach. Technology as an art—technology as it is. We have nothing to hide.[39]

Notes

1 Davies, "RCA Electronic Music Synthesizer," in *The New Grove Dictionary of Musical Instruments*, 199-200.

2 Pinch and Trocco, *Analog Days*, viii. The last phrase is a signal of the authors' allegiance to the social studies of knowledge, or SSK. (Pinch, in fact, is one of the founders of this field.) Pinch and Trocco keep things light, although they do pay attention to local practices of production and consumption – a nod in the direction of the soft Marxism that helped shape SSK. The book is clearly influenced by Th# SYMBOL 233 \f "Times New Roman" \s 10#berge's more rigorous *Any Sound You Can Imagine: Making Music/Consuming Technology.*# Th# SYMBOL 233 \f "Times New Roman" \s 10#berge has wider-ranging subject matter (and therefore less detail on the synthesizer), but his analysis is more detailed. The two books, along with popular guides to instruments and the major secondary sources on electronic music, are indispensable to any account of the synthesizer's development. Major works in SSK include Harry Collins, *Changing Order: Replication and Induction in Scientific Practice* (Beverly Hills and London: Sage, 1985), David Bloor, *Knowledge and Social Imagery* (London: Routledge and Kegan Paul, 1976), and Sheila Jasanoff, et al. (including Pinch himself), *Handbook of Science and Technology Studies* (Thousand Oaks, CA: Sage, 1995).

3 Pinch and Trocco, *Analog Days*, 21, 22. Pinch and Trocco are not engineers at heart – *Analog Days* is considerably weaker on technical detail than many of the other books referred to in this historical assessment. In addition to Deutsch, Moog collaborated with Wendy Carlos (see below) and Gustav Ciamaga (at the University of Toronto), as well as others. Théberge, *Any Sound*, 52.

4 Connor Freff Cochran and Bob Moog, "The Rise and Fall of Moog Music," in Mark Vail, ed., *Vintage Synthesizers* (San Francisco: Miller Freeman, 1993) 30-31. This book is a collector's guide to synthesizers. Other valuable resources are Martin Newcomb, *The Museum of Synthesizer Technology* (Hertfordshire, England: Albury, 1994), and Peter Forrest's two-volume *The A-Z of Analogue Synthesizers* (Devon, U.K.: Susurreal Publishing, 1994).

5 Holmes, *Electronic and Experimental* Music, 162. Manning's *Electronic and Computer Music*, as always, is rich in technical detail. See chapter 6, "The Voltage-Controlled Synthesizer."

6 e.g., low A at 220 Hz to middle A (concert pitch) at 440 Hz.

7 Holmes, *Electronic and Experimental* Music, 180 and Pinch and Trocco, *Analog Days*, 65-66.

8 Pinch and Trocco, *Analog Days*, 28.

9 Pinch and Trocco refer to these events by the more general sixties term 'Happening' (p. 37), but Thom Holmes, in his chapter on the San Francisco Tape Music Center calls them 'Sonics' – see p. 190 of *Electronic and Experimental Music*.

10 See Manning, *Electronic and Computer Music*, chapter 7, "The Electronic Repertory from 1960."

11 Ibid., 157.

12 Mark Vail, "Buchla's First Modular System," in Mark Vail, ed., *Vintage Synthesizers*, 97.

13 *Analog Days*, 43. Other synthesizer designs experimented with joysticks. See Manning, *Electronic and Computer Music*, 105-106. For a history of keyboard design, see Tom Rhea's articles, reprinted in Tom Darter and Greg Armbruster, eds., *The Art of Electronic Music* (New York: W. Morrow, 1984). The comparison to Le Caine is made by Vail, *Vintage* Synthesizers, p. 98.

14 Vail, "Buchla's First Modular System," 99.

15 "About Morton Subotnick," biography posted on Subotnick's website, mortonsubotnick.com/about.html.

16 Ibid.

17 Pinch and Trocco, *Analog Days*, 48-51, Holmes, 185. The Buchla and Associates website is www.buchla.com.

18 Vail, "Buchla's First Modular System," 101.

19 Possibly the Buchla would have had a better chance today, given that touchpads have become very common. However, as Thomas P. Hughes has persuasively argued, once a particular technology has the upper hand, it tends to accrue momentum. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore: Johns Hopkins, 1983).

20 Pinch and Trocco, *Analog Days*, 54, 63-64.Théberge, *Any Sound*, 52.

21 Cochran and Moog, "The Rise and Fall of Moog Music," 31.

22 Ibid., 32.

23 Cited Pinch and Trocco, *Analog Days*, 134.

24 Holmes, *Electronic and Experimental* Music, 178.

25 Union musicians remained suspicious of synthesizer players well into the 1970s (*Analog Days*, 149). According to Paul Théberge, this was largely part of the widespread anti-Disco movement (a movement far greater than Disco itself ever was – see below). *Any Sound*, 2.

26 Manning, *Electronic and Computer Music*, 172, 173. On Brian Eno, see Eric Tamm, *Brian Eno: His Music and the Vertical Color of Sound* (Boston: Faber and Faber, 1989) and Michael Bracewell, *Roxy Music: Bryan Ferry, Brian Eno, Art, Ideas, and Fashion* (Cambridge MA: Da Capo Press, 2007). *Music for Airports* was installed for a while at the Marine Terminal of New York's La Guardia Airport. On Muzak in its many forms, see Joseph Lanza, *Elevator*

Music: A Surreal History of Muzak, Easy-Listening, and Other Moodsong (Ann Arbor: University of Michigan Press, 2003).

27 Pinch and Trocco, *Analog Days*, 138. Carlos has given other interviews, all to music writers; they are cited in Holmes, pp.168-178. Her request that people respect her privacy is repeated on her website, wendycarlos.com.

28 Pinch and Trocco, *Analog Days*, 159. It is influenced by feminist historian of science Evelyn Fox Keller's work, which in turn was deeply influenced by Carol Gilligan's pioneering work of essentialist feminism, *In A Different Voice* (1982).

29 Holmes, *Electronic and Experimental Music*, 181. An important contemporary guide to patching techniques was Allen Strange's *Electronic Music Systems, Techniques, and Controls* ([Dubuque, Iowa:] W.C. Brown Co. [1972]). This book was revised and republished in 1983. Both editions are now out-of-print and quite rare.

30 On Emerson, see "Keith Emerson's Moog: The World's Most Dangerous Synth," *Vintage Synthesizers*, 107-115.

31 Pinch and Trocco, *Analog Days*, 121

32 Ibid., 214, 234.

33 Cochran and Moog, "Rise and Fall," 34.

34 His work is detailed in Chapter 12 of *Analog Days*, "Inventing the Market." Paul Théberge's version of the little bit of corporate history is different: he credits Moog (who worked for Moog Music for a time) with the name change associated with the change in corporate ownership. See *Any Sound*, 55. After a protracted legal battle, Moog won the right to use the names 'Moog Music, Inc.' and 'Minimoog.' He founded a new company, Big Briar, to manufacture theremins, and later, versions of the Minimoog. (*Analog Days*, 323). He died in 2005.

35 Mark Brend, *Strange Sounds: Offbeat Instruments and Sonic Experiments in Pop* (San Francisco: Backbeat Books, 2005) 92-93, 97.

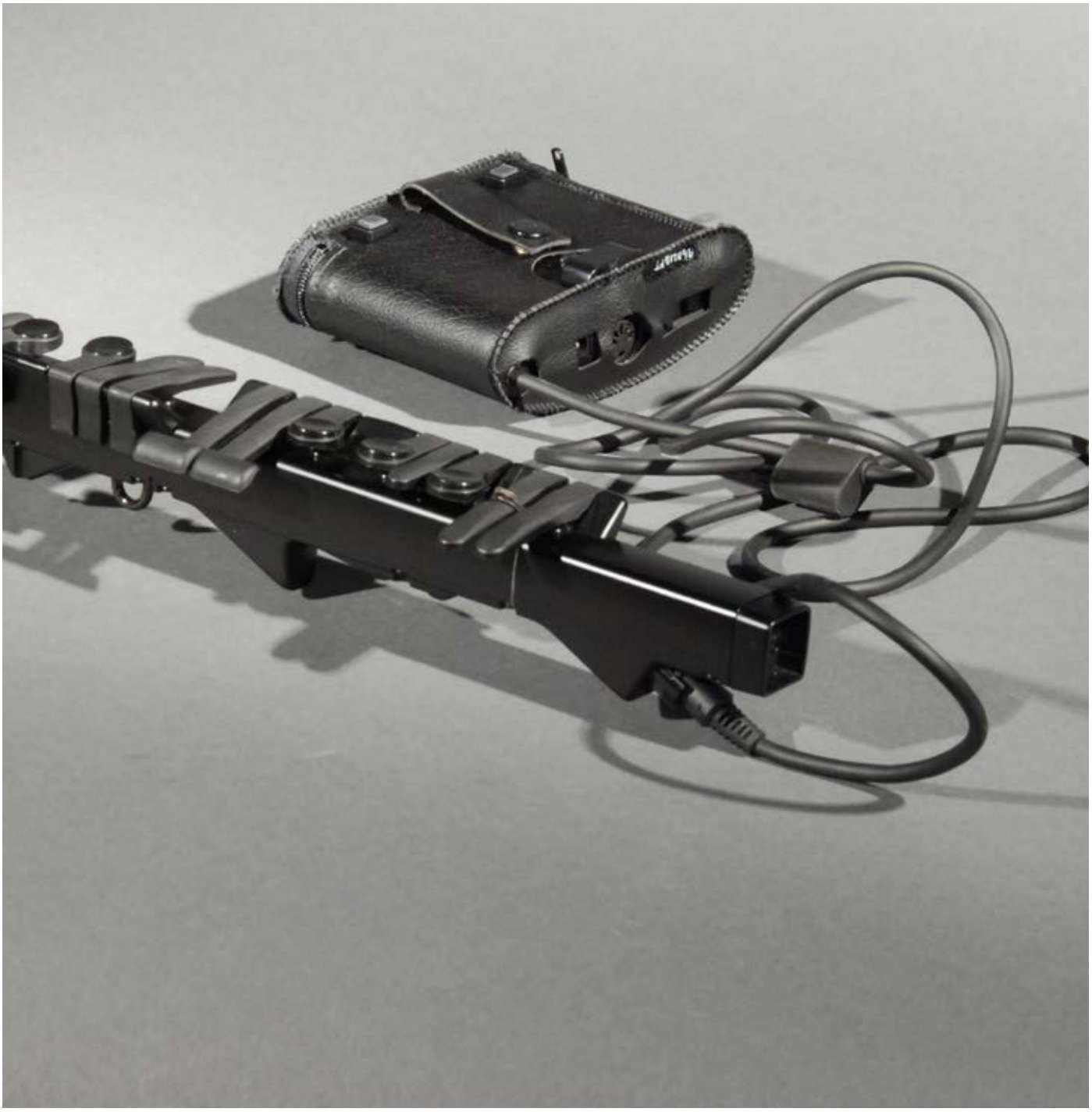
36 Dominic Milano, "American Synthesizer Builders," in *Vintage Synthesizers*, 19. See also Craig R. Waters and Jim Aikin, "The Rise and Fall of ARP Instruments: Too Many Chefs in the Kitchen,"pp. 40-50.

37 See Paul Wiffen and Mark Vail, "The Euro-Synth Industry: Classic Sounds, Exotic Hybrids, Lost Opportunities," *Vintage Synthesizers*, pp. 51-71 and Vail, "EMS VCS3 and Synthi A/AKS: British Modular Systems," pp. 102-106. The EMS VCS3 proved popular with prog rock concept albums, notably Pink Floyd's *Dark Side of the Moon* (1973).

38 Manning, *Electronic and Computer Music*, 129. Théberge, *Any Sound*, 36.

39 Greg Rule, "Kraftwerk," in Rule, *Electro-shock!* 180.

7. Music Goes Digital



7. Music Goes Digital

7.1 Computer Music and MIDI

Beginning in 1955, Lejaren Hiller and Leonard Isaacson used a computer program to generate the characteristics of a musical score, resulting in the *Illiac Suite* for string quartet in 1957. In 1957, Max Mathews, an engineer at Bell Labs, wrote a music program for the IBM 704 mainframe computer using a digital-to-analog converter to convert the numerical characteristics of an acoustic wave into equivalent voltage steps so that the music would play through speakers. MUSIC I was followed a year later by MUSIC II, which "was a little more flexible, allowing four functions to be manipulated simultaneously, drawn from a repertory of sixteen different waveforms."[1] Not surprisingly, the programmer's interest was actually voice transmission. But in the music programs that followed, researchers shifted their attention to university-based composers, for both IBM and non-IBM machines.

> Portability was achieved at a price, since these compiler-generated programs were inevitably less efficient than versions written directly in assembler code. The primary consequence was a significant increase in the time taken to process synthesis tasks, making computer music composers particularly unpopular with computing centers.[2]

Through the 1960s, composers and engineers continued to explore the possibilities that computers held for music, but none of this activity was particularly widespread since mainframes were not widely available or accessible. By the 1970s, however, the world of electronics was at the threshold of a profound change. The introduction of integrated circuits—mass-produced circuits with microscopic transistors on silicon chips—made computers lighter, cheaper and more powerful by several orders of magnitude. Electronic composers began tinkering with new devices such as the KIM-1, a single-board microcomputer that accepted machine-language programming. It was cheap (about $250), and musicians adapted it to control their homemade, chip-based synthesizers.[3] Things in the electronic music world had always been hands-on and often a little messy: composers spliced tape or soldered circuit components, and patched their way to particular sounds. As computers reached the point where they could accept instructions in the early software languages, composition took a step towards the abstract, becoming a process of coding rather than physical construction or action. Thom Holmes comments,

> What made microcomputer music different was the concept of computer memory as an adjunct to human memory. Software allowed one to save a control sequence. Actions could be stored and repeated as often as originally conceived, and repeatedly performed by the computer as often as one liked. The circuits themselves were transitory rather than hardwired. One's actions were reversible, unlike soldering, where you could permanently melt your best work away with one false move of the heating element.[4]

The League of Automatic Music Composers formed in the mid-1970s in Oakland, California (many of them were associated with Mills College); its performances were all on KIM-1 computers.

Some electronic instrument manufacturers began to produce their own chips: Ensoniq was founded by engineers from Commodore who were searching for a viable market in the technology slump of the early 1980s. Using their own chip design, the Ensoniq Digital Oscillator Chip (Ensoniq ES5503 DOC), they produced the Mirage, a digital sampler at less than a quarter of the price of those that were then available. Their strategy was to choose a market price and then design a product to fit it—a strategy that would become increasingly common for manufacturers of computers and computer peripherals, but which was new to the musical instrument market. Théberge remarks, "The success of [Ensoniq's] marketing research and its imposition of a precise and relatively fixed 'price point' at the outset of the innovation process suggest that marketing expertise may be one of the most essential complementary skills required of the innovating firm." They later licensed the chip to Apple, who used it in their Apple IIGS, which made it, according to one user, "the most powerful home computer in existence for music and sound capabilities" at the time.[5]

Generally, however, North American and European manufacturers took a while to introduce digital oscillators into their machines. To Western ears, pure digital sound was initially "cold and thin." Japanese manufacturers like Yamaha and Roland, however, accepted this sound in exchange for better control over the tuning and harmonics.[6] Western designers typically began with some sort of hybrid device, such as the Canadian-designed and manufactured McLeyvier. The system, sold by Hazelcom, also had a brief existence under the names Interactive Music Processor and Amadeus "before sinking without a trace." Composer Laurie Spiegel blames poor timing: "One of the big problems was that the com-

Figure 40: A low-end Casio digital portable from the early 1980s. (Tom Alföldi / CSTM 2005.0107)

pany put out a computer-controlled analog system in the very year when digital synthesis was becoming the next big thing." David McLey, the designer, went back to composition, and Spiegel was left to try to redesign the software for a fully digital version. Hazelcom soon jettisoned the project, leaving Spiegel to lament an instrument that "could do things that nothing else today can."[7]

By the late 1970s, the ground was well-prepared for an all-digital synthesizer. In 1976, the New England Digital Corporation (founded by Jon Appleton, Sydney Alonso and Cameron Jones) began commercial manufacture of a digital synthesizer, the Synclavier. The Synclavier had a bank of voice generators (the user could choose from eight to more than thirty-two), which could be controlled via push buttons. Programs and data were initially stored on floppy disks, but later versions included a hard drive, as well as a visual display for waveform manipulations. Composers liked it: Joel Chadabe developed the performance program PLAY for the Synclavier in 1978, and it was used in many advertising jingles and movie soundtracks. But it was very expensive. "Carrying an initial price tag in the area of $500,000, a fully equipped Synclavier system was so far beyond the financial means of even relatively successful musicians that its attributes took on a mystical aspect. The impression was that mere mortals could not understand its capabilities, much less its operation."[8] Similar systems that soon followed, such as the Australian Fairlight (which used sampled natural sounds for its source material—a digital version of the Mellotron) and the General Development System from Crumar in Italy, cost in the range of $30,000 U.S.—still well beyond the reach of most.[9] Even E-MU's Emulator, a digital sampling keyboard brought to market in 1981, was about $8,000, within the reach of commercially successful musicians, but too expensive for anyone still waiting for a break. The price barrier was broken in 1980, when Casio introduced the VL-Tone, a 2.5-octave keyboard with memory capacity. It sold for $70. In 1983, Casio introduced another cheap synthesizer, the PT-20, a 2.5-octave instrument with 7 voices, 17 preset rhythms and a 508-note sequencer—all for under $100.[10] The digital synthesizer was now available to the mass, non-professional market. But as journalist Paul Stump suggests, the extravagance of many of the machines may have been part of their allure for prog rock groups (and their fans), who were then in their final stages of decadence. The group Twelfth Night, for instance, had a non-working Mellotron on stage to satisfy the audience's expectation of a high-tech visual feast. Stump comments that the stage shows were "musical-instrument trade fairs."[11] Thanks to the lavish budgets that record companies awarded to rock spectacle tours, high-end synths had a fairly secure market, at least while prog rock lasted.

Manning describes three "areas of activity" in the electronic instrument market at this point: the high-end digital systems, the low-end digital portables and the broad middle, which still belonged to voltage-controlled analog synths like the Minimoog. The Japanese had an increasingly strong presence at the high and low ends, both from traditional instrument manufacturers like Yamaha (which had been in business for nearly a century), and from electronics firms like Roland. In 1973, Yamaha released the analog GX-1 and continued to make both high-end (the CS80) and low-end (the SY1 and SY2) systems into the late 1970s. The competition from Roland was increasingly stiff, too: 1980s new wave groups like Duran Duran used their Jupiter-8 (1980). Korg, meanwhile, attempted to capture both the professional and mass digital markets.[12]

As digital synths became more popular through the 1980s, the analog market began to languish. The instruments made their way to the bargain bins, where younger musicians picked them up. When the music they made rose to prominence, they fuelled an analog revival. Robert Moog recalls,

> By 1983, digital instruments with MIDI interfaces were stealing the show, and for a while, analog sounds were out of favour. Now [1989] they're back in, especially the Minimoog bass sounds. During the mid-80s, it was possible to pick up Minis on the used market for under $300 (the original price was $1,495). Nowadays, we've seen Minis selling for well over $1,000. And if you live in Europe, we've heard the going rate is much higher.[13]

Pinch and Trocco believe that the analog revival is likely an appreciation for the inherent unpredictability of the sound of the older synths, its fuzziness or dirtiness.[14]

As the number of digital instruments steadily increased, a problem became obvious: modules and devices from different manufacturers were not compatible with each other. Dave Smith, president of Sequential Circuits (which produced the Prophet 5 and Prophet 10 systems), together with one of his design engineers, Chet Wood, convinced I. Kakehashi from

Figure 41: Yamaha KX88, a MIDI keyboard controller (ca. 1985). (Tom Alföldi / CSTM 2005.0105)

Roland and Tom Oberheim from Oberheim that a universal communication standard was necessary. Smith presented their proposal to the Audio Engineering Society in 1981. In early 1982, they had NAMM (the International Music Products Association—the acronym dates from an earlier phase of their existence) on board. Manning reports that "by September the draft of a considerably expanded specification was complete, including the final choice of an acronym, the Musical Instrument Digital Interface, or MIDI."[15] MIDI provides an excellent example of what historian of technology Thomas Hughes calls "technological momentum": because it ensures that all instruments built after its adoption can communicate with one another, it stabilizes the market and gives consumers confidence that the expensive instruments they are buying are not doomed to obsolescence only a few years down the road. It thus has a tendency to persist, even when it is possible to replace it with a better technology.[16]

MIDI established 31,250 as the standard baud rate, laughably slow by today's standards. If the notes are played very fast, or if there are a large number of voices, it can result in "MIDI choke" as, in Manning's words, "delays in transmission as channel commands are forced to queue." Naturally, the baud rate has also led to difficulties in networked devices, since "even when sophisticated routing facilities are deployed, opportunities still abound for data bottlenecks and consequential timing delays." Compensating for these weaknesses demands some sophisticated electrical engineering. Paul Théberge points out that MIDI's wide use is not an indication that there is any deep respect for the technology, since consumers were never given any choice. There was an attempt to bring things up to a more standard speed with a proposal for ZIPI (Zeta Instrument Processor Interface) in the early 1990s, but according to Manning, instrument manufacturers were not interested.[17] They had too much invested in MIDI-based manufacture and were surprisingly conservative in their approach to the market in comparison to other digital communications endeavours, where speed was king. None of the other protocols has had much traction: Open Sound Control (OSC), the proprietary mLAN (from Yamaha) or HD-MIDI (High Definition MIDI), currently under discussion in the MIDI Manufacturers Association (MMA).[18]

Not everyone is a fan of MIDI. Vince Clarke of the British band Erasure took all the MIDI retrofits out of his older gear, claiming, "It's crap. It gives you a constantly sloshy sound. I can't stand it."[19] Clarke's reaction seems at first surprising: MIDI is a communications protocol—it is not a way of generating sound, and there ought not to be a distinctive MIDI sound. However, because MIDI assigns a numeric value to every aspect of a note, a musician has to think about the music differently (an effect that is magnified when playing real-time, rather than entering the notes into a sequencer).

> Whereas traditional notation uses a cluster of symbols indicating pitch, duration, dynamics, and articulation around each individual note… the data contained in the MIDI sequencer is often presented to the user in the form of separate lists of numbers or in the form of graphical representations, limited to one or more of the characteristics of the note at any given time. The various elements of gesture and performance thus undergo a fragmentation far greater than that associated with conventional notation.[20]

MIDI does have a characteristic effect on the sound, but this is a result of how MIDI-based techniques shape the way the musician plays the music, or, under extreme conditions (very rapidly played notes, for example), the imprecision that results from reaching MIDI's operational limits. It is not because MIDI is a way of generating sound. It is understandable that the role of MIDI is unclear even to musicians, because the term has expanded in use to refer to the data and file formats. This is all further complicated by the addition of proprietary extensions to MIDI, with the result that the same data may not sound the same on all machines.[21]

Nor was the mimicry of acoustic instruments perfect. This was partly because instrument designers and consumers were still wedded to the keyboard as a control device

for all instrument sounds, although most instruments are not keyboard-based. In the late 1980s, companies brought out "performance sensing devices," which adapt the physical characteristics of acoustic instruments to their electronic counterparts. For instance, rather than triggering a drum sound through a keyboard, the musician uses MIDI drum sensor pads, which are played more like traditional percussion. Yamaha is a major force in this area, "mainly as a result of its continuing interests as a manufacturer of conventional acoustic instruments." However, Peter Manning reports that most of the effort in this century has gone into products for the games market, rather than into instrument development.[22]

In tandem with the burgeoning technologies available to composers and musicians in the MIDI era, the electronic repertory increased enormously. But specialized music studios, devoted to experimental music intended for a knowledgeable audience, had declined precipitously in influence. Electronic instruments now belonged primarily to the pop and rock worlds. Manning suggests that MIDI was reflective of this: its introduction "saw a marked change in emphasis toward servicing the requirements of the rock and pop industries."[23] The history of the analog Moog indicates that this change was under way prior to the introduction of MIDI, however. MIDI may simply have been the culmination of manufacturers' recognition of the larger (and therefore more lucrative) market.

7.2 Alternate Controls: Wind Instruments and Microsound

From time to time, inventors tried applying electricity to wind instruments, although they never saw much success and only really came into their own with computer technology. Even then these instruments remained relatively obscure. Electricity applied to wind instruments seemed to have aroused the same broad ambivalence as for bowed strings. Benjamin Miessner experimented with the clarinet, saxophone and mouth organ, although nothing commercial ever came from it. In 1939, Buddy Wagner formed an amplified wind ensemble, but it too seems to have been a novelty more than anything else.[24] In 1965, instrument manufacturer H&A Selmer worked with loudspeaker and microphone company Electro-Voice to develop an electric saxophone. The impulse was good—electric instruments had a natural place in jazz and pop music, both because they could be louder than their acoustic counterparts and because of their capacity for sound effects. But Selmer's insistence on a design that allowed players to turn off the instrument and play it as a normal acoustic instrument suggests that, like the electric violin, the electric saxophone would always be an addendum to the acoustic. Microphone construction was hampered by the particular qualities of a wind instrument: sound pressure

Figure 42: Lyricon II wind synthesizer. (Tom Alföldi / CSTM 2005.0096)

levels in the instrument body could be extremely high, and the player's breath produced acidic moisture. Pickup placement had to be very exact: "When the pickup is in the wrong location, some notes will sound louder than others and there will be a definite loss of tone quality."[25] In the end, the control unit was mounted so that the player could make use of a variety of processed effects—volume, echo, loudness of a synthesized tone an octave down from the played notes, tremolo and tone quality—while continuing to play with the left hand. A separate cabinet housed the preamp, amp, power supply and speaker. But musicians did not take up the instrument with any enthusiasm. Selmer had anticipated that musicians wanted an instrument that would also play acoustically, but players did not believe that this new instrument could do that (despite the company's design efforts). An exception was Eddie Harris, who used the Varitone on albums such as *The Electrifying Eddie Harris* (1987). But it was not enough to generate the interest necessary to keep the instrument in production. Saxophonist Jason DuMars concludes, "The Varitone was in many ways ahead of its time, and could in fact be made today in a much smaller version with almost no impact on the instrument. Perhaps a company will again offer a system such as this."[26]

In 1974, Bill Bernardi and Roger Noble developed a synthesizer that was controlled with the player's breath. The Lyricon converted wind pressure information to synthesizer control information.[27] Soon after, Nyle Steiner invented the Steinerphone for saxophonist Michael Brecker. The Steinerphone uses the same fingering as a saxophone, but the musician can produce various pitch effects using his or her thumbs. If the player increases air pressure, volume increases (as it would on a regular wind instrument), but the timbre also changes appreciably with a variety of overtones. Brecker used it with jazz fusion group Steps Ahead on the *Magnetic* album (1986). Steiner also created the Electronic Valve Instrument, a breath-driven synthesizer controller that resembles a trumpet. Japanese firm Akai licenced these technologies in 1987 and renamed the Steinerphone the Elec-

Figure 43: Yamaha WX7 wind MIDI controller. (Tom Alföldi / CSTM 1996.0218)

tronic Wind Instrument, or EWI (pronounced to rhyme with "kiwi"); updated versions of these are still sold.[28] There was even a concert repertoire for EWI and EVI, which includes works by Maurice Jarre and Morton Subotnick.[29]

In the 1980s, Yamaha developed the WX7 controller as an experiment in breath control. The idea was that the player could hold a note by pressing on a key and then alter the quality of the sound using breath. It was MIDI-compatible, which allowed the player to assign any quality he or she liked to the various levels of wind and lip pressure. Richard Ingram points out that if air pressure is assigned to pitch rather than volume, the player can experiment with microtones and complete glissando. Being able to harness the power of breath in this exact way makes for a very different experience with the synthesizer, comparable to the biosignal-controlled synthesizers that are connected to eye movements or heartbeat.[30]

Acoustic wind instruments were also combined with studio techniques. Milton Babbitt composed *Images* (1979) for saxophone and taped saxophone. In her history of the flute, Nancy Toff explains that "composers have also found that the flute sound combines well with electronically produced sounds, and the ability to play with preprogrammed recorded sounds adds another dimension to the techniques that the modern flutist must master." Flutist Samuel Baron found that the results were not always what one might have expected. Of Meyer Kupferman's 1971 *Superflute*, which combined a live flute with taped flute and piccolo passages to sound like a single flute, Baron said, "The joke was on me. The final result was not like flute playing at all. It sounded like electronic music." Toff agrees that it is difficult to understand why such painstaking technique would be used only to give the flute a purely electronic tone.[31] Researchers at the Institut de Recherche et Coordination Acoustique/Musique in Paris developed a MIDI-compatible flute in the 1980s that used sensors on the keys to identify fingering. More recently, Montreal-based Cléo Palacio-Quintin developed the Hyperflute, a standard Boehm flute that is "extended" using electronic sensors for the inclination, rotational angle, speed of the breath stream at the embouchure, as well as other parameters, so that the player can control the digital sound that is processed. Brass instruments have been the subject of similar experimentation, and Tod Machover has a hyper-trumpet in his family of instruments.[32]

In addition to breath control, synthesizer developers have also experimented with various forms of biometric and random controls, such as Sile O'Modhrain and Georg Essl's PebbleBox, part of a series of projects they did for Enactive, the European Union project on human-machine interfaces. O'Modhrain describes the effort as one to "seek to exploit the tacet knowledge of the behaviour of physical systems with well understood auditory and haptic percepts (collision, friction, etc.) to design new musical instruments."[33] It senses the collisions of pebbles inside a foam-padded box with a microphone and then recombines them in a way that is characteristic of the granular synthesis pioneered by Iannis Xenakis and Curtis Roads, which splits sound samples into tiny pieces, one to fifty milliseconds long. The ideas are based on the proposal that sound could be reduced to the quantum level. These quantum "grains" are then layered into a high-density sound event that sounds the same played backwards and forwards. Barry Truax at Simon Fraser University developed a real-time version of granular synthesis in his 1986 work *Riverrun*.[34]

Notes

1 Manning, *Electronic and Computer* Music, 187. There's a fair bit of technical detail and the finer points of electronic music's development here, even if he and his editor were weak on Canadian geography: he refers to MUSICn programs installed in "Ontario and Waterloo in Canada," 196.

2 Manning, *Electronic and Computer* Music, 188-189.

3 "MOS Kim-1," www.bytecollector.com/mos_kim_1.htm.

4 Holmes, 235. On the League of Automatic Music Composers, see William Duckworth, *Virtual Music: How the Web Got Wired for Sound* (New York: Routledge, 2005) 60-62.

5 Théberge, *Any Sound,* 65-66. Mitchell Spector, posted on www.apple-history.com

6 Vail, *Vintage* Synthesizers, 51-52. Vail does not mention whether there was any cultural dimension to the acceptance of particular sounds; he implies that this was purely a hard-headed business decision.

7 Ted Greenwald and Jeff Burger, "It Came from the Music Industry," in *Vintage Synthesizers*, 78-79

8 Ted Greenwald, "N.E.D. Synclavier," in *Electro-Shock!* 133.

9 Manning, *Electronic and Computer Music*, 224-225, 229. Holmes, *Electronic and Experimental Music*, 218.

10 Holmes, *Electronic and Experimental* Music, 218, 219.

11 Stump, *The Music's All That Matters*, 200.

12 Manning, *Electronic and Computer* Music, 264.

13 Bob Moog, "Moog Minimoog," in Rule, *Electro-Shock!* 157. According to *Beyond MIDI: The Handbook of Musical Codes*, the first commercial use of a MIDI hardware interface was in 1986, and the protocol specifications were published in 1988 (p. 42). Holmes states that MIDI was established in 1984 (p. 22), but given the various dates that different authors give as the definite

inception of what would better be treated as a process, this is hardly surprising.

14 Pinch and Trocco, *Analog Days*, 318.

15 Manning, *Electronic and Computer Music*, 267. The history of MIDI's establishment is described on pp. 268-278.

16 Again, Thomas Hughes explains this phenomenon with the example of electrical networks in *Networks of Power* (1983).

17 *Any Sound*, 149, Manning, *Electronic and Computer Music*, 274, 277.

18 On OSC: cnmat.berkeley.edu/OpenSoundControl/. On HD-MIDI: "Manufacturers Investigate Possible Major Update to MIDI," www.midi.org/newsviews/hdmidipr2.shtml. This may not go anywhere; there seems to be a deep satisfaction among manufacturers with the current state of affairs. See Tom White, "MIDI at 20: Let's Share the 'Secret,'" www.midi.org/newsviews/secret.shtml. See also "Making Music with MIDI," www.midi.org/about-midi/aboutmidi3.shtml; "Tutorial on MIDI and Music Synthesis," www.midi.org/about-midi/tutorial/tutor.shtml.

19 Greg Rule, "Vince Clarke," in *Electro-Shock!* 171.

20 *Any Sound You Can Imagine*, 225.

21 Eleanor Selfridge-Field, ed., *Beyond MIDI: The Handbook of Musical Codes* (Cambridge MA: MIT Press, 1997) 41.

22 Manning, *Electronic and Computer Music*, 377, 385.

23 Ibid., 406.

24 Hugh Davies, "Electronic Instruments," *Grove Music Online*.

25 Jason DuMars, "The Varitone 'Electric Saxophone,'" http://www.saxophone.org/varitone.html (1998).

26 http://www.saxophone.org/varitone.html

27 Richard Ingram, "MIDI Wind Instruments," in Richard Ingram, ed., *The Cambridge Companion to the Saxophone* (Cambridge U.P., 1998) 184-188.

28 Gary W. Kennedy, "EWI," Grove Music Online, ed. L. Macy; http://www.ewi-evi.com/intro.htm; Hugh Davies, "Electronic Instruments," IV, 4, iv "Control Devices," Grove Music Online, ed. L. Macy. See also the Nyle Steiner homepage, http://www.patchmanmusic.com/NyleSteiner-Homepage.html.

29 Ingram, 187.

30 Ibid., 185 and Eduardo R. Miranda and Marcelo M. Wanderley, *New Digital Musical Instruments: Control and Interaction Beyond the Keyboard* (Middletown WI: A-R Editions, Inc., 2006).

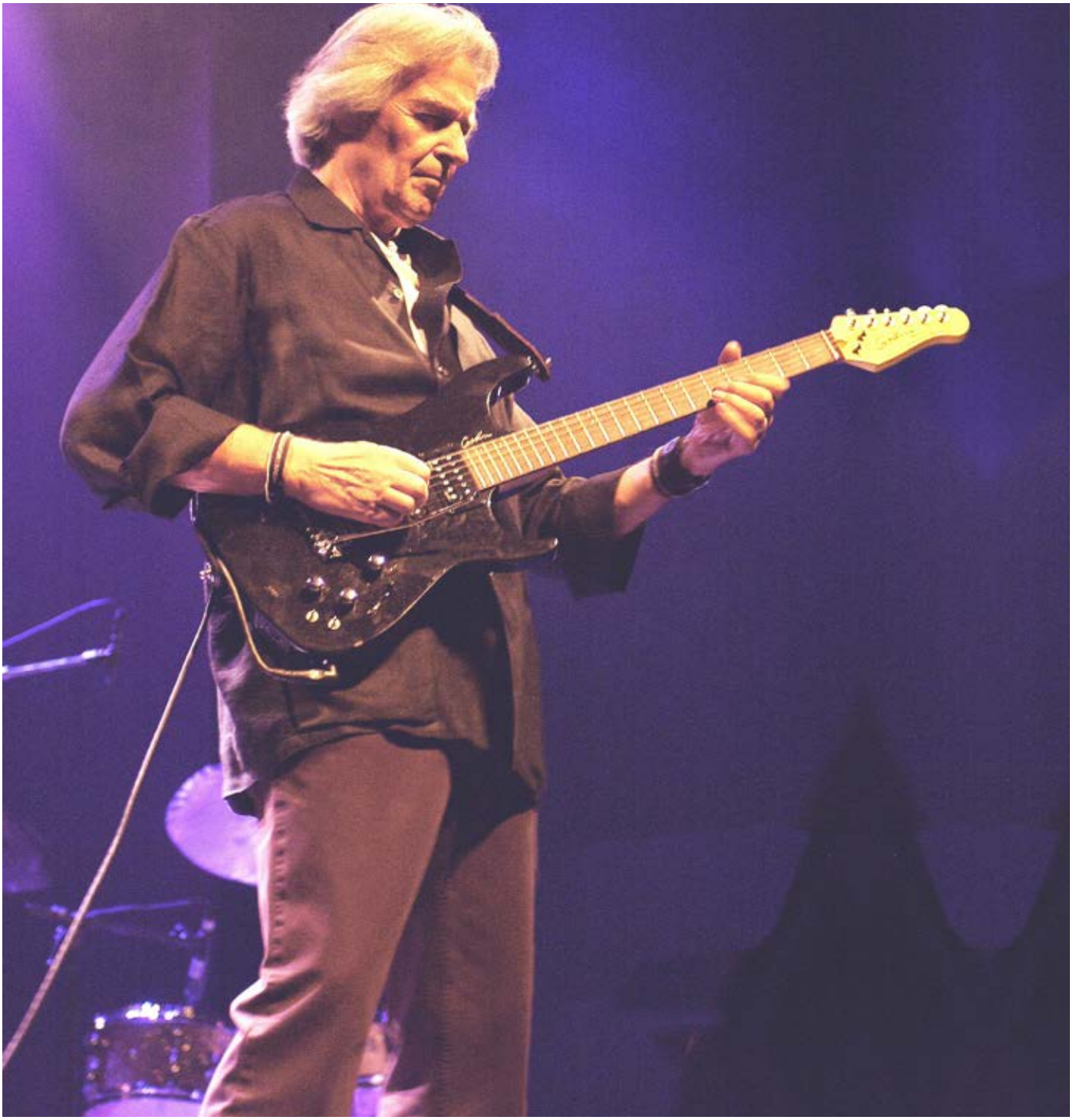
31 Nancy Toff, *The Flute Book* (New York: Scribner, 1985) 279, 280, 281.

32 Eduardo R. Miranda and Marcelo M. Wanderley, *New Digital Musical Instruments: Control and Interaction Beyond the Keyboard* (Middletown WI: AR Editions, 2006); Cléo Palacio-Quintin, "The Hyper-Flute," *Proceedings of the 2003 Conference on New Interfaces for Musical Expression*, published online at http://www.music.mcgill.ca/musictech/nime/onlineproceedings/Papers/NIME03_PalacioQuintin.pdf

33 "Sile O'Modhrain's Research Projects," http://www.sarc.qub.ac.uk/~somodhrain/palpable/projects.html; Sile O'Modhrain and Georg Essl, "PebbleBox and CrumbleBag: Tactile Interfaces for Granular Synthesis," *Proceedings of the 2004 Conference on New Interfaces for Musical Expression* (Hamamatsu, Japan: Shizunoka Univ. of Art and Culture, 2004) 74-79.

34 Curtis Roads, *Microsound* (MIT Press, 2001); Barry Truax, Real-time granular synthesis with a digital signal processor. *Computer Music Journal*, vol. 12 no. 2 (1988) 14-26.

8. Cultivated Authenticity



8. Cultivated Authenticity

8.1 Bullies and Virtuosos: The Guitar Hero

Among popular writers on the guitar, most are unabashed fans. Tim Brookes is an exception, and his book strikes an unusually regretful note. But when it comes to relating the significant moment when Bob Dylan used an electric guitar at the Newport Folk Festival in 1965, Brookes cannot muster the vitriol that characterized the reaction of many fans; instead he implies that it might have something to do with the guitar itself:

> In the history of the guitar, at best an amoral instrument, Bob Dylan was, I think, a mixed blessing.... Accounts of audience reactions vary. Some booed, though it's not clear if they were booing Dylan's abandonment of acoustic folk music or the fact that the amplification was so poor and the band so untogether that the performance was a disaster.[1]

Nonetheless, popular memory has preserved this moment as the failed test of Dylan's loyalty. For folk music fans, the electric guitar had become the acoustic guitar's "Other": technological rather than pastoral, dependent on the grid and therefore on organized society in general, loud rather than quiet, a marketed and marketable item from the crass world of record-company commerce. None of these oppositions was strictly true, of course; the revival that folk music was enjoying was deeply shaped by and dependent on the technology, manufacture, distribution and purchase of recorded music. However, the association of the acoustic guitar with protest and authenticity—an association that dated to at least the time of Woody Guthrie—and the increasingly decadent antics of rock stars put the electric guitar in a less flattering light. This is why Dylan's switch seemed like a betrayal. Brookes finds the source of the ambivalence in the guitar itself, arguing that the guitar had surrendered its claim to virtue: he claims that around this time, the guitar "went from being a quiet, hollow, light, vulnerable instrument, embodying the small but brave voice of the oppressed, to something tougher and louder that would make its point by shouting down the opposition. The oppressed as oppressor, in fact. A bit of a bully."[2] Certainly, by the late 1960s, the electric guitar and bass were louder than ever. The "San Francisco Sound" exemplified by bands like Jefferson Airplane featured the "thundering late-'60s tone" of Jack Casady's semi-hollow Guild Starfire bass with a Versatone amp that separated high- and low-frequency amping so that it growled rather than broke up at high volumes.[3] Others, such as Dave Davies, Eric Clapton and, especially, Jimi Hendrix, were making the guitar "the sound of a louder, harder rock and a symbol of the rebel lifestyle."[4] Through his astonishing virtuosity and musical and technological innovation, Hendrix turned the electric guitar into the symbol of rock, the symbol of a particular masculinity and the symbol of a generation. Steve Waksman devotes an entire chapter of *Instruments of Desire* to understanding the meaning of Jimi Hendrix, and *The Greenwood Encyclopedia of Rock* calls his music "a mix of the old and the new—field hollers, call and response, and the chords and the scales of the blues tradition, coupled with unusual audio effects and the free-ranging solos of psychedelia."[5] These audio effects included the fuzzbox and the wah-wah pedal, as well as octavers, which duplicated the note an octave lower than the guitar's tone, giving a synchronized bass effect. (Later octavers also added notes above the main tone.) In 1970, Hendrix established a $250,000 studio, Electric Lady, "which was packed with every gadget Hendrix could find, and he would spend hours trying to manipulate a single sound."[6]

As the 1960s gave way to the 1970s, rock music split uneasily into the arty, progressive rock of bands like Emerson, Lake and Palmer and Pink Floyd, who continued the 1960s psychedelic efforts to alter the listener's consciousness, and into what would become heavy metal. Like many genre distinctions, this rests at least as much on philosophy and ideas as on musical style. Prog rock used the techniques of the experimental tradition of the 1950s university music studios: heavy synthesizer use (especially Emerson, Lake and Palmer) and "improvised soundscapes" including "random elements such as radio broadcasts and the sound of ball bearings being rolled down guitar strings to create arresting harmonic overtones."[7] Heavy metal, pioneered by bands like Led Zeppelin, Blue Cheer, Black Sabbath and Iron Butterfly exposed the hippie scene's harder side. "The troubled turn of the 1970s made rock angry," Chris Smith writes. "More than any other form of rock music, heavy metal is about power and the funneling of aggression."[8] The music, which Brookes calls "the quintessential electric guitar genre," is loud and characterized by extremely distorted guitars.[9] In his history of heavy metal, Robert Walser says that, by the 1970s, "heavy metal was the main site of technical innovation and expansion" and explains the aural effect of distortion:

> Overdriving an amplifier actually creates two main effects: harmonic distortion and signal compression. The latter usually translates aurally as sustain; while a note

played on an acoustic guitar or a nonoverdriven electric guitar decays quickly, a heavily distorted guitar signal is compressed and fed back so that the note, once struck, can be held indefinitely, with no loss of energy or volume. Since sustaining anything requires effort, the distorted guitar sound signals power, not only through its distorted timbre but also through this temporal display of unflagging capacity for emission.

Distortion results in higher harmonics (making the overall tone brighter), but heavy metal is also reliant on "power chords": open fifths and fourths that produce lower tones. The result is an expansion of tone into both higher and lower harmonics.[10] The technology for achieving this expansive sound was growing more sophisticated. The microchip revolution allowed manufacturers to package several effects into programmable floor-mounted units. As these got larger and more powerful, they were mounted on racks, becoming a sort of portable studio.[11]

Like prog rock, heavy metal had a curiously fertile relationship with classical music. Many heavy metal guitarists were well acquainted with academic music theory, since they had begun their training in classical music. Classical guitarist Andres Segovia, made famous through the recording age, had trained a generation of teachers. Parents with a well-stocked music library could think of the classical guitar as an alternative to the piano or the violin. Some of these grew up to play rock, and heavy metal in particular encouraged a dexterous virtuosity the likes of which would have been familiar to Niccolo Paganini. Although the blues influence was still clearly present, "the classical model, stressing rationalization and technical rigor, was ascendant throughout the 1980s."[12] This reached the most rarefied heights of silliness in the work of Swedish-born Yngwie Malmsteen, whose shred guitar (from the way "in which guitarists were prone to 'tear up' the fretboard") adopted "not only classical music and vocabulary, models of virtuosic rhetoric, and modes of practice, pedagogy, and analysis but also the social values that underpin these activities." [13] Classical music, according to Malmsteen, was the very example of what all music ought to be. Much of his work, though, seemed to be more about the display of expertise and speed rather than about musicality. "By the end of the 1980s, 'classical' metal had become almost a sub-genre unto itself; Vinnie Moore, Tony MacAlpine, Paul Gilbert, and a host of others released albums that were, at root, variations on the pattern established by Malmsteen's debut solo album, *Yngwie Malmsteen's Rising Force.*"[14]

Canadians were busy, too. In *1000 Great Guitarists,* Hugh Gregory gives Randy Bachman full credit (there is no mention of Gar Gillies) for the "neat fuzz guitar effect" on "American Woman," although he is a little dismissive of Bachman's overall originality. Indeed, many of the guitarists who have earned a place in the Canadian Music Hall of Fame are better remembered for their monster hits than their technique. Guitarists like Bryan Adams ("Cuts Like a Knife," "Run to You," "Summer of '69") and Tom Cochrane ("Big League," "Life is a Highway") are primarily songwriters. Alex Lifeson, guitarist for the hard-rocking and hard-working Rush, has a "general efficiency" that "will allow the band to continue as long as they see fit," according to Gregory. Domenic Troiano, who replaced Bachman in the Guess Who, is now remembered for his composition for television shows like *Night Heat* (1985–1991).[15]

However, there are Canadians who deserve to wear the mantle of the guitar hero, even if they did not all enjoy fame. Jazz guitarist Lenny Breau used innovative fingering techniques that were inspired by Chet Atkins. Breau's career was cut tragically short when he was murdered just after his forty-third birthday in 1984. Breau, whose "mastery of chime-like harmonics have been emulated by many other guitarists," has become better known to contemporary musicians thanks in part to a 1999 documentary produced by his daughter, *The Genius of Lenny Breau.* Robbie Robertson is a more familiar name, thanks both to his recent film compositions and to his "superbly spiky support"[16] as part of the Band on Bob Dylan's folkie-goes-electric tour and *The Basement Tapes.* Jeff Healey, blind from childhood, "developed an unorthodox over-the-neck fretting technique" in order to play the guitar on his lap, but was "as bluesy and soulful as any conventional guitar approach." Rik Emmett's versatility and taste for literary allusion is responsible for the signature "thinking man's arena rock" sound of the band Triumph. After Emmett left the band in 1988, their attempt at a revival was unsuccessful.[17] But the guitarist who would be most likely to win a Canadian Guitar Hero contest is the superbly anti-heroic Neil Young. Young, who remains a Canadian citizen despite having lived and worked in the United States for decades, is a favourite among musicians and listeners. An entire musical genre claimed him as their own when he became known as "the godfather of grunge" in the 1990s. He has inspired an outpouring of popular and scholarly literature that merits comparison with Jimi Hendrix. Hugh Gregory describes his distinctive style of play as "wonderfully negligent of 'rules,'" with "the supreme ability to sound as if it is just about to collapse into a heap of feedback and broken strings." Young's mixture of musicianship, rebelliousness and carefully cultivated authenticity are indicators of a guitar hero, a figure who was becoming increasingly important in popular music and culture by the 1970s.[18]

The origins of Eddie Van Halen's distinctive "brown sound" are similar: "I tend to pick really hard, and when I play, the high-E string always gets caught in the pickup coils. That breaks the winding on the coil, and when someone tries to measure the pickup's output, it reads zero. I don't know if the damn thing is out of phase or what, but it definitely has a unique sound." His modified Fender Strat—which he

called Frankenstein or the Frankenstrat, since he had patched it together out of different components—became available as a reproduction in 2007. With a suggested price of $25,000–$30,000, this was not merely about selling the means to reproduce Van Halen's sound. Even a quarter that he had screwed to his guitar to get the tremolo bar back in place after he had taken the guitar apart was faithfully reproduced for all the former disaffected teenagers who had gone legit (it was a foregone conclusion that many of them would) and now had the money to buy themselves copies of their hero's guitar.[19] It is perhaps fitting that a musical movement that revelled in its own excess (volume, speed, feedback, technical expertise, costumes, arena size, masculinity and, let's not forget, hair) would produce consumers well-heeled enough to buy an excessively expensive instrument. But that very excess—naturally—quickly spawned a back-to-basics backlash, which put simple guitar chords back at the forefront. The twilight of the guitar gods was upon the world of rock 'n' roll.

8.2 Backlash: Punk, Grunge and Women

In 1976, the fanzine "Sideburns" instructed its (small) readership: "This is a chord … this is another …this is a third … Now *form a band*."[20] It is a concise version of punk's lean and hungry DIY simplicity, in contrast to the cynicism of manufactured pop hits and the bloated self-satisfaction of progressive rock. The Ramones (in the U.S.) and the Clash and the Sex Pistols (in the U.K.) all eschewed complicated chords and solos in exchange for fast-paced, sometimes very aggressive music. Waksman describes the difference:

> Electric sound, viewed during the 1960s as a medium for establishing new modes of community, was within punk valued as much for its potential to create new bases of separation, new boundaries between the different styles of rock performance. Such logic was implicit in the rock guitar styles that had taken shape in the previous decade, but punk brought this logic out into the open through the aggressive combination of sonic excess and basic rock structures.[21]

Although it was often seen as a sharp contrast to heavy metal, the music drew on some of the same influences, such as the Stooges and the MC5. Perhaps inevitably—it was, after all, still the age of the rock star—punk also became known for its own ridiculous excesses: Malcolm McLaren and Vivienne Westwood, the fashion impresario and designer who formed and managed the Sex Pistols, were known to stage fights in order to attract the press and did little to rescue the band during their final, disastrous American tour.[22] Meanwhile, punk had taken over as the defining genre of the moment. Punks sought inspiration in rhythms of dub reggae, funk and even disco. While few of these early bands (like the Sex Pistols in London or the Ramones in New York) used much electronics beyond guitars and amps, the groups that followed did. "Before we became accustomed to associating the synthesizer with gloss, sophistication, and 'the new,'" writes Peter Shapiro, "musicians on the fringes of the punk and post-punk scenes were using the new technology to expose the alienated underbelly of society." Cabaret Voltaire used synth riffs and tape loops to create their "electronic noisescapes," and new wave groups like Human League, Depeche Mode and New Order put out deliberately mechanical-sounding music made with synthesizers. Shapiro calls it "synth pop," and wryly comments that it was "the preserve of angry young men with a tenuous grasp of Marxism."[23]

The musical structure of punk had a lasting effect on popular music, both in the softer, poppier new wave movement, and in the punk revival of the 1990s. A new generation of guitarists had emerged that was deeply suspicious of a form that they thought prized technique over musicality. "Technique vs. emotion became a hardened dichotomy by the 1990s, exacerbated by the resurgence of punk values that occurred under the rubric of 'grunge.'"[24] Shrapnel Records founder Mike Varney, who launched the career of Yngwie Malmsteen and was critical to the 1980s shred-guitar boom, claims, "During the early nineties, lots of proficient guitarists had to hide the fact that they could actually play." Varney likely has an axe to grind. But distortion-heavy grunge was to prove surprisingly short-lived, perhaps because of the suicide of its best-known figure, guitarist Kurt Cobain, in 1993.[25] By the 1990s, DJ-led dance music was neck and neck with hip hop for musical supremacy. Neither of these relied on the guitar:

> The emergence and success of non-guitar-based musical styles such as hip-hop and the various musical offshoots of electronic dance music (techno, electronica, jungle, drum 'n 'bass, etc.) have displaced questions about the value of virtuosity onto a different plane where they have been conjoined with questions about the continued expressive vitality of the guitar itself.[26]

However, it is possible that this shift away from the showy excesses of arena rock, as well as from the particular instantiation of early-punk belligerence, allowed women to be a stronger presence on the electric guitar than they had been up to this point.

For most of its history, the guitar (like the harp) had been associated with femininity and was often depicted with a woman playing it.[27] But the twentieth-century electric guitar was a man's instrument. This is not to say that there were not women guitarists: country and rockabilly had many women players, though few of them gained broader notice. Tim Brookes, for instance, mentions several women guitarists—Bonnie Buckingham, Peggy Jones and Martha Carson among them.[28] But electric guitars were styled for male play-

ers. Gibson's endorsement relationship was with Les Paul, not with Paul's wife, guitarist and singer Mary Ford. Waksman devotes considerable space to Ford, who worked closely with Paul in his studio and was pictured in Gibson's advertising. Paul and Ford had sixteen top-ten hits between 1950 and 1954, had a radio and then television series and performed together at Carnegie Hall and at the White House. Ford was a very talented guitarist, though her skills saw the spotlight far more rarely than Paul's. Usually she sang while Paul played. Waksman suggests that Ford's and Paul's respective roles were a reflection of 1950s gender norms: "In singing women could present the illusion that their musicality was inseparable from their physicality, that it was the result not of instrumental mastery but of a more 'natural' expression of self." Ironically, Ford's vocal tracks were as much the product of studio technology as Paul's guitar tracks.[29] Moreover, the postwar period saw many popular male vocal groups, too, such as the Temptations or the Four Tops. These African-American groups, however, were presented with a highly clean-cut and restrained masculinity in order to be marketable to a white audience—in comparison to the antics of a later generation of white rock stars, their presentation was practically neutered.[30] In Ford's case, it is likely—given the spirit of the times—that she would have been better known as a singer than as a guitarist even if she had not been married to Paul. But her relationship with Paul seems to confirm the idea that music technology, including the electric guitar, was still largely a masculine domain.

Brookes also speculates on why women guitarists have gone uncounted: "What changed around the end of the nineteenth century was that music became a business and a trade," that is, a man's world. The determined pursuit of a "normal" femininity in the postwar years, with its girl groups "packaged to look as if they were off to the senior prom," was incompatible with instruments, since instruments signified work rather than fun.[31] It was not until second-wave feminism coincided with the splintering of rock in the 1980s that women took up the electric guitar in significant numbers. Mary Ann Janosik writes, "The 1980s became a watershed decade for women in rock 'n' roll, especially those who had imagination and a sense of humour. For them, the option of 'appropriating the traditional images of femininity and, through blatant exaggerations, subverting them' became a means of artistic empowerment."[32] Janosik reports that this happened primarily through the music video. The music video might have been expected to strengthen the association of guitars and masculinity, but instead, perhaps thanks to the easily parodied self-importance of many 1980s male rock stars, it seemed to open the doors for women. However, true recognition would still be a while in coming: Joan Jett and Chrissie Hynde tend to be better known for their singing than their guitar playing. The highly skilled Jennifer Batten, while touring with Michael Jackson, found she constantly had to tell people that, yes, she really was a woman. It would not be until after the 1990s riot grrl movement had been fully absorbed that a woman with an electric guitar would go relatively unremarked upon, and even then, some would continue to wonder if women were simply less capable of guitar excellence and therefore could not be "authentic" guitar heroes.[33]

The guitar is so deeply enmeshed in particular ideas of authenticity that it is not surprising guitarists are among the strongest champions of the analog and tube-based equipment that was once discarded as obsolete. But these very sounds have also been picked up by those who are not particularly driven by this ideal and are interested in it from a slightly more detached perspective. Waksman points out that the house duo the Chemical Brothers relies on sampled electric guitar sounds and effects for many of their source sounds. "That the sounds generated by decades-old guitar effects still retain an 'experimental' aura says much about the continued expressive and even transformative potential of rock guitar when approached with an open imagination."[34] However, popular music history continues to be shaped by a prelapsarian fantasy. Collecting vintage instruments, for instance, took on a high level of self-consciousness from fairly early on. Stan Werbin founded the *Elderly Instruments* catalogue in Michigan in 1972 so that those who believed rock's best sounds were always behind it would have a reference for pricing their passion.

Digital however, is a serious force. In an article on the use of the guitar in country music, Gordon Ross mentions,

> The late twentieth century saw new amplifier models like the Line 6 with built-in computers that are able to digitally model the tone of any amplifier or speaker the guitarist chooses. This negates the need to have a particular amplifier to get "the sound"; with modelling amps, the guitarist simply dials in the sound he or she wants and the computer does the rest. [35]

This process, called modelling, means that no matter how long an amplifier has been out of production, guitarists can achieve its effects through a virtual amp. For the most advanced versions, the guitar needs special digital pickups called hexaphonic pickups.[36] The Line 6 people soon turned their attention to the guitar itself. Their Variax guitar, released in 2001, has digital modelling built right into the guitar. "Your next guitar could be 25 guitars in one" was the company's suggestive promise. Fender responded with the VG Strat and Gibson with the HD.6X-Pro, although these do not mimic as many different sounds. Line 6 has since put out a modelling acoustic guitar (actually an electric guitar that models several acoustic guitars) and a modelling electric bass.[37] Several companies have also made guitar-controlled synthesizers—more successfully than ARP's ill-fated attempt—although these were not necessarily designed to produce the sounds of par-

ticular classic guitars rather than the usual array of synthesizer voices. The sound of a string can be altered with the fretting finger after it has been plucked, making the synthesis of guitar sounds trickier. Guitarists were put off by guitar-controlled synthesizers—they wanted it to feel more like a real guitar. H.P. Newquist commented, "Guitarists tend to want to have their cake and eat it, too, especially given the singular importance of the guitar in modern music." The SynthAxe, also from the 1980s, ran into the same development expenses as ARP's project and never found enough buyers to keep the company afloat.[38] As digital components became cheaper, other companies saw more success, such as Roland with its VG-8. Guitarists, who had thought themselves under threat from the synthesizer-heavy pop music of the 1980s, could now join in the fun. And, as the Line 6 Variax shows, no guitar-amp-effect combination need ever die. Once accurately sampled, it can live forever.

Notes

1 Brookes 217, 218.

2 Ibid., 259.

3 "Fender didn't distort well," Casady remarked. *How the Fender Bass Changed the World*, 94-95.

4 Chris Smith, *The Greenwood Encyclopedia of Rock: The Rise of Album Rock, 1967-1973*, 32.

5 Ibid., 45.

6 Hilton, *The Bonehead's Guide to Effects,* 36. Waksman, *Instruments of Desire*, 183, *Greenwood Encylopedia of Rock: The Rise of Album Rock*, 45.

7 Alan di Perna, *Guitar World Presents Pink Floyd* (Hal Leonard, 2002) 4.

8 *Greenwood Encyclopedia of Rock: The Rise of Album Rock*, 33. See also Deena Weinstein, *Heavy Metal: A Cultural Sociology* (New York: Lexington Books, 1991) and Andy Brown, "Rethinking the Subcultural Commodity: The Case of Heavy Metal T-Shirt Culture(s)" in Paul Hodkinson and Wolfgang Deicke, *Youth Cultures: Scenes, Subcultures, and Tribes* (New York: Routledge, 2007).

9 Pete Brown and H.P. Newquist, *Legends of Rock Guitar* (Hal Leonard, 1997). Brookes, 256.

10 Walser, *Running with the Devil*, 90, 42-43. See also p. 44. Harris M. Berger and Cornelia Fales confirm this with a detailed acoustical analysis in "'Heaviness' in the Perception of Heavy Metal Guitar Timbres: The Match of Perceptual and Acoustic Features over Time," Greene and Porcello, *Wired for Sound: Engineering and Technologies in Sonic Cultures* (Wesleyan U.P., 2005) 181-197.

11 *The Bonehead's Guide to Effects*, 14-15.

12 *Running with the Devil*, 93.

13 Steve Waksman, "Contesting Virtuosity: Rock Guitar since 1976," Victor Coelho, ed. *The Cambridge Companion to the Guitar* (Cambridge Univ. Press, 2003) 127; *Running with the Devil*, 98.

14 Waksman, "Contesting Virtuosity," 127.

15 Hugh Gregory, "Randy Bachman," *1000 Great Guitarists* (San Francisco: Miller Freeman, 1994) 7; Canadian Music Hall of Fame website, http://www.junoawards.ca/vhof/index.php; Sterling C. Whitaker, *Unsung Heroes of Rock Guitar* (BookSurge, 2003) 10-28 (this self-published book contains interviews with 15 guitarists); Mark Miller, "Adams, Bryan," "Cochrane, Tom," and "Cockburn, Bruce" *Encyclopedia of Music in Canada*, Helmut Kallman, Gilles Potvin, Kenneth Winters, ed. (Toronto: University of Toronto Press, 1992) 4, 279-280; Gregory, "Alex Lifeson," 83; Miller, "Troiano, Domenic," 1315.

16 Pete Brown and H.P. Newquist, *Legends of Rock Guitar* (Hal Leonard, 1997) 221. In 2008, Healey died from the same cancer that had blinded him.

17 Sterling C. Whitaker, *Unsung Heroes of Rock Guitar* (BookSurge Publishing, 2003) 85; www.rikemmett.com.

18 Mark Miller, "Breau, Lenny," *Encyclopedia of Music in Canada*, 159; The Lenny Breau website includes a number of laudatory articles, www.lennybreau.com; Mark Miller, "The Band" and "Robertson, (Jamie) Robert" 74, 1137; Gregory "Robbie Robertson," 119-120; Gregory, "Neil Young," 154. There are several biographies of Young, including John Einarson, *Don't Be Denied: The Canadian Years* (Quarry Press, 1992) and Jimmy McDonough, *Shakey: Neil Young's Biography* (Random House Canada, 2002). Kevin Chong uses Young to structure his memoir, *Neil Young Nation* (Greystone, 2005), and William Echard brings ideas from ethnomusicology and semiotics to bear on Young's oeuvre in *Neil Young and the Poetics of Energy* (Bloomington and Indianapolis: Indiana Univ. Press, 2005). Young was recently the subject of Jonathan Demme's film, *Neil Young: Heart of Gold* (2006).

19 Gill, "Repro Man," *Guitar World* (March 2007) 65-68. On the Frankenstrat, as well as Van Halen's amps, see Chris Gill, "Some Kind of Monster," *Guitar World* (March 2007) 57-62, 104, 106.

20 Waksman is no exception: "Contesting Virtuosity: Rock Guitar since 1976," *The Cambridge Companion to the Guitar* (Cambridge U.P., 2003) 122.

21 Waksman, "Contesting Virtuosity," 124.

22 "Punk Music in Britain," http://www.bbc.co.uk/dna/h2g2/A791336.

23 Shapiro, "Post-Punk," *Modulations*, 61, 62. See also Dick Hebidge, *Subculture: The Meaning of Style* (London: Methuen, 1979).

24 Waksman, "Rock Guitar since 1976," 128.

25 Joe Lalaina, "Dawn of the Shred," *Guitar World*, vol. 29 no. 11 (November 2008) 70-74. On grunge's demise, see Kyle Anderson, *Accidental Revolution: The Story of Grunge* (Griffin, 2007).

26 Waksman, "Rock Guitar since 1976," 130.

27 We should be cautious here about interpreting all this iconography literally, although the majority of historians do: is it possible that future historians, looking at bikini-clad girls posed with Fender guitars, will assume that the 1960s electric guitar was also a woman's instrument?

28 Brookes, 181-2.

29 Waksman, *Instruments of Desire*, 60.

30 Phillip Brian Harper, *Are We Not Men?: Masculine Anxiety and the Problem of African-American Identity* (Oxford University Press, 1996) 83-88.

31 Brookes, 183.

32 Maryann Janosik, *The Greenwood Encyclopedia of Rock History 5: The Video Generation, 1981-1990* (Greenwood, 2006) 137, citing Gillian G. Gaar, *She's a Rebel: The History of Women in Rock & Roll*, 2nd ed. (New York: Seal Press, 2002) 260.

33 Waksman, "Rock Guitar since 1976," 129. On whether wome simply aren't as capable, see John Strohm's essay "Women Guitarists," in Millard's *The Electric Guitar*, which takes seriously this very question. See also Marion Leonard, *Gender in the Music Industry: Rock Discourse and Girl Power* (Ashgate, 2007).

34 Waksman, "Rock Guitar since 1976," 131.

35 Brookes, 274; Ross, "The Guitar in Country Music," *Cambridge Companion to the* Guitar, 145.

36 *The Bonehead's Guide to Effects*, 34.

37 See www.line6.com.

38 H.P. Newquist, *Music and Technology* (New York: Billboard, 1989) 107; http://www.hollis.co.uk/john/synthaxe.html

9. Percussion, Disco, Dance and Sampling

9. Percussion, Disco, Dance and Sampling

9.1 Vibes and Drum Machines

The various electric and electro-pneumatic carillons and chimes were the fist percussion instruments to harness the power of electricity. The earliest, like J.C. Deagan's 1913 Una-Fon, were electromagnetically activated but not amplified (in the same manner as the early electric pianos). Hugh Davies lists Hugo Gernsback's electromagnetic glockenspiel and Jörg Mager's electromagnetic Javanese gongs (used for the bells in Wagner's *Parsifal* in performances in Cologne and Beyreuth, Germany) among these early devices.[1] Dutch composer Daniel Ruyneman oversaw the development of the Electrophone electric bells in the 1930s. Theremin, too, developed a keyboard-based electronic timpani in addition to the Rhythmicon, but neither of these went into commercial production. Benjamin and Otto Miessner also invented an instrument they called a Rhythmicon, based on similar principles.[2] But the most successful of all these instruments were those that became known collectively as vibraphones, or (to use the professionally accepted term) vibes.

Figure 44: J.C. Deagan's Una-Fon. (Tom Alföldi / CSTM 1989.0252)

Herman Winterhoff of the Leedy Manufacturing Company began experimenting with electromechanical methods to achieve a tremolo effect on the three-octave steel marimba (a popular vaudeville instrument) in 1916. Six years later, he saw success by using electrically powered discs to alternately open and close the resonator banks beneath the sounding bars, which resulted in a phase shift heard as a tremolo. In 1924, Signor Frisco (Louis Frank Chiha), a vaudeville performer, used it on a record he made for the Edison label. The recording was a popular radio hit, and Leedy began to market the instrument under the name vibraphone (an apt coinage of Leedy's sales and advertising manager, George H. Way). However, it was to suffer the same fate as so many other novelty instruments: about twenty-five were produced before manufacture ceased in 1927.[3] Chicago company J.C. Deagan introduced the vibraharp that same year. Chief engineer Henry J. Schluter's Model 145 design used "cord-suspended, half-inch-thick, graduated-width, tempered aluminum tone bars with harmonic tuning, [and] had a pedal-operated damper and adjustable vibrato speed."[4] It was popular both as a performance and recording instrument, and the design was to prove the basis for the family of instruments that followed. Leedy, in fact, resumed production of the vibraphone in 1928, introducing a model that featured all of the design elements of the Deagan instrument. Vibes became a standard instrument in the jazz repertoire that coalesced in the

Figure 45: Catalogue entry for Leedy & Ludwig's Royal Vibraphone (ca. 1950). (CSTM L4848)

Figure 46: Deagan model 515 ElectraVibe (1970). (Tom Alföldi / CSTM 2005.0098)

Figure 47: Advertising tearsheet for Deagan ElectraVibe (1970) featuring Paul Hoffert, founding member of hit-making Canadian "rock orchestra" Lighthouse. (CSTM 2005.0136)

Figure 48: The crude frame of Paul Hoffert's prototype Deagan ElectraVibe was fitted with a handle, highlighting the instrument's portability. (Tom Alföldi / CSTM 2007.0097)

postwar years, but reached the pinnacle of their popularity with the Hawaiian music revival of the 1960s (with musicians such as the Arthur Lyman Group). "In the wake of the great popularity of these percussion-oriented groups," Hal Trommer writes, "interest in percussion ensembles gained momentum in the schools…. Today, the vibraphone is standard equipment in the inventory of all institutions offering percussion education."[5]

Clair Omar Musser, the percussionist who became famous for his marimba orchestras, worked for J.C. Deagan during the 1930s (he founded his own company in 1948). His marimba celeste (1930) introduced microphones into some resonator tubes, which enabled electronic amplification and tone control of the resulting signal. The Deagan and Musser companies returned to this approach in the 1960s with the Magni-Sound, Ampli-Vibe and Ampli-Pickup. Deagan's 1970 ElectraVibe, on the other hand, used a piezoelectric pickup embedded in each bar and dispensed with resonator banks entirely.[6] Unlike the vibraphone, a player could not simply switch off the motor in order to produce a different sound. (Reginald Smith Brindle calls the sound of the turned-off vibraphone "cool" and "level … quite in contrast to the warmth of the vibrato tone."[7]) The ElectraVibe was easily portable, however, and its output signal could be modified using the common electronic effects of the period.

In the 1950s, home organ manufacturers soon began to include various percussion effects with their instruments. These rhythm boxes —the first drum machines—had a variety of settings ("march" or "samba," for example), "but the imitation of percussion timbre and attack was not very realistic."[8] The Ludwig Drum Company introduced the Electro-Vibe Pickup in 1960, which allowed for tone, tremolo and reverb control.[9] Wurlitzer had earlier brought out the Sideman, which used vacuum tubes to generate percussion sounds and a variable-speed rotary wiper to contact prewired rhythm patterns. Japanese accordionist Tadashi Osanai was using it for just this purpose in a Tokyo nightclub when he approached the club's owner, Tsutomu Katoh, with an idea for a better version. In 1962, they opened a factory to produce the DA-20 Disk Rotary Auto Rhythm Machine, or Donca Matic. It was very similar to the Sideman, and over the next few years, the company put out versions with increased features. In the late 1960s, they began producing keyboard instruments under the Korg name. They are still a major force in the electronic music market today. Roland had a similar start: in 1967, the Japanese company launched the Ace Tone FRI Rhythm Ace, which had more preset rhythms than any of the Donca Matics and the added capacity to combine them. Hammond soon incorporated the FRI presets into its organs. Like Korg, the company expanded into a wide variety of electronic instruments for both the home and professional market.[10]

In the 1970s, companies around the world began to produce drum machines with touch-sensitive rubber or plastic-coated foam rubber surfaces with piezoelectric crys-

Figure 49: Interior of Wurlitzer Sideman drum machine. (Don Kennedy/ Cantos Music Foundation)

Figure 51: Linn 9000 drum machine (ca. 1984). (Tom Alföldi / CSTM 2005.0099)

tal pickups. Programmable drum machines with sampled sounds first appeared with Roger Linn's LM-1 in 1980. Roland produced a number of drum machines, including the analog TR-808, which became coveted among techno and hip hop musicians in the 1990s. "The TR-808 became so popular, in fact, that you can find renditions or imitations of its sound in all kinds of contemporary sample libraries, synth sound sets, and emulations software such as Steinberg's popular ReBirth."[11] Drum machines emphasized rhythm in isolation, a phenomenon that was increasingly important in DJ-driven dance music. They also provided a way for DJs to

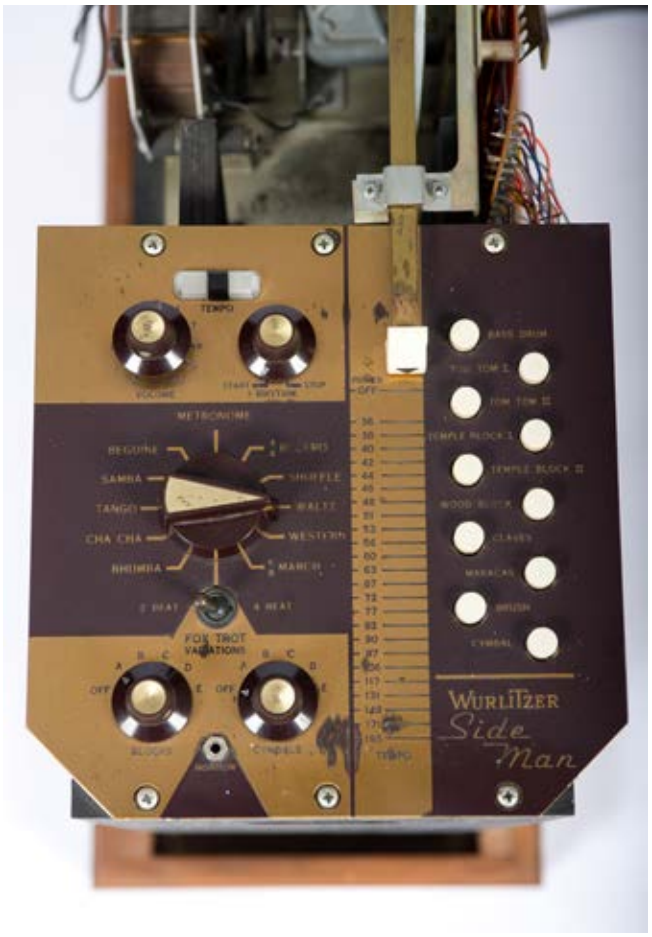


Figure 50: The Sideman offered a range of percussion sounds and rhythms. (Don Kennedy/ Cantos Music Foundation)

move seamlessly from one record to another without losing the beat.

9.2. Disco Didn't Suck!

From the 1970s to the 1990s, the disc jockey and producer became more powerful influences in popular music than any of the tape music pioneers could possibly have imagined, eventually provoking a broad public discussion on just what counted as a musical instrument and just what constituted a creative act. Pinch and Trocco suggest that this problem was perhaps inherent to electronic music because of the way we perceive electronics: "Recognition of their efforts was a problem facing all early synthesists. Was the actual creation of original electronic sounds—the patching or programming—an artistic or engineering achievement?"[12] Certainly it was clear that the idea of creativity was shifting in important ways, and new figures had stepped in to claim it. The growth of the music studio, with its microphones, processors and mixers, had created a new figure in the ex-

panding recording industry: the producer.[13] By the 1980s, Paul Théberge points out that producers were well known to the music-buying public, including Canadian superstars like David Foster and Daniel Lanois.[14]

Electronics firms had found that there was a ready market for home studio equipment, too. In 1972, the TEAC 3340, a four-track tape recorder intended for amateur use, came to market. In 1977, Roland introduced one of the first polyphonic digital sequencers, the MC-8. Based on the design of a Vancouver musician, Ralph Dyck, the MC-8 had 16K of RAM, enabling it to store over 5,000 notes that had been entered via a numerical keypad. By the 1980s, the scope of equipment available to amateur musicians who could find the money was staggering, and a peculiar contrast emerged between the specialized team of the professional studio and the burden on the shoulders of struggling musicians, who had to learn to produce and market demonstration cassettes in order to get noticed in the industry:

> The particular notion of independent, solitary production in the home studio, however, is related not only to the rise of consumer multitrack equipment but also to the availability of (and reliance on) digital synthesizers, sequencers, and drum machines. Only with the aid of these technologies was it possible for an individual to perform all the roles necessary to make a successful recording.[15]

Using the raw, unmixed tracks, even amateur producers could create different versions of songs. This proved especially popular in dance music, where longer versions—to keep the dancers on the dance floor—led to a number of important developments. In the 1950s and 60s, these longer remixes were typically recorded onto vinyl discs, which by now had strayed far from their original function as authoritative versions of performances. Jamaican DJs began staging sound-system-against-sound-system contests to see who could attract the most dancers. Mimicking the style of American radio broadcasts, they added a Master of Ceremonies (or MC), who announced the music selections and kept the crowd excited. Winston "Count" Machuki used the mike to make clever jokes, and he soon began copying the rhyming, jive-influenced slang that American radio disc jockeys used to introduce songs and adding vocal clicks and beats to enhance the record. Others soon followed. The competition between dance halls was fierce enough to generate a steady demand for exclusive tracks, which producers met with "versions" (which stripped out the vocals allowing the MC to speak against the rhythm and instrumental tracks) and "dubs" (which added a number of processed sound effects to the isolated rhythm track).[16] Robert Philip emphasizes that this made records into sonic objects: "This is not just a new kind of sound or even a new musical style, but a transformation of music, in which the 'misuse' of music becomes a new norm."[17]

With the international rise of reggae music in the 1970s, Jamaican ideas exercised a profound influence on the producers of dance music elsewhere, an influence that continues to be felt today. Jamaican immigrants brought this new music to the Bronx, where they "became leading innovators in American music."[18] In their history of the DJ and popular dance music, music journalists Bill Brewster and Frank Broughton write, "Today's remixers still use principles first developed by Jamaica's visionaries, and almost every dance track has some sort of 'dub' mix to fuel the dancefloor."[19] Innovations from European and North American DJs were slower. But by the 1970s, they were taking advantage of mixers (and sometimes drum machines) to shift from one turntable to another, "so that the party continued in a seamless flow of sound," music journalist Nelson George writes. "The entire American disco experience, which flowered underground before its mainstream discovery circa 1975, was predicated on this simple technological breakthrough."[20] For those who were there, disco is suffused with nostalgia. Before the days of Studio 54, cocaine-fuelled excess and designer jeans, early club dancers report that disco was the music of egalitarianism and acceptance. This is especially true of accounts of The Loft, a weekly after-hours party that David Mancuso started giving in his New York loft in 1970. Music journalist Vince Aletti recalls, "It was like going to a party, completely mixed, racially and sexually, where there wasn't any sense of someone being more important than anyone else. It really felt like a lot of friends hanging out."[21] While there were white working-class discos in neighbourhoods in Brooklyn and the Bronx (as chronicled in the movie that made disco famous, 1977's *Saturday Night Fever*), on the whole the music and the dance clubs were "the cultural adjunct of the emerging Gay Pride movement."[22] Liberation was in the air, and disco—with its heavy use of synthesizers and drum machines—was its soundtrack. Brewster and Broughton estimate that The Loft's clientele was probably about "sixty percent black and seventy percent gay."

Much as in Jamaica, a professional rivalry between the various club DJs soon developed: who could bring in the most dancers? Who could keep the crowd dancing? Influenced by the techniques of Jamaican immigrants to New York, they began remixing and lengthening tracks. The popularity of funky grooves did not escape the record companies' notice, and they rushed to put out disco records, even when the music was a poor fit for the artist's talents. Peter Shapiro believes that, for a brief moment, disco transcended the whole sorry history of race relations in the United States: "By the tail end of the funk and disco era, the boundaries separating 'black' and 'white' music were as tenuous as they had ever been (and probably ever will be)…. Perhaps more than anything, this brief period when 'black' and 'white' music arrived at the same conclusions will be disco's lasting legacy."[23] What strikes even the most casual observer of the history of disco is how quickly public taste turned against it: the T-shirt slogan "Disco Sucks" became better known than any of the

music. No one has a very persuasive explanation for just why this happened, although music writers seem united in their opinion that major labels' rush to cash in with a lot of second-rate recordings hastened disco's disappearance from mainstream consciousness. Journalist Dan Sicko calls it "one of the least documented periods in dance music." He continues, "By 1980, disco backlash had reached massive proportions throughout the United States, with the possible exception of metropolitan New York (where discos kept drawing crowds until well into the 1980s)."[24] Brewster and Broughton see a vicious strain of homophobia in the backlash; because the music was primarily created by black musicians (and heavily indebted to the African-American soul tradition), Nelson George accuses it of racism.[25] Most commentators conclude, though, that the reaction against disco was a blessing in disguise: since no new dance records were being made, this encouraged the development of the sampling and remixing that was to characterize the next major phase in pop music.

9.3 But Is It Art? Hip Hop and Sampling

In their book on DJ history, Bill Brewster and Frank Broughton write, "Hip Hop, or (loosely speaking) rap music, is defined in a hundred proudly self-referential songs as music made with just two turntables and a microphone. As such, like dub reggae, hip hop is DJs' music first and foremost." [26] DJ Kool Herc (born Clive Campbell), a Jamaican immigrant to the Bronx, began playing the breaks of various funk tunes back to back in the Bronx nightclub Disco Fever in the mid-1970s. The break, "edited on turntables in real time," eliminated all but the "internally complex percussive cell, a fragment and memory trace of the history of a track." It was a catchy bit of rhythm and percussion played over and over to encourage the young black and Latino breakdancers to strut their stuff. Another Bronx DJ, Grandmaster Flash (born Joseph Saddler in Barbados), took up the task of improving the timing of these breaks. Still in high school at the time, he developed a technique to improve the cueing of the records:

> The mixer I was using at the time was a Sony MX8. It was a microphone mixer. So I had to go out and buy two external preamps from Radio Shack, and these would take the voltage of the cartridge and boost it to one millivolt, so now it has line output voltage and I could put it inside the mixer and hear it. I had to put two bridges in between the left and right turntable so that I could hear the music before it goes out, so I had a single-pole, double-pole throw switch, and I had to Krazy Glue it to the top of the mixer.[27]

It was an odd mix of high-tech and kitchen-sink wizardry that was to have an enduring effect on popular music. Like the techniques of Jamaican dub, the idea was to attract the most dancers and to triumph in the Bronx's competitive DJings.[28]

But it was the incredible collection of records that belonged to a third Bronx DJ, Afrika Bambaataa, that would lead thousands of young DJs to mine any record from any genre for catchy breaks. The first of these to attract mainstream notice was Run DMC's 1986 "Walk This Way," which sampled the song of the same title by Aerosmith (and reinvigorated the fluffy-haired rockers' careers). Bambaataa may have been the catalyst, but as scholar Tricia Rose points out, DJs had been using "an extraordinary range of musics" right from the beginning—from Led Zeppelin to Joni Mitchell. "Records were no longer recordings of instruments being played," Nelson George comments. "They had become a collection of previously performed and found sounds." This has been interpreted as an example of the disenfranchised taking up high tech for their own use, but that might attribute to the record player and the LP a greater technological sophistication than they ever had. Most of the turntable techniques, while highly skilled, demanded little in the way of electronic expertise.[29] It was certainly a case of taking technology and tastes that were soon to be discarded (mainstream record stores were selling mainly new wave music on cassette) and twisting its purpose slightly. It may not have been deliberately transgressive to begin with, but it would become so.

The very idea of what counts as an instrument had been challenged. While the tape music composers had used recording equipment to create music, they had never met with an audience on this scale. As Kai Fikentscher concludes,

> With the arrival of the disco deejay in the early 1970s, the turntable became an instrument of musical performance in the hands of men whose role gradually changed from programming prerecorded music on LPs and 45s to arranging and editing multitrack recordings for the purposes of producing 12-inch singles, to composing and recording original music modeled on the previous two concepts of music-making while mixing all of the available sound sources into hours of uninterrupted dance-music-drama.[30]

Following in the footsteps of both John Cage's chance music and the Futurists, the turntablists who followed would revel in the noise produced by accidental scratches and dirt—often the result of damage incurred from stacking the records during a performance. It adapted 1950s hi-fi worship to a dirty, damaged, basement-rec-room aesthetic. In the 1990s, the avant-garde DJ Spooky (Paul D. Miller) performed "illbient" music—an intensely urban and harsh soundscape performance.[31]

As hip hop worked its way onto centre stage in the 1980s, DJs turned into record producers. The borrowed basslines and breaks became the subject of controversy. African-American producer and songwriter Mtume angrily dismissed it as "nothing but Memorex music." Hip hop artists were

using samples more frequently in part because they had an easy way to repeat a break: the E-MU Emulator, the digital sampling keyboard first marketed in 1981. Where sampling had previously been used to fill in a missing instrument in pop record production, "a hip hop producer, whose sonic aesthetic was molded by the use of break beats from old records pulled from dirty crates, wasn't embarrassed to be using somebody else's sounds."[32] By the late 1980s, groups like Public Enemy and De La Soul made liberal use of sounds sampled from earlier recordings. As hip hop gained wider listenership, the question of whether this constituted fair use entered the courts.[33] In 1992, Gilbert O'Sullivan sued Biz Markie's record label for the unauthorized use of his easy-listening hit from the 1970s, "Alone Again (Naturally)." O'Sullivan succeeded in putting a stop to all sales and further pressings of the record, "severely damaging Biz Markie's career" and sending "a chill through the industry that is still felt." [34] It likely did not help that the public was disinclined to explore any of the subtleties of sampling—their cynicism about the uses of recording had been well-stoked by the Milli Vanilli lip-synching scandal of 1990. Currently, anyone using a sample must pay a licensing fee, and brokers specializing in this have set up shop.

While composers have always turned to past works for inspiration (think of the powerful English-folk-music revival at the turn of the last century, used to powerful effect by composers like Ralph Vaughan Williams), recording technology gave musicians the ability to do much more than cite a musical passage. They could now cite a specific performance, and it is this capacity, in combination with the record industry's business structure, that made it contentious. What's more, as digital sampling succeeded live turntable performance, musicians had the ability not only to quote a performance for another use, but to change it: the tempo of a drum solo, for instance, could be changed without affecting the pitch (something that was not possible on vinyl discs or magnetic tape). Samples became an obvious way to achieve particular rhetorical effects. Mark Katz discusses in detail the example of Public Enemy's samples in "Fight the Power" (1990), which he calls "a four-and-a-half minute treatise on the phonograph effect, one that reveals … the complex relationship between artist and technology." As a legal entity, the sample is treated as the property of whoever owns the rights to the original recording. Most of those who write about hip hop, however, treat the sample as found material: this is what the work of art has become this far into the age of reproduction. Katz emphasizes that the sample almost never exists purely as a sample, as a quotation—rather, it is transformed, mixed, looped and deployed in such a way that it is difficult to see it as anything other than a starting point. "Composers who work with samples work directly with sound, thus becoming more like their counterparts in the visual and plastic arts…. Sampling is a rich and complex practice, one that challenges our notions of originality, of borrowing, of craft, and even of composition itself."[35]

In its most extreme form, it is no longer sampling at all but a mashup. Mashups (sometimes called bootlegs—but not to be confused with illegal concert recordings) combine the music and vocals of different songs, in some cases from completely different genres. They hit the mainstream media when EMI's lawyers tried to put a stop to DJ Danger Mouse's mashup of Jay-Z's a cappella from the *Black Album* and instrumentals from the Beatles' the *White Album*. The resulting publicity caught the attention of many critics, and a large number of websites posted copies of the album for free download during a 24-hour protest against EMI and the illegality of sampling more generally.[36] Naturally, mashups are a popular DIY project for amateurs, especially younger, technologically savvy music fans. The tracks they use are usually obtained (illegally) through file-sharing networks and manipulated with sound-editing software such as ACID Pro. The spirit of homemade tape music lives on.[37]

9.4 Everybody Dance Now: Notes on Contemporary Music

The vast majority of the action in electronic music today is in dance music, which has splintered into a large number of subgenres: garage, house (in its various local versions), jungle, drum 'n' bass, techno (in its various local versions), hardcore techno, trance, trip hop, downtempo, big beat, acid house.[38] In the U.K. in the 1990s, the children of Pakistani and Indian immigrants adapted Punjabi lyrics to electronic techniques, a style which came to be called bhangra. Asian-inflected music became well known through the work of Apache Indian and the hit Fatboy Slim remix of Cornershop's "Brimful of Asha," and it continues to gather a broad listenership through musicans like M.I.A. (Mathangi Arulpragasam).[39] As DJs look further afield for interesting beats and grooves, we can expect to hear many parts of the world represented. A syllabus for a course at Harvard's Extension School on the history of post-1960s popular electronic music allots one-third of the course time to Bollywood, bhangra, reggaeton and Brazilian funk—among other permutations.[40]

These dozens of subgenres are indebted to electronic instruments, recording technologies and music software. Jim Aiken and Greg Rule note the influence of a piece of sampled-rhythm-loop-editing software, ReCycle, that appeared in 1994. "ReCycle has almost single-handedly spawned new dance music genres. Creators of the signature sliced/diced drum 'n' bass (jungle) drum patterns, in particular, owe an enormous debt of gratitude to this ingenious piece of software."[41] The precise differences between subgenres can be the subject of heated discussion, and coinages like "remixology" simultaneously emphasize the Talmudic nature of the debate and unabashed love of technology—and throw in a happy

reference to the bartender at the party, to boot. Brewster and Broughton, for instance, initiate the newbie into the precise differences between Detroit house and Chicago house. They explain the development of the rave culture in the U.K. that made demigods of DJs (they approve of this). They also explain something that strikes even the casual observer of popular electronic music: techno, in particular Detroit techno, has a disproportionate number of apologists. Many of its fans insist its only forbearer is abstract theory, and they write lengthy pieces explaining this. No less than the distinguished CBC Radio One program *Ideas* aired an episode on techno, by Toronto writer Russell Smith.[42] Brewster and Broughton trace this analytical turn to journalistic interest in the fact that the music came out of the dystopia that was 1980s Detroit: "The journalists laid the postindustrial imagery on thick and the producers saw that intellectualizing their music would help promote it." Eager college students lapped it up, and techno soon had a body of literature that suggested it was more serious than mere dance music. Brewster and Broughton urge caution: "There's nothing wrong with a selective approach to music criticism, but don't think that techno's postpartum rationalizations give you any more reason to write about it than about house, funk or disco."[43]

Many recent technological developments seem less innovative than anything from the heady days of the electronic music studios or the Bronx nightclubs where DJs battled it out. "Glitch," for example, is the term for the sampled sound of a scratched CD. Its most passionate genealogists see this as a tribute to Pierre Schaeffer and have tried to synthesize the sound digitally using software—often bootlegged—like SuperCollider and GRM Tools (software that comes from the descendant of Schaeffer's studio). Synthesizer designers have responded to this interest in jumps and skips with the analog Wasp, and the Swedish company Nord has produced expensive modules with noises and filters that are "inherently lores."[44] It is high-level digital geekery, and even the song titles seem to belong to computer files and cannot be articulated. Pita's "~/," for example, can be the subject of email or online chat, but is unpronounceable in unmediated conversation. (It is also perhaps a sly nod at postmodernist writing in general.) Not everything is so obscure: Moby had a huge crossover hit with *Play* in 1999, and mainstream musicians routinely use overtly electronic production—but little of this shows much inventiveness.

These production techniques have shaped and responded to a broad public taste for beats and grooves. Canadian music critic Robert Everett-Green has mused that, as popular music has turned more and more to texture, songcraft has diverged sharply from traditional music composition.

> Many songs like *Say It Right* [by Nelly Furtado] are built from the bottom up, starting with a drum track, then a bass line, and only then a tune and lyrics that can co-exist with the elements already recorded. This is more or less the opposite of what Irving Berlin used to do at his piano, where he used to plunk out a tune that someone else would write down and arrange.

As a result, Everett-Green claims, much contemporary songwriting still uses "training wheels," relying extensively on stalwart intervals like the major third and the perfect fifth, filling in with the notes in between. "As long as everyone is cued primarily into beats, grooves, and textures, we're going to hear many more ditto tunes and training-wheels melodies, blaring from every radio in the land."[45]

It is hardly surprising, then, that performance now seems to belong mainly to the DJs, whose fans line up for tickets and drive long distances just as their parents might have done for live concerts. We are no closer to answering the question of what a "live" performance means than we were in Schaeffer's time. John Cage had a fine sense of these absurdities, and his performances highlighted how the idea of performance had become unhinged in an era of recording and broadcasting. Computer music composer Paul Lansky's 1988 granular synthesis piece "Notjustmoreidlechatter" uses random elements to add unpredictability in order to

> compensate for the fixity of the recorded medium, and in so doing simulate the spontaneity, the "danger" of live performance…. The composer imbues the work with the unpredictability of a live performance, while the listener assumes the executant's interpretive duties.[46]

Yet, the lure of a concert remains strong: Farmers Manual, a group specializing in sounds based on spoken words, continues in the tradition of the twentieth-century's avant-garde, although their static performances are done with Powerbooks rather than radios or tape players. "Aural outcomes refuse to tally with what you actually see the individuals doing on stage—there is a perceptual displacement that leaves you feeling there's something wrong with where you are," one critic concludes.[47] As Simon Emmerson writes in his overview of developments in contemporary electroacoustic music, "it is precisely this ambiguity between 'live' and 'studio-created' which is increasingly highlighted in contemporary practice."[48] The avant-garde may have diminished greatly in power, but it can still self-consciously adapt the new technology to the old ideas.

Notes

1 Fred Dahlinger, Jr, "Ringing and Ringling; Showmen's Bells, Chimes and Related Novelty Musical Instruments," Part II, *Carousel Organ*, 21 (October 2004), 19-26. Mager's instrument is mentioned in the January 16, 1932 edition of *The Literary Digest*, p. 30. Hugh Davies mentions that the *Parsifal* bells have also been supplied by the Trautonium (1950s) and the Fairlight CMI (1980).

2 Hugh Davies, "Electronic Percussion," *Grove Music Online*.

3 Hal Trommer, "The Vibraphone, Vibraharp, and Vibes," John H. Beck, ed. *Encyclopedia of Percussion* 2nd edn. (New York: Routledge, 2007) 399. "Leedy Vibraphone," http://www.pas.org/Museum/tour/0699.cfm.

4 Hal Trommer, "The Vibraphone, Vibraharp, and Vibes," 399

5 Hal Trommer, "The Vibraphone, Vibraharp, and Vibes," 402.

6 "Xylophone like a pipe organ electrically controlled," *Popular Mechanics* (March, 1930) 355; http://www.musser-mallets.com/features/musser. Hal Trommer, "The Vibraphone, Vibraharp, and Vibes," 401.

7 Reginald Smith Brindle, *Contemporary Percussion* (London: Oxford U.P., 1991) 46. Two prototype amplified vibraphones survive in the collection of the Percussive Arts Society; it is possible that these were the forerunners of the commercial Electra Vibe. The date of the instruments is not entirely clear from the PAS's website: http://www.pas.org/Museum/tour/0312.cfm. Other sources indicate that these instruments appeared in the 1970s, but do not say so specifically: http://www.pas.org/Museum/tour/0312.cfm; http://www.kksound.com/ vibereviews.html. Blades states that electronic amplification was introduced only with Ludwig's Electro-Vibe pickup - see note 185 below, as does Milton Weil, ed., *The Purchaser's Guide to the Music Industries* (Englewood, N.J.: Music Trades Corp., 1974) 122.

8 Davies, "Electronic percussion," *The New Grove Dictionary of Musical Instruments,* 692.

9 James Blades, *Percussion Instruments and Their History*, Revd. Edn. (Westport CT: Bold Strummer, 2005) 409, note 1.

10 Mark Brend, *Strange Sounds: Offbeat Instruments and Sonic Experiments in Pop* (San Francisco: Backbeat, 2005) 61-64.

11 Mark Vail, "Roland TR-808," in Rule, *Electro-Shock!* 95. The market for electronic instruments was mature by this time; for a complete list of models and manufacturers (there were several), see Hugh Davies, "Electronic Percussion," *Grove Music Online*.

12 Pinch and Trocco, *Analog Days*, 125. In their work recording *The Nonesuch Guide to Electronic Music* (1968), Bernie Krause and Paul Beaver initiated the development of notation system for synthesized sounds. On the professionalization of the recording engineer, see Thomas Porcello, "Speaking of Sound: Language and the Professionalization of Sound-Recording Engineers," *Social Studies of Science* vol. 34, no. 5 (October 2004) 733-758.

13 There is nothing that deals primarily with the role of technological change in this period. Most of the books (usually intended for a popular audience) are pop culture history.

14 Théberge, *Any Sound*, 219.

15 Ibid., 223, 222.

16 There is relatively little mention of female MCs in the literature. Nelson George examines the idea of hip-hop misogyny in the context of the public scandal over 2 Live Crew's rhyming in "Too Live," chapter 13 of *Hip Hop America* (New York: Viking Penguin, 1998). See also Katz, *Capturing* Sound, 131-135. Some of this may simply be because some of the best-selling female hip-hop artists come from the more R&B-inflected side of the spectrum and their music is not always considered rap music: Lauryn Hill or Missy Elliot, for example. On the other hand, the deliberately shocking and foul-mouthed L'il Kim has matched many of her male counterparts, even doing time behind bars. See Tricia Rose, *Black Noise: Rap Music and Black Culture in Contemporary America* (Hanover: Wesleyan Univ. Press, 1994).

17 Philip, *Performing Music in the Age of Recording*, 150.

18 Rachel Rubin and Jeffrey Melnick, *Immigration and American Popular Culture* (New York Univ. Press, 2007) 179. See also all of Chapter 5, "South Bronx, 1977: Jamaican Migrants, Born Jamericans, and Global Music."

19 Bill Brewster and Frank Broughton, *Last Night a DJ Saved My Life: The History of the Disc Jockey* (New York: Grove Press, 2000) 121. Partly because this book has no references, partly because of its dewy-eyed accounts of various dance subcultures, it often seems that the authors believe that DJs did save the world. Throughout, there are statements that arouse the suspicion of the scholar, and it is probably more primary source than secondary. However, there is nothing else that rivals it as an account of the development of the various forms of electronic dance music. Its weaknesses are fairly typical of the written works on dance music in general – it's all about the scene and the vibe, and only occasionally about the technical intricacies of music creation, reproduction, or performance. Tim Lawrence covers disco in *Love Saves the Day: A History of American Dance Music Culture, 1970-1979* (Duke University Press, 2003). See also Dick Hebdige, *Cut'n'Mix: Culture, Identity, and Caribbean Music* (London: Comedia, 1987).

20 George, *Hip Hop America*, 5.

21 Cited in Brewster and Broughton, *Last Night*, 147.

22 Peter Shapiro, "Disco: Playing with a Different Sex," *Modulations* 41. See also his book, *Turn the Beat Around: The Secret History of Disco* (New York: Faber and Faber, 2005).Brewster and Broughton, *Last Night*, 147. Stevie Wonder was the most prominent user of the synthesizer in 70s R&B, and its increasing use "drove most of the great African American bands of the '70s to either shrink or disband in its wake." George, *Hip Hop America*, 81.

23 Shapiro, "Disco," 47. Through the mid-80s, this was a broad phenomenon; television had a number of crossover hits, notably *The Cosby Show*.

24 Dan Sicko, *Techno Rebels: The Renegades of Electronic Funk* (New York: Billboard Books, 1999) 44.

25 George, *Hip-Hop* America, 8.

26 Brewster and Broughton, *Last Night*, 205; David Toop, "Hip Hop," in *Modulations,* 92.

27 Cited in Brewster and Broughton, *Last Night*, 215.

28 Katz, *Capturing Sound*, chapter 6.

29 Rose, *Black Noise*, 52; *Hip Hop America*, 93. One of the better known turntable techniques is the scratch, which exploits a weakness in vinyl – its tendency to scratch – to deliberate effect. It is not an easy thing to do, and later DJs began using sampled scratches, something Grandmaster Flash took "as a personal insult." Toop, 97. According to Katz, the inventor of scratch was DJ Grand Wizard Theodore (Theodore Livingston) from the Bronx (*Capturing Sound*, 116). Assigning credit to a single inventor is a tricky business, especially in a broad popular movement like turntablism.

30 Kai Fikentscher, "'There's Not a Problem I Can't Fix, 'Cause I Can Do It in the Mix,': On the Performative Technology of the 12-inch Vinyl," *Music and Technoculture* 309.

31 Holmes, *Electronic and Experimental Music*, 268-270.

32 George, *Hip-Hop America*, 89, 92.

33 Actually, it entered the courts for a second time. Nile Rodgers and Bernard Edwards successfully sued for songwriting credit and royalties on Sugar Hill's landmark *Rapper's Delight* (1979), which sampled their work. Ponderous defences of sampling appeared in the mid-80s. See John Oswald's manifesto "Plunderphonics, or Audio Piracy as a Compositional Prerogative," www.plunderphonics.com/xhtml/xplunder.html.

34 George, *Hip-Hop* America, 95. An overview of the law in the U.S. is at www.music-law.com/sampling.html. The enormous growth in copyright and trademark legislation and its relationship to our fondness for pop-culture references is beyond the scope of this paper. There are a number of spirited rejoinders to the bloat in intellectual property, but the only defences seem to be in the case law and in legislative debates. See, for example, Kembrew McLeod, *Freedom of Expression©: Resistance and Repression in the Age of Intellectual Property* (Minneapolis: University of Minn. Press, 2007) – an update to the 2005 edition which bore the subtitle *Overzealous Copyright Bozos and Other Enemies of Creativity*, just in case you wondered where the author stands. There is also Peter K. Yu, *Intellectual Property and Information Wealth: Issues and Practices in the Digital Age* (Westport, CT: Praeger, 2007) and Joanna Teresa Demers, *Steal This Music: How Intellectual Property Law Affects Creativity* (Univ. of Georgia Press, 2006). See also Katz, *Capturing Sound*, chapter 7, and Kodwo Eshun, *More Brilliant Than the Sun: Adventures in Sonic Fiction* (London: Quartet Books, 1998).

35 Katz, *Capturing Sound*, 156, 157.

36 Ben Greenman, "The Mouse That Remixed," *The New Yorker* (February 9, 2004) 24., Renée Graham, "Jay-Z, the Beatles Meet in 'Grey' Area," *The*

Boston Globe (February 10, 2004); archived online www.boston.com/news/globe/living/articles/2004/02/10/jay_z_the_beatles_meet_in_grey_area/, "Grey Tuesday: Free the Grey Album, February 24, 2004," greytuesday.org.

37 See the wikipedia entry, "mashup (music)."

38 See "Ishkur's Guide to Electronic Music," www.di.fm/edmguide/edmguide.html, always likely to set off academic debate among fans.

39 It is quite possible that dance music has resulted in the contemporary fascination with Indian pop culture, rather than the reverse.

40 "Electronic Music: History and Aesthetics of Popular Music Since the 1960s," taught by Wayne Marshall, www.courses.dce.harvard.edu/~musie145/.

41 Jim Aiken and Greg Rule, "Steinberg Recycle," in Rule, *Electro-Shock!* 107.

42 "Tick Tock Bang: Noise in Modern Art," broadcast January 27, 1999.

43 Brewster and Broughton, *Last Night*, 332. Ibid., 336. In addition to Dan Sicko's book, see Simon Reynolds, *Energy Flash: A Journey Through Rave Music and Dance Culture* (London: Picador , 1998), and Sarah Thornton, *Club Cultures: Music, Media, and Subcultural Capital* (Cambridge: Polity Press, 1996).

44 Rob Young, "Worship the Glitch: Digital Music, Electronic Disturbance," in Rob Young, ed., *Undercurrents: The Hidden Wiring of Modern Music* (London: Continuum, 2002) 49, 51.

45 Robert Everett-Green, "The Fall of the Song," *The Globe and Mail* (Saturday, February 3, 2007) R2.

46 Mark Katz, *Capturing Sound*, 143.

47 Young, "Worship the Glitch," 52. See also Mathias Gmachl (Farmer's Manual) in Nick Collins and Julio d'Escriván, ed. *The Cambridge Companion to Electronic Music* (Cambridge Univ. Press, 2007).

48 Simon Emmerson, *Living Electronic Music* (Burlington VT: Ashgate, 2007) xvi.

Conclusion

Electric and electronic instruments and music have contributed to broader cultural changes than Thaddeus Cahill could ever have imagined. Cahill dreamed only of the broadcast of live performances of electronic music. Recording was still young, and the interest in its malleability that would come only with the advent of magnetic tape could not have been predicted. The explosion in consumer electronics for the ever-growing middle class would bring about instruments that were progressively smaller, more affordable and more capable, thanks first to the triode, then the transistor and then microchips.

Because this document was an overview of the secondary literature, it necessarily leaves a number of questions unanswered. When I spoke to David Kean, president and founder of the Audities Foundation, an organization dedicated to the preservation of electronic musical instruments, I mentioned that the entire field seemed to be vibrating with potential research dissertation topics. He answered, "Amen!" What is remarkable about the history of electric and electronic music and instruments is how rich it is in unanswered questions. There is little historical work on the evolution of commercial studio recording equipment, for example, despite everyone's recognition that this is the reason that the music producer has come to be an important figure—in some cases the lead figure—in the creative process. Most of the superior secondary work tends to be instrument-specific or guided by the instruments (as is this document), rather than organized around more general cultural changes such as the relationship between instruments, recording, performance and privacy. As Trevor Pinch and Karin Bijstersveld point out, sound studies is a very new area of scholarship, but it holds the most promise for the kind of fruitful crossover of history and sociology of music and technology that is necessary to begin to assess the impact of all those professional and amateurs using amplified instruments, magnetic tape, speakers, function generators and recording devices. The new kinds of music that developed unsettled conventional notions of creativity and authorship—notions that were themselves at most a century or so old, and for which some musicians and companies continue to fight long and hard.

Although any clear distinction between high and low culture has been thoroughly muddied in a culture that quotes and reworks aspects of each of these into examples of the other, there are still strains of electronic music that remain largely separate from each other. This is not for lack of ambassadors—Radiohead has sampled Paul Lansky's 1973 computer composition "mild und liese," and contemporary rock music abounds with examples of musicians who are conscious of the history of the electronic avant-garde. Thom Holmes worries, though, that it is going to become impossible to trace the lines of influence, because digitization has made many of the techniques pioneered by the previous generations of composers and producers deceptively simple.[1] However, the existence of studio techniques on recordings enabled them to influence later generations of musicians: as Tyler Cowen writes in his examination of the effects of a market economy on art,

> The studio experimentation of the Beatles was presaged by Stockhausen, whom they put on the cover of their *Sgt. Pepper* album. Minimalist LaMonte Young served as muse for the Velvet Underground. The alternative tunings used by Sonic Youth and My Bloody Valentine show the influence of Glenn Branca and Harry Partch…. Recording frees creators from conceiving only what others can perform or understand.[2]

Peter Manning, who is concerned about the "slow descent into obscurity" of many important electronic works, is cautiously optimistic about the potential the internet has for disseminating music and reaching a new audience.[3] Like all antiques, the market seems to be prone to sudden bursts of enthusiasm: the theremin enjoys more attention than mixing consoles, for example, despite not being nearly as influential. This imbalance has begun to correct, with the appearance on the scene of more and more scholars interested in sound studies and auditory culture. This is still in its early stages—as the omissions and elisions in this document show—and there remains a great deal of work to be done. But the soil is rich and will no doubt find willing tillers. As Hans-Joachim Braun notes, "Sound Studies is a field that has been budding for some time and will undoubtedly be flourishing before long."[4]

Notes

1 Holmes, *Electronic and Experimental Music*, 273.

2 Tyler Cowen, *In Praise of Commercial Culture* (Harvard Univ. Press, 1999) 149.

3 Manning, *Electronic and Computer Music*, 402.

4 Hans-Joachim Braun, "Review: Modern Sounds," *Social Studies of Science* 34 no. 5 (October 2004) 816.

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