ELECTRONIC MUSIC UNIT

Compelling Question	**How do Garage Band and Soundcloud promote democracy?**
Standards and Practices	*C3 Historical Thinking Standards* – D2.His.1.9-12. Evaluate how historical events and developments were shaped by unique circumstances of time and place as well as broader historical contexts. *C3 Historical Thinking Standards* – D2.His.2.9-12. Analyze change and continuity in historical eras. *Common Core Content Standards* – CCSS.ELA-LITERACY.WHST.9-10.1.B Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns.
Staging the Question	How do you listen to music? Did your parents get their music in the same ways?

Supporting Question 1	**Supporting Question 2**	**Supporting Question 3**	**Supporting Question 4**
What were the first musical applications of electricity and in what ways did they advance electric/electronic music?	What is a vacuum tube and how was it used to revolutionize electric/electronic music?	In what ways was the computer used to further advance and democratize music?	What new technologies are on the horizon and how might they change and advance music?
Formative Performance Task	**Formative Performance Task**	**Formative Performance Task**	**Formative Performance Task**
Create a timeline showing the key developments in electro-mechanical sound production and recording.	Write an Ode to the Vacuum Tube. In your poem, extol the virtues of the vacuum tube as well as its many accomplishments.	Conduct an interview with a classmate who uses computer technology to produce, distribute, or sell music.	Write a recent "history" of music from the perspective of a music reviewer in the 22nd century.
Featured Sources	**Featured Sources**	**Featured Sources**	**Featured Sources**
1A. Helmholtz, Hermann von. *On the Sensations of Tone as a Physiological Basis for the Theory of Music: By Hermann L.F. Helmholtz*	2A. Lee, Thomas H. *Planar Microwave Engineering: a Practical Guide to Theory, Measurement, and Circuits*. Cambridge: Cambridge University	3A. Dubois, R. Luke. "The First Computer Musician." The New York Times. The New York Times, June 9, 2011.	4A. Alves, K. and K. Michael. "The Rise and Fall of Digital Music Distribution Services: a Cross-Case Comparison of MP3.com, Napster and

... *Translated with the Authors Sanction from the Third German Edition, with Additional Notes and an Additional Appendix, by Alexander J. Ellis*. Translated by Alexander John Ellis. London: Longmans, Green, and Co., 11912. https://books.google.com/books?id=x_A5AAAAIAAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

1B. Stross, Randall. “The Making of America: Thomas Edison.” Time. Time Inc., June 23, 2010. http://content.time.com/time/specials/packages/article/0,28804,1999143_1999210,00.html

1C. “The 'Telharmonium' or 'Dynamophone' Thaddeus Cahill, USA 1897.” 120 Years of Electronic Music, June 7, 2016. http://120years.net/the-telharmonium-thaddeus-cahill-usa-1897/

1D. Russolo, Luigi. *The Art of Noise: (Futurist Manifesto, 1913) Translated by Robert Filliou* (version Ubu Classics, 2004). New York: Something Else Press, 1967.

Press, 2004. https://books.google.com/books?id=cnhhBAAAQBAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

2B. “The 'Audion Piano' and Audio Oscillator. Lee De Forest. USA, 1915.” 120 Years of Electronic Music, June 17, 2016. http://120years.net/the-audion-pianolee-de-forestusa1915/

2C. “US1661058A - Method of and Apparatus for the Generation of Sounds.” Google Patents. Google, n.d. https://patents.google.com/patent/US1661058A/en

2D. Alba, Michael. “Vacuum Tubes: The World Before Transistors.” Engineering.com, n.d. https://www.engineering.com/ElectronicsDesign/ElectronicsDesignArticles/ArticleID/16337/Vacuum-Tubes-The-World-Before-Transistors.aspx

https://opinionator.blogs.nytimes.com/2011/06/08/the-first-computer-musician/

3B. Leonard, Andrew. “Mod Love.” Saloncom RSS, April 29, 1999. https://web.archive.org/web/20121025040018/http://www.salon.com/1999/04/29/mod_trackers/

3C. Ferguson, Ben. “Interview: Juan Atkins.” Red Bull Music Academy Daily, May 23, 2017. https://daily.redbullmusicacademy.com/2017/05/interview-juan-atkins

Kazaa.” Research Online. 2005. https://ro.uow.edu.au/infopapers/379/

4B. Sparrow, Mark. “Sales Of Physical Music Media Slump As Consumers Move To Streaming Services.” Forbes. Forbes Magazine, January 4, 2019. https://www.forbes.com/sites/marksparrow/2019/01/03/sales-of-physical-music-media-slump-as-consumers-move-to-streaming-services/#6803d3052255

4C. Seppala, Timothy J. “Music Streaming Is Fueling Vinyl's Resurgence.” Engadget, December 4, 2018. https://www.engadget.com/2018/12/04/music-streaming-is-fueling-vinyls-resurgence/

4D. Sheehy, Maeve. “Now That You're Here, Check out My SoundCloud.” The Daily Tar Heel, January 20, 2019. https://www.dailytarheel.com/article/2019/01/soundcloud-rappers-0120

http://ubu.com/historical/gb/russolo_noise.pdf			
Audio Sources	**Audio Sources**	**Audio Sources**	**Audio Sources**
1A. Antonio Russolo – "Corale" (1921) https://www.discogs.com/Filippo-Tommaso-Marinetti-Il-Futurismo/release/2559759 Unfortunately due to the lack of widespread recording technologies at the time, few recordings of the Italian Futurist movement are extant. This piece by Antonio Russolo, brother to Luigi, is somewhat late in the Futurist movement, but is a good representative of soundscapes produced by the homemade Intonarumori instruments. These instruments were purely mechanical and had no electric component, but were created to produce non-traditional sounds that are described in Luigi Russolo's "The Art of Noises". When listening to this piece, think of how modern electric and electronic instruments could generate sounds that would accompany the music.	2A. Clara Rockmore – "Nocturne in C# Minor" (1975) https://www.discogs.com/Clara-Rockmore-Nadia-Reiseberg-Clara-Rockmores-Lost-Theremin-Album/release/1655212 Recorded late in Rockmore's life, a piece like this would have been typical of her performances during the height of her fame in the 1930s. Many public performances on emerging electronic instruments such as the Theremin, were renditions of classical pieces, such as this one, originally composed by Chopin. The Theremin, which comes in at around fifteen seconds, is accompanied by a piano. This piece highlights how the Theremin sounds and is performed, with its evocative vibrato and almost otherworldly tone. Keep this in mind as you listen to the piece. When a key on a piano is pressed, it always plays the same note, which also holds true for electronic pianos like the Audion Piano at the time. The Theremin has a different approach to sound	3A. Max Mathews – "Numerology" (1960) https://www.discogs.com/Various-Music-From-Mathematics/release/1411970 Max Mathews is sometimes referred to as the "father of computer music". While not the first to compose music on a computer, his work explores the mathematical theoretical side of music and goes beyond renditions of popular songs and classical pieces. When listening to "Numerology", it feels more like a special effects demo than a deliberate piece. Shifting from one effect to another through its length gives the listener a good idea of what sorts of mathematical functions computers can generate with respect to music. It is recommended this piece be listened to with software capable of displaying a spectrograph as the relatively basic mathematics are visually rather striking and easy to see. 3B. Kraftwerk – "Trans-Europe Express" (1977) and "The Man Machine" (1978)	No Audio Sources

	generation as pitch is controlled by the distance the player's hand is from a radio antenna. Each subsequent key on a piano represents a half-step on the scale, but a Theremin produces an analog gradient of pitch, making it possible to, intentionally or otherwise, play microtuned notes or unconventional scales. Rockmore's work is rarely adventurous in this sense, but the potential is there for future composers. 2B. Pierre Schaeffer – "Symphonie pour un homme seul: Intermezzo" (1957) https://www.discogs.com/Various-Panorama-Of-Musique-Concr%C3%A8te-No-2/release/405830 One of the first major Musique concrete pieces utilizing tape composition methods. The nature of tape allows the composer to cut and splice pieces, bend the tape to change pitch, reverse the tape, layer it onto other tapes, etc. When listening to the piece, consider the level of effort and time required to manually manipulate tape this way. Depending on the fidelity of the medium, several inches of tape could correspond with less than a second of sound. As	https://www.discogs.com/Kraftwerk-Trans-Europa-Express/master/2877 https://www.discogs.com/Kraftwerk-The-ManMachine/master/4010 Kraftwerk's late 1970s output is considered by many to be the foundation of modern popular electronic music, and some music critics have considered them as important, if not moreso, than the Beatles to the development of late 20th century popular music. As computing technology improves throughout the 1960s and 1970s, Kraftwerk utilized sequencers, synthesizers and drum machines, most often homemade or customized by the band, to create their mechanical, futuristic, robotic pop sound. These records were highly influential to the development of disco, techno and hip-hop. 3C. Afrika Bambaataa & the Soul Sonic Force – "Planet Rock" (1982) https://www.discogs.com/Afrika-Bambaataa-the-Soul-Sonic-Force-Music-By-Planet-Patrol-Planet-Rock/master/19152 An early Afrofuturistic hip-hop track that samples the refrain from Kraftwerk's "Trans-Europe Express" at around 45 seconds in.	

	computers were on the horizon at this point and not widely available for sound arrangements in this fashion, composing even brief pieces by tape was extraordinarily time consuming.	Technology at the time made it far easier to sample passages of music than the manual manipulation of tape from several decades prior. As such, sampling was a prominent feature of hip-hops development through the 1980s and 1990s. On this track, the recontextualization of Kraftwerk's futuristic sound is a good example of how their influence spread to a wider audience. 3D. Model 500 – "No UFOs" (1985) https://www.discogs.com/Model-500-No-UFOs/master/5405 An early Detroit techno track, this piece showcases how the lowered cost of music technology reduces the gatekeeping to composing. Juan Atkins began experimenting with synthesizers when he was still in high school, and was able to compose in his bedroom. While "No UFOs" was written when Atkins was in his early 20s, it demonstrates the possibilities for aspiring musicians at the time. Using homemade studios without major label backing, the early techno artists are very "ground-up" and independent, versus composers from the 1960s who were often attached to a television or	

			radio studio like RTF or the BBC.	
Summative Performance Task	**Argument**	Write a thesis essay that directly addresses the compelling question using specific claims and relevant evidence from historical sources to support your claims while acknowledging competing views.		
	Extension	Create a trifold board detailing the changes in music creation, music distribution, and music consumption that may or may not have occurred in the 20th and 21st centuries as the result of the electrification of music.		
Taking Informed Action	**UNDERSTAND:** Research the ways in which patent and copyright laws are used to protect intellectual property rights in the US. **ASSESS:** Examine the advantages and disadvantages of intellectual property protection under the US Patent Office. **ACTION:** Develop a government policy that protects the intellectual property rights of music creators while giving them the freedom to produce, distribute, and profit from their own creations.			

TO THE TEACHER

All *REACH* Instructional Units are intended to be "classroom-ready." Each unit begins with a *Unit Plan* in the form of a *C3 Inquiry Design Model*. The *Unit Plan* includes learning objectives, content standards, formative and summative tasks, links to primary and secondary resources, and a warm-up activity.

Units are organized around a *Compelling Question* designed to inspire curiosity and promote discussion among students. To that end, we have also included a brief student introduction to the topic entitled, *Staging the Question*. Once students have been introduced to the topic, any number of *Formative Performance Tasks* may be completed using the included *Document Excerpts* (teachers may elect instead to utilize full-text documents linked within the *Featured Sources* section). *Document Excerpts* are print-ready in single-sheet format and keyed to the citations in the *Featured Sources* section of the *Unit Plan*. Teachers should select the *Formative Performance Tasks* and accompanying *Sources* that best suit their own instructional needs – content requirements, performance goals, student readiness, and time constraints. Upon the completion of each unit, students should be adequately prepared to complete the *Summative Performance Task* and *Taking Informed Action* sections of the *Unit Plan*.

To further assist the teacher, we have included a more thorough *Background Information* section. This document is intended to serve as professional reading prior to implementing the unit. Teachers may also wish to read the full-length primary and secondary sources from which the shorter excerpts were taken.

STAGING THE QUESTION

Chances are good that you and your friends don't get your music in the same way that your parents did. Their generation was much more likely to hear a new song on the radio and go out to Sam Goody's to buy the CD, cassette or 8-track tape, or vinyl album. They probably invested hundreds of dollars into playback equipment that included turntables, tape decks, stereo receivers, amplifiers, and large speaker systems, and their music collection likely filled shelves or towers next to their "hi-fi" system. On the other hand, you probably hear new music online, download it to your phone (maybe at no cost), and listen through a pair of Bluetooth-connected ear buds.

Music has changed quite a bit in the past 25 years, but that is just the tip of the iceberg! Prior to the start of the 20th century, instrumental music was confined to acoustic presentations in large halls or in the parlors of the wealthy who might be able to afford the expensive instruments and music lessons. What changed? To understand the changes in music production, distribution, and consumption, we need to analyze innovations in several component technologies as well as new understandings of the structure of sound waves.

As early as the mid-18th century, Ben Franklin's experiments with electricity inspired others to create novel new instruments like the Clavecin électrique (1759) and the Denis D'or (1753). These early curiosities, while minimally functional, lacked the benefit of any clear understanding of the mathematics of electromagnetic induction or the physical structure of sound. It would be another hundred years before those concepts began to take form in the scientific community. The work of Faraday (1831) and Maxwell (1850-61) provided the fundamental building blocks necessary to create the earliest devices which could record and play back sound. The phonautograph (1857), recorded sound from a horn attached to a sharp point but could not play sound back. In 1877, Thomas Edison invented the phonograph, which was the first devices able to play back sound.

In 1863, Hermann von Helmholtz wrote his seminal paper "On the Sensations of Tone as a Physiological Basis for the Theory of Music", the foundation of modern acoustics. This paper states that any sound can be reproduced by adding some number of sine waves together. Helmholtz's work had profound implications for the synthesis of sound by means of electricity. As would be demonstrated by the telephone, electromagnetic waves can be converted to mechanical waves and heard by the ear via an electromagnet.

Late 19th century experiments into electric musical instruments were often derived from work done on the telephone. The first electric instrument that garnered successful commercial performances was the Telharmonium, invented by Thaddeus Cahill. The first model was completed in 1901, and used tone-wheels, giant cylinders that when spun would generate an electromagnetic field which was then converted to a sound wave. As one tone-wheel was needed for each note, the machine was huge – the first model weighed seven tons, and the second two, from 1906 and 1911, weighed 200 tons and spanned 60 feet. Performances on the instrument were broadcast through telephone lines. The Telharmonium was cumbersome and impractical, but the age of electric music was underway.

Around this time, vacuum tubes were developed. The diode (1904) and the triode (1907) were two of the earliest and most important tubes, which are the foundation of modern electronics. Vacuum tubes found frequent use in radio sets, but also could be applied to musical instruments. With the tube's heterodyning effect, Lee De Forest was able to construct an electronic piano in 1915, which was far smaller than a Telharmonium and could be practically sold on the commercial market. All electronic instruments used vacuum tubes until the development of the transistor. While many used a familiar keyboard-based input model, others operated on wireless principles such as the Theremin. Many early public performances using electronic instruments were renditions of popular or classical songs.

For recording and playback of music, the major next step after the phonograph was the Dolby magnetic tape recorder, which was demonstrated in 1946 at the Institute of Radio Engineers meeting and had profound implications for radio broadcasting. Editing and splicing tape was far easier and more cost efficient than previous editing methods. Additionally, tape could be stretched or played back at different speeds to induce certain effects or generate unique tones. Halim El-Dabh's 1944 "The Expression of Zaar", a wire recording, is an early example of this method of composition.

Towards the end of World War II, all-purpose electronic digital computers were developed by the military for the purpose of computing ballistics tables. Similar to the Telharmonium, the computer was too large to be reproduced commercially. Early electronic computers like the ENIAC made extensive use of vacuum tubes which made them extremely large, often the size of several rooms of a house. The development of the transistor and its commercial introduction in the late 1940s and 1950s revolutionized electronics, allowing for greater miniaturization, and computers shrunk in size while they increased in power.

The earliest use of a computer to play music was in 1951, but at this time computers were not powerful enough to play music in real-time. A melody had to be preprogrammed and processed, often very time intensive taking several days to process a few seconds of music. Computers during the 1960s were often used as compositional aides by avant-garde composers like Xenakis, who used computers to calculate the mathematical placement of certain notes. One of the earliest pieces of software for real-time music performance on a computer was GROOVE, developed by Max Mathews at Bell Labs in 1970. Along with the development of transistors and computers came the development of synthesizers, allowing musicians to easily create new sounds.

Traditional narratives of 1960s counterculture often focus only on American, and sometimes British artists, but the movement was largely global. In particular, the German progressive rock scene often employed heavier and more dissonant sounds than their US or UK counterparts. By the early 1970s, artists like Faust, Can, Neu or Amon Düül, incorporated tape loops, non-traditional instruments, electronic dissonance and noise, into their songs. The most important group to come out of the German progressive rock scene was Kraftwerk, whose 1974 "Autobahn" album, shifted to an all-electronic sound with homemade instruments. Kraftwerk's sound throughout the mid and late 1970s greatly influenced virtually every genre of popular electronic music to follow – namely techno, industrial, disco, hip-hop, and synthpop.

By the late 1970s, the price of home recording technology sharply dropped, with the widescale introduction of cassettes. It was now possible for a musician to easily record music and distribute it to friends or record labels without having to go through an expensive process at a recording studio. The PC revolution of the late 1970s also brought down prices for computers, drum machines and synthesizers.

The wide array of new tools combined with the availability of recording software led to the development of several new underground genres, now led by young musicians without formal training, instead of previously being led by academics steeped in formal music theory. Popular club genres like house and techno were pioneered by working class African American DJs and aspiring musicians from Chicago and Detroit, respectively, and tape trading allowed artists to bypass the traditional gatekeepers of record labels, creating an underground network of fans.

By the late 1980s and early 1990s, techno and industrial had received mainstream recognition, and the genres further fractured into countless subgenres, nearly all of which were pioneered from the ground up, rather than the top down. As computing power increases throughout the late 1980s and early 1990s, it became possible to compose entire tracks using software like a tracker, which functions in a similar way as a sequencer, mapping out various sound samples. These files were small enough to be distributed through the large network of dial-up Bulletin Board Systems (BBS) that were prevalent throughout the 1980s and early 1990s before the popularization of the Internet.

By the mid 1990s, the Internet had rapidly eclipsed the popularity of the BBS, offering worldwide interconnectivity. Compositional software became more advanced, and the MP3 compressional algorithm offered near-CD quality in a much smaller file size. Much like how tape-trading scenes allowed independent artists to bypass the record label infrastructure, the Internet greatly simplified the process, with peer-to-peer filesharing programs, websites and platforms offering the ability to instantly access and share music with anyone from around the world. This is such a profound change to how the music industry fundamentally operates that many key figures expressed reactionary ideas at first. Napster, the earliest prominent peer-to-peer filesharing program, was sued and shutdown, and similar lawsuits were filed against other filesharing platforms. As a result of Napster's popularity, CD sales rapidly declined. Innovative companies realized that sales of CDs would never return to their former levels and instead offered artists and industry players a way to monetize content through streaming subscription services like Spotify, or ad-based platforms like YouTube. Other sites like Soundcloud and Bandcamp allow artists to directly upload and sell their works, as well as connect with fans and other people within the community.

Clearly, the music world has changed since your parents made and shared their mixtapes. Record labels no longer hold an exclusive monopoly on the production and distribution of music. Musicians and consumers have gained seats at the table as the music industry appears to have become more democratic. Although the most revolutionary changes seem to have originated with the creation of the MP3 format and filesharing platforms like Napster, it was the gradual evolution of electrical technologies like the vacuum tube that laid the groundwork for this revolution in music. There would be no SoundCloud or YouTube without the work of Maxwell, Helmholtz, Edison, and Cahill.

(Click here to view a visual PowerPoint of a lecture on the subject.)

PRINT DOCUMENTS

Document 1A

Then comes the further question: On what difference in the external means of excitement does the difference between noise and musical tone depend? The normal and usual means of excitement for the human ear is atmospheric vibration. The irregularly alternating sensation of the ear in the case of noises leads us to conclude that for these the vibration of the air must also change irregularly. For musical tones on the other hand we anticipate a regular motion of the air, continuing uniformly, and in its turn excited by an equally regular motion of the sonorous body, whose impulses were conducted to the ear by the air.

Those regular motions which produce musical tones have been exactly investigated by physicists. They are oscillations, vibrations, or swings, that is, up and down, or to and from motions of sonorous bodies, and it is necessary that these oscillations should be regularly periodic. By a periodic motion we mean one which constantly returns to the same condition after exactly equal intervals of time. The length of the equal intervals of time between one state of the motion and its next exact repetition, we call the length of the oscillation, vibration, or swing, or the period of the motion…. As illustrations of periodical motion, take the motion of a clock pendulum, of a stone attached to a string and whirled round in a circle with uniform velocity, of a hammer made to rise and fall uniformly by its connection with a water wheel…. The length of their periods … is relatively long in comparison with the much shorter periods of the vibrations producing musical tones, the lowest or deepest of which makes at least 30 in a second, while in other cases their number may increase to several thousand in a second.

Our definition of periodic motion then enables us to answer the question proposed as follows: --*The sensation of a musical tone is due to a rapid periodic motion of the sonorous body: the sensation of a noise to non-periodic motions….*

Having thus spoken of the principal division of sound into Noise and Musical Tones, and then described the general motion of the air for these tones, we pass on to the peculiarities which distinguish such tones one from the other. We are acquainted with three points of difference in musical tones, confining our attention in the first place to such tones as are isolatedly produced by our usual musical instruments, and excluding the simultaneous sounding of the tones of different instruments Musical tones are distinguished:

1. By their force
2. By their pitch
3. By their quality.

It is unnecessary to explain what we mean by the force and pitch of a tone, By the quality of a tone we mean that peculiarity which distinguishes the musical tone of a violin from that of a flute or that of a clarinet, or that of the human voice, when all these instruments produce the same note at the same pitch.

We have now to explain what peculiarities of the motion of sound correspond to these three principal differences between musical tones.

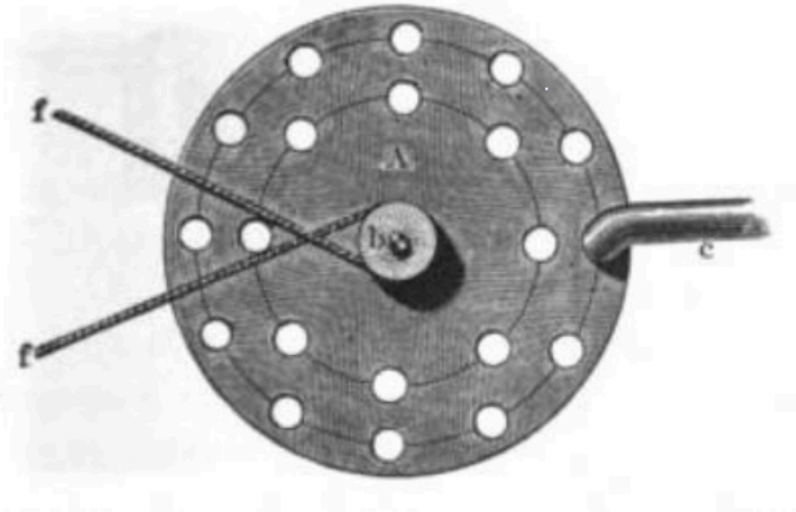
First, we easily recognize that the force of a musical tone increases and diminishes with the extent or so-called amplitude of the oscillations of the particles of the sounding body. When we strike a string, its vibrations are at first sufficiently large for us to see them, and its corresponding tone is loudest. The visible vibrations become smaller and smaller, and at the same time the loudness diminishes. The same observation can be made on strings excited by a violin bow, and on the reeds of reed-pipes, and on many other sonorous bodies. The same conclusion results from the diminution of the loudness of a tone when we increase our distance from the sounding body in the open air, although the pitch and quality remain unaltered; for it is only the amplitude of the oscillations of the particles of air which diminishes as their distance from the sounding body increases. Hence loudness must depend on this amplitude, and none other of the properties of sound do so.

The second essential difference between different musical tones consists in their pitch. Daily experience shows us that musical tones of the same pitch can be produced upon most diverse instruments by means of most diverse mechanical contrivances, and with most diverse degrees of loudness. All the motions of the air thus excited must be periodic, because they would not otherwise excite in us the sensation of a musical tone. But the sort of motion within each single period may be any whatever, and yet if the length of the periodic time of two musical tones is the same, they have the same pitch. Hence: Pitch depends solely on the length of time in which each single vibration is executed, or, which comes to the same thing, on the number of vibrations completed in a given time. We are accustomed to take a second as the unit of time, and shall consequently mean by the pitch number [or frequency] of a tone, the number of vibrations which the particles of a sounding body perform in one second of time. It is self-evident that we find the periodic time or vibrational period, that is length of time which is occupied in performing a single vibration backwards and forwards, by dividing one second of time by the pitch number.

Musical tones are said to be higher, the greater their pitch numbers, that is, the shorter their vibrational periods.

The exact determination of the pitch number for such elastic bodies as produce audible tones, presents considerable difficulty, and physicists had to contrive many comparatively complicated processes in order to solve this problem for each particular case. Mathematical theory and numerous experiments had to render mutual assistance. It is consequently very convenient for the demonstration of the fundamental facts in this department of knowledge, to be able to apply a peculiar instrument for producing musical tones—the so-called siren—which is constructed in such a manner as to determine the pitch number of the tone produced, by a direct observation. The principal parts of the simplest form of the siren are shown in Fig. 1, after Seebeck.

FIG. 1.



A is a thin disc of cardboard or tinplate, which can be set in rapid rotation about its axle b by means of a string ff, which passes over a larger wheel. On the margin of the disc there is punched a set of holes at equal intervals: of these there are twelve in the figure; one or more similar series of holes at equal distances are introduced on concentric circles (there is one such of eight holes in the figure), c is a pipe which is directed over one of the holes. Now, on setting the disc in rotation and blowing through the pipe c, the air will pass freely whenever one of the holes comes under the end of the pipe, but will be checked whenever an unpierced portion of the disc comes under it. Each hole of the disc, then, that passes the end of the pipe lets a single puff of air escape. Supposing the disc to make a single revolution and the pipe to be directed to the outer circle of holes, we have twelve puffs corresponding to the twelve holes; but if the pipe is directed to the inner circle we have only eight puffs. If the disc is made to revolve ten times in one second, the outer circle will produce 120 puffs in one second, which would give rise to a weak and deep musical tone, and the inner circle eighty puffs. Generally, if we know the number of revolutions which the disc makes in a second, and the number of holes in the series to which the tube is directed, the product of these two numbers evidently gives the number of puffs in a second. This number is consequently far easier to determine exactly than in any other musical instrument, and sirens are accordingly extremely well adapted for studying all changes in musical tones resulting from the alterations and ratios of the pitch numbers.

….

It is clear that when the pierced disc of one of these sirens is made to revolve with a uniform velocity, and the air escapes through the holes in puffs, the motion of the air thus produced must be periodic in the sense already explained. The holes stand at equal intervals of space, and hence on rotation follow each other at equal intervals of time. Through every hole there is poured, as it were, a drop of air into the external atmospheric ocean, exciting waves in it, which succeed each other at uniform intervals of time, just as was the case when regularly falling drops impinged upon a surface of water (p. 10a). Within each separate period, each individual puff will have considerable variations of form in sirens of different construction, depending on the different diameters of the holes, their distance from each other, and the shape of the extremity of the pipe which conveys the air; but in every case, as long as the velocity of rotation and the position of the pipe remain unaltered, a regularly periodic motion of the air must result, and consequently the sensation of a musical tone must be excited in the ear, and this is actually the case.

It results immediately from experiments with the siren that two series of the same number of holes revolving with the same velocity, give musical tones of the same pitch, quite independently of the size and form of the holes, or of the pipe. We even obtain a musical tone of the same pitch if we allow a metal point to strike in the holes as they revolve instead of blowing. Hence it follows firstly that the pitch of a tone depends only on the number of puffs or swings, and not on their form, force, or method of production. Further it is very easily seen with this instrument that on increasing the velocity of rotation and consequently the number of puffs produced in a second, the pitch becomes sharper or higher. The same result ensues if, maintaining a uniform velocity of rotation, we first blow into a series with a smaller and then into a series with a greater number of holes. The latter gives the sharper or higher pitch.

With the same instrument we also very easily find the remarkable relation which the pitch numbers of two musical tones must possess in order to form a consonant interval. Take a series of 8 and another of 16 holes in a disc, and blow into both sets while the disc is kept at uniform velocity of rotation. Two tones will be heard which stand to one another in the exact relation of an Octave. Increase the velocity of rotation; both tones will become sharper, but both will continue at the new pitch to form the interval of an Octave. Hence we conclude that a musical tone which is an Octave higher than another, makes exactly twice as many vibrations in a given time as the latter.

The disc shown in Fig. 1 … has two circles of 8 and 12 holes respectively. Each, blown successively, gives two tones which form with each other a perfect Fifth, independently of the velocity of rotation of the disc. Hence, two musical tones stand in the relation of a so-called Fifth when the higher tone makes three vibrations in the same time as the lower makes two.

If we obtain a musical tone by blowing into a circle of 8 holes, we require a circle of 16 holes for its Octave, and 12 for its Fifth. Hence the ratio of the pitch numbers of the Fifth and the Octave is 12 : 16 or 3:4. But the interval between the Fifth and the Octave is the Fourth, so that we see that when two musical tones form a Fourth, the higher makes four vibrations while the lower makes three.

The polyphonic siren of Dove has usually four circles of 8, 10, 12 and 16 holes respectively. The series of 16 holes gives the Octave of the series of 8 holes, and the Fourth of the series of 12 holes. The series of 12 holes gives the Fifth of the series of 8 holes, and the minor Third of the series of 10 holes. While the series of 10 holes gives the major Third of the series of 8 holes. The four series consequently give the constituent musical tones of a major chord.

By these and similar experiments we find the following relations of the pitch numbers –

1 : 2 Octave
2 : 3 Fifth
3 : 4 Fourth
4 : 5 major Third
5 : 6 minor Third

When the fundamental tone of a given interval is taken an Octave higher, the interval is said to be inverted. Thus a Fourth is an inverted Fifth, a minor Sixth an inverted major Third, and a major Sixth an inverted minor Third. The corresponding ratios of the pitch numbers are consequently obtained by doubling the smaller number in the original interval.

From 2:3 the Fifth, we thus have 3:4 the Fourth
From 4:5 the major Third ... 5:8 the minor Sixth
From 5:6 the minor Third, 6:10 = 3:5 the major Sixth.

These are all the consonant intervals which lie within the compass of an Octave. With the exception of the minor Sixth, which is really the most imperfect of the above consonances, the ratios of their vibrational numbers are all expressed by means of the whole numbers, 1, 2, 3, 4, 5, 6.

Comparatively simple and easy experiments with the siren, therefore, corroborate that remarkable law mentioned in the Introduction (p. 1d), according to which the pitch numbers of consonant musical tones bear to each other ratios expressible by small whole numbers. In the course of our investigation we shall employ the same instrument to verify more completely the strictness and exactness of this law.

Long before anything was known of pitch numbers, or the means of counting them, Pythagoras had discovered that if a string be divided into two parts by a bridge, in such a way as to give two consonant musical tones when struck, the lengths of these parts must be in the ratio of these whole numbers. If the bridge is so placed that of the string lie to the right, and on the left, so that the two lengths are in the ratio of 2:1, they produce the interval of an Octave, the greater length giving the deeper tone. Placing the bridge so that of the string lie on the right and on the left, the ratio of the two lengths is 3 : 2, and the interval is a Fifth.

SOURCE: Helmholtz, Hermann von. *On the Sensations of Tone as a Physiological Basis for the Theory of Music: By Hermann L.F. Helmholtz ... Translated with the Authors Sanction from the Third German Edition, with Additional Notes and an Additional Appendix, by Alexander J. Ellis*. Translated by Alexander John Ellis. London: Longmans, Green, and Co., 11912.
https://books.google.com/books?id=x_A5AAAAIAAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

Document 1B

In the end, they named it the phonograph. But it might have been called the omphlegraph, meaning "voice writer." Or the antiphone (back talker). Or the didasko phone (portable teacher). These are some of the names someone wrote in a logbook in Thomas Edison's laboratory in 1877, after Edison and his assistants invented the first rudimentary machine for recording and playing back sounds. From the first, they thought it would be used to reproduce the human voice, but they had no clear idea of its exact purpose.

Edison once said, "Anything that won't sell, I don't want to invent." But all his life, he was a better inventor than salesman. The phonograph, his first invention to make him world-famous, is a perfect example. It was the product of a well-prepared but wandering mind.

It was also the outcome of an amazing burst of inventiveness. One evening in July 1877, while relaxing with his assistants after their regular midnight dinner, Edison had an idea. They were working with ways to use paper strips to make a record of telegraph messages. Why not adapt those to record the vibrations of the diaphragm in a telephone mouthpiece? Thinking out loud, Edison suggested attaching a needle to the back of the diaphragm and mounting it above rollers for the paper strips. Speaking into the mouthpiece would cause the diaphragm to move, which in turn would cause the needle to inscribe squiggled indentations into the strips. If the paper were then pulled through the rollers again with the needle resting in the groove, the indentations would move the attached diaphragm, which should reproduce the original sound.

Edison's assistants set to work. Within the hour, they had a working device they tried out by reciting "Mary had a little lamb" into the telephone. In the first trial, all that could be heard from the playback was "ary ad ell am." But that was encouraging. The staff went on working through the night, fiddling with the gizmo — and thus occurred the first midnight recording session.

Edison and his crew later replaced the paper and rollers with tinfoil, which was wrapped around a cylinder attached to a crank. But Edison did not regard the machine as commercially promising. At best, he thought, it might be an office machine allowing businessmen to dictate letters.

When word of the invention spread, however, the outside world saw greater possibilities. The dead could speak to us, eternally! Collectors could keep what the New York Times called a "well-stocked oratorical cellar." But the primitive phonograph that Edison demonstrated for the editors of Scientific American that December remained exceedingly limited. It could clearly introduce itself — "How do you do? How do you like the phonograph?" — but that exhausted its recording capacity.

Still, the editors were excited enough to publish an admiring bulletin about the device — a first shot that set off an avalanche of publicity. A reporter wrote him, "I want to know you right bad," and everyone else did too. Investors enlisted him in a new venture, the Edison Speaking Phonograph Co. But he soon lost interest in making the phonograph a salable product. The company introduced a toy model that functioned badly and a second, more expensive one that was used by show-business entrepreneurs who rented concert halls to demonstrate the wondrous machine to paying audiences. It broke down frequently and required a trained technician's constant attention.

Ten years elapsed before Edison returned to the phonograph, only after a competitor developed a wax-coated cylinder that could be removed without ruining the recording, something impossible to do with Edison's delicate tinfoil. To him, the idea that his most cherished invention faced competition was unendurable. He set to work on what he would call the Perfected Phonograph. When he introduced it to the market, however, in 1889, it was anything but perfect as the dictation device he still thought it to be. But it played music beautifully. Edison's backers tried to persuade him that the phonograph could be marketed for entertainment purposes, but he could not let go of his conviction that it was destined for the office.

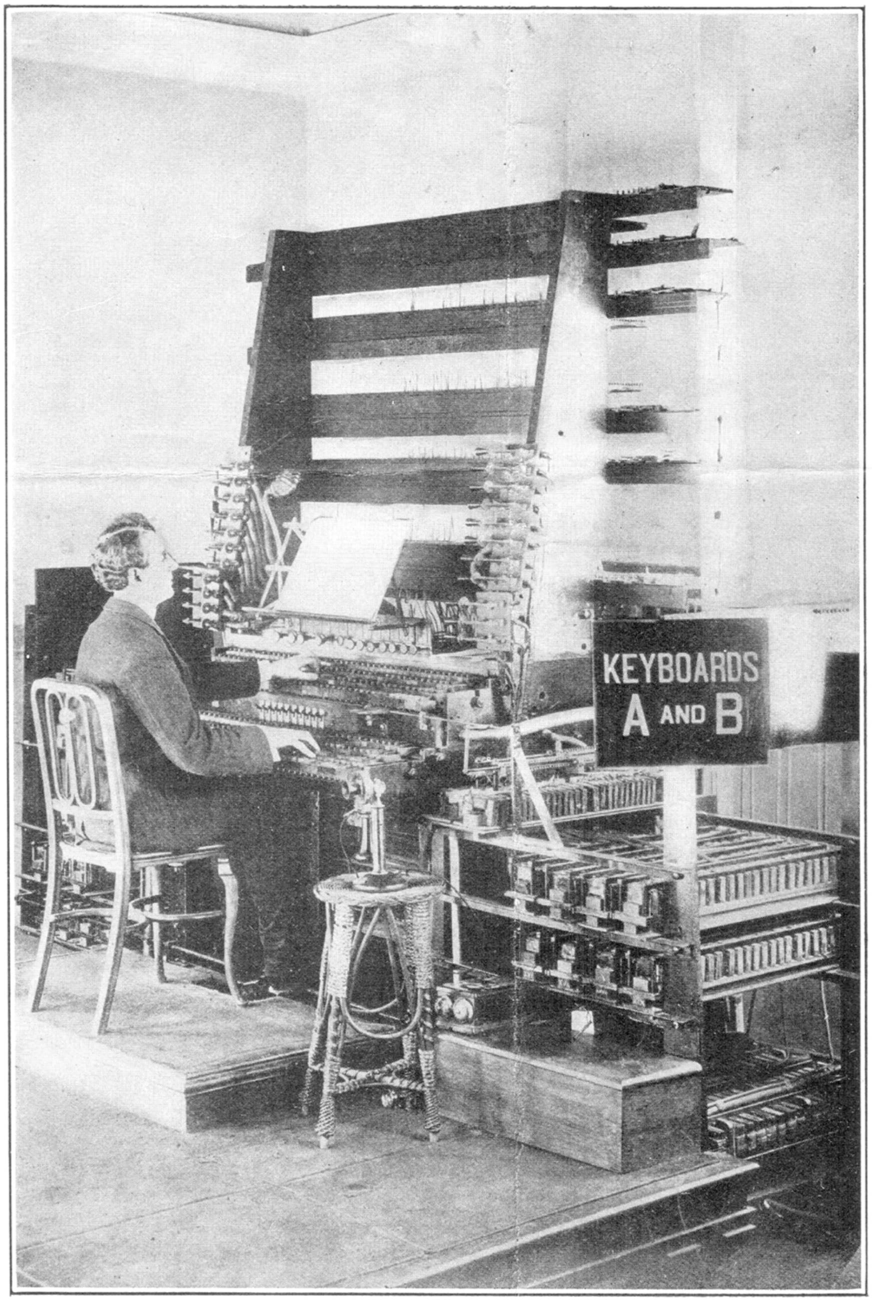
Competitors leaped further ahead, developing a new recording medium, the disc, and rushing to sign musical artists to recording contracts. Eventually, Edison capitulated and entered the recorded-music business too — a business he was poorly suited to as a man who disapproved of most genres of popular music. He dismissed "miserable dance and ragtime selections" and described jazz as something for "the nuts." Another competitor soon emerged, the Victor Talking Machine Co. and its Victrola. And while Victor built a stable of notable musical artists, Edison remained unwilling to pay royalty advances necessary to recruit stars.

In the 1920s, Edison's phonograph faced a new challenge, commercial radio. The other phonograph companies introduced radios but Edison refused, wanting nothing to do with the medium's inferior sound quality. Prodded by his sons, he grudgingly relented, but the move came too late — in the midst of the stock-market crash of 1929. Within a year, his radio company ceased production. Edison died a year later. The music industry he had set in motion lived on, evolving into stereo, iPods and streaming music. He had made it all possible, without ever quite grasping how to make the most of it for himself.

SOURCE: Stross, Randall. "The Making of America: Thomas Edison." Time. Time Inc., June 23, 2010.
http://content.time.com/time/specials/packages/article/0,28804,1999143_1999210,00.html

Document 1C

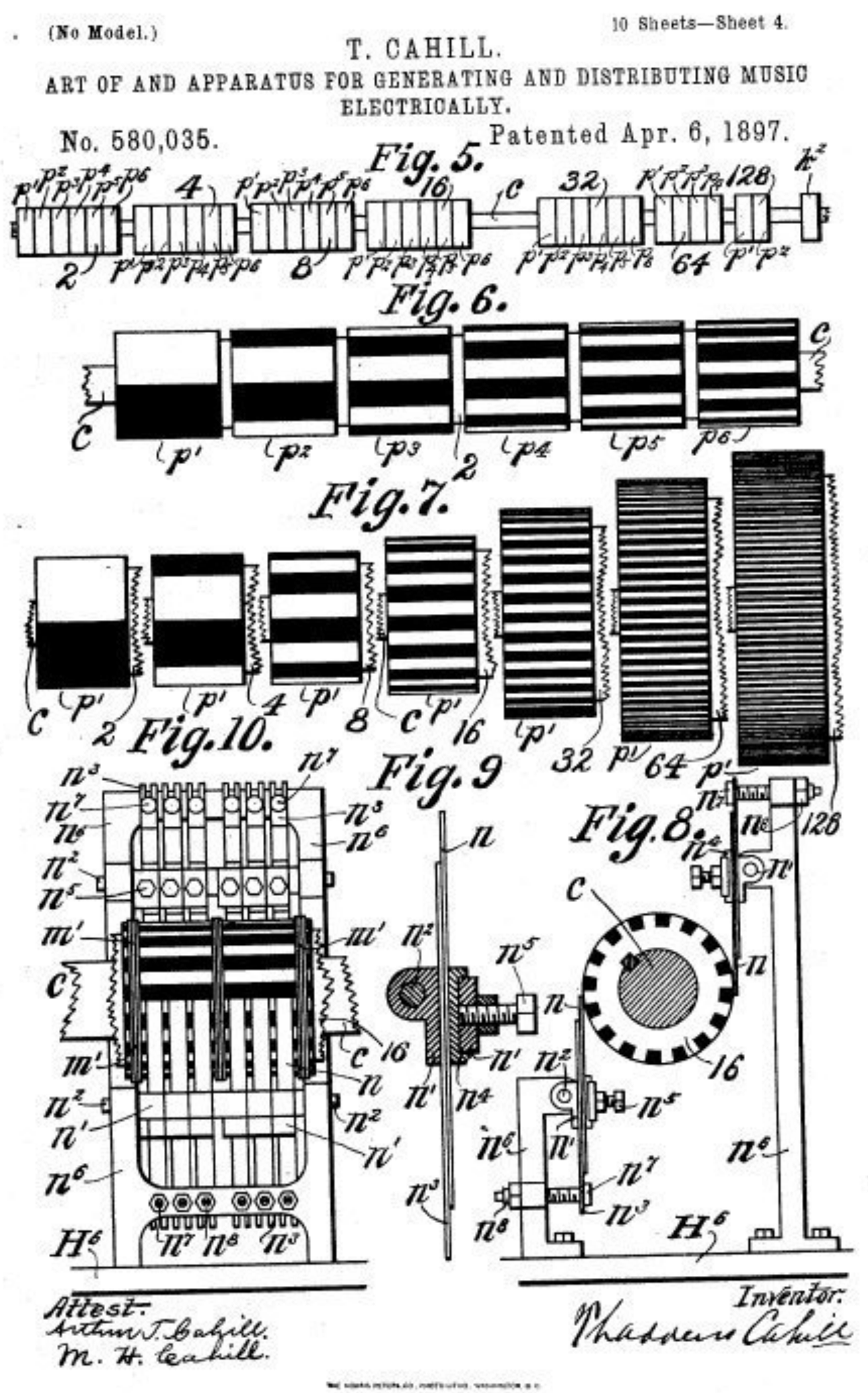
In 1895 Thaddeus Cahill submitted his first patent for the Telharmonium "The Art of and Apparatus for Generating and Distributing Music Electrically". The Telharmonium can be considered the first significant electronic musical instrument and was a method of electro-magnetically synthesizing and distributing music over the new telephone networks of Victorian America.



THE KEYBOARD OF THE TELHARMONIUM

The dual manual of the MkII Telharmonium. Gunter's Magazine June 1907

This first patent was initially rejected by the patent office because the "plan contained principles and practices found in other patented devices". Cahill, a trained lawyer, eventually succeeded in having his patent accepted in 1897.



Thaddeus Cahill's patent documents for the first Telharmonium of 1897 showing the arrangement of rotor alternators and rheostat brushes.

The first design of the instrument set out the principles of the 'Telharmonium' or 'Dynamophone' that would be developed by Cahill over the next twenty years. Cahill's vision was to create a universal 'perfect instrument'; an instrument that could produce absolutely perfect tones, mechanically controlled with scientific certainty. The Telharmonium would allow the player to combine the sustain of a pipe organ with the expression of a piano, the musical intensity of a violin with polyphony of a string section and the timbre and power of wind instruments with the chord ability of an organ. Having corrected the ‘defects’ of these traditional instruments the superior Telharmonium would render them obsolete.

Influences

In 1885 Hermann Helmholtz’s ‘On the Sensations of Tone’ (1862) appeared in English translation and had an immediate and profound impact on scientific and musical thinking. Helmholtz defined the concept that a tone was composed of a single fundamental sound which, combined with a set of higher sounds, gave each musical tone a unique quality or timbre – and that these tones were a collection of ‘pure’ sine tone. Cahill’s reasoning was that the ‘perfect instrument’ could be built to created sine tones that could be combined to recreate the qualities of existing instruments without their ‘defects’.

The idea of transmitting music over the telegraphic or Telephone network was not new. Cahill was well aware of previous inventions and experiments with Telegraphic music. As far back as 1809, the Prussian anthropologist, paleontologist and inventor Samuel Thomas Soemmerring created an electrical telegraph that triggered an array of tuned bells from a distance of several kilometers. This experiment was originally intended as an investigation into human consciousness and perception but led to speculation about the possibilities of transmitting music electronically over great distances.

In 1893 the Hungarian engineer and inventor Tivadar Puskás established the ‘Telefonhírmondó’ or ‘Telephone Herald’ a type of telephone based newspaper that broadcast music and news over the telephone network in Budapest to as many as 91,000 subscribers which continued (in tandem with a radio service) until World War II when the wire network was destroyed.

In Paris, Clément Ader created the ‘Théâtrophone’ a type of early binaural or stereo audio transmission of music and theatre in 1881 which ran until it was superseded by radio in 1931 and similarly, in London in 1895, the ‘Electrophone’ service distributed music hall and light music to an audience of subscribers.

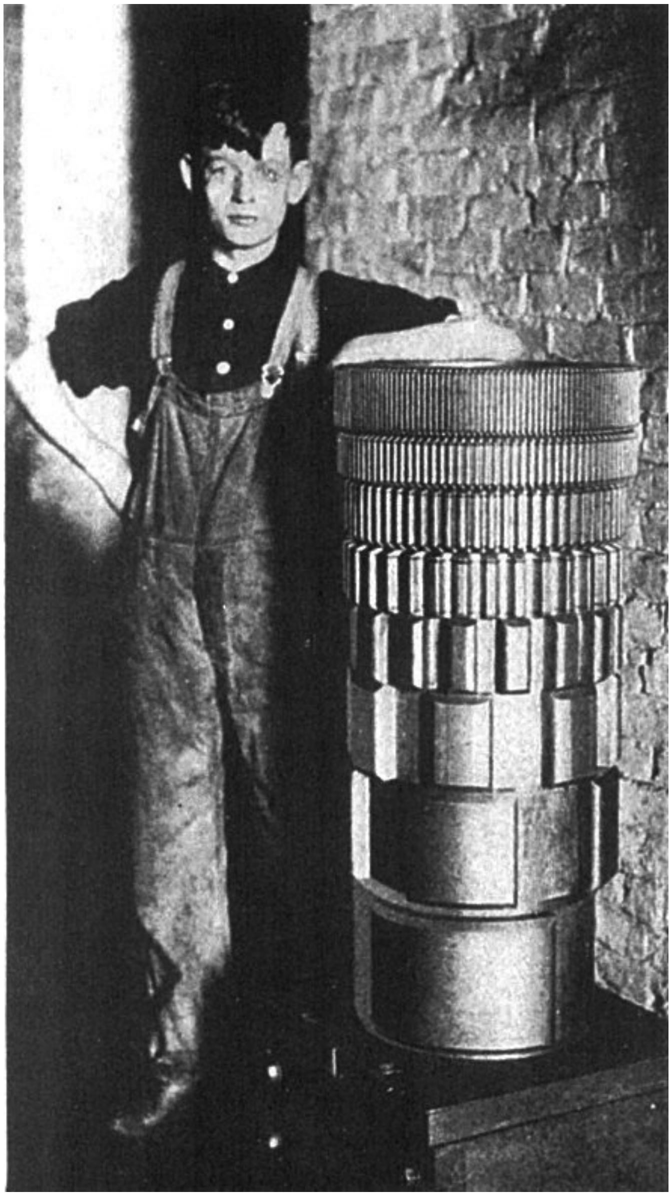
But probably the biggest technical influence on Cahill was Elisha Gray’s ‘Musical Telegraph’ of 1874. Gray, one of the inventors of the telephone, had developed a way of transmitting pitched tones over a long distance telegraph network using electromagnetically controlled vibrating metal reeds. Gray had originally intended to use this as a way of sending multiple messages over a network (a predecessor of multiplex signals) and had created a musical keyboard instrument to promote his ideas. It was the similarity of Gray’s work to Cahill’s initial concept that led to the rejection of Cahill’s first patent and in response Cahill was scathing about Gray’s instrument declaring that the Musical Telegraph was:

“practically useless. No person of taste or culture could be supposed to derive any enjoyment from music rendered in poor, harsh tones, with uneven power, and absolutely without expression or variation.”

…and that Gray’s patented machine was unable to produce sine waves or complex harmonics of the Telharmonium…. Cahill restructured his patent to accentuate the differences between his invention and that of Elisha Gray – nevertheless, Gray’s ‘Musical Telegraph’ clearly had a major influence on Cahill’s new instrument.

The ‘Telharmonium’ or ‘Dynamaphone’

Cahill’s major criticisms of Gray’s ‘Musical Telegraph’ was that by using electromagnetically oscillating metal reeds, Gray’s instrument only had enough power to be heard at close range to a telephone receiver and, the Musical Telegraph's oscillators could only create harsh, simple tones that lacked character and expression. Cahill's proposal was to generate complex mixtures of sine tones using multiple electrical dynamos that would be powerful enough to be audible to an audience from a distance.



A single tone wheel generator with eight alternators.

The core of his invention was the tone wheel; essentially a rotor with variably shaped alternators that spun within a magnetic field (The early versions used rheotomes; a set of brushes that contacted the rotor as it spun.) to generate a tone. Each tone wheel was composed of the fundamental tone and six ascending partials. The first model consisted of a mainframe of twelve identical rotors each of the twelve pitch-rotors carried seven fundamental alternators, six third-partial alternators, and five fifth-partial alternators. These rotors were spun at the relevant speed by a belt driven motor, giving the instrument a six octave range. This arrangement gave the Telharmonium two tuning systems; one being a pure harmonic series used for building the timbre of each note, and the other, an equal tempered scale used for combining notes into a scale.

Table 1
Vibration Frequencies of All Alternators on One Pitch-Shaft

Hz	Fundamental	Third-Partial (Perfect Fifth)	Fifth-Partial (Major Third)
3072		96n (288)	
2560			80n (240)
2048	64n (192)		
1536		48n (144)	
1280			40n (120)
1024	32n (96)		
768		24n (72)	
640			20n (60)
512	16n (48)		
384		12n (36)	
320			10n (30)
256	8n (24)		
192		6n (18)	
160			5n (15)
128	4n (12)		
96		3n (9)	
64	2n (6)		
32	n (3)		

Diagram showing frequencies of the Telharmonium alternators. image from 'Magic Music from the Telharmonium' By Reynold Weidenaar

The output quality of the tone wheels – especially with the rheotome versions – was harsh and unpleasant. The sound quality was softened by passing the signal through a series of secondary induction coils that filtered the harshness from the sound to a tone approximating a sine wave. (These induction could also be controlled by the velocity of the keyboard, allowing the musicians a complex level of expressive influence over the tone). Cahill was able to dispense with these purifying circuits in later models after perfecting rotor teeth cutting techniques to provide an almost pure sinusoidal output.

The number of partials for each fundamental could be controlled with familiar organ like stops allowing the instrument to imitate orchestral instruments. In this way, the Telharmonium was the first additive synthesizer; recreating instrumental timbres by adding and mixing harmonics.

Less familiar was the keyboard arrangement; for the second Telharmonium, Cahill hired the pianist Edwin Hall Pierce to develop a repertoire for the instrument as well as create sounds from the multiple harmonics. Pierce, with Cahill, also defined the unusually complex keyboard arrangement. Because they Telharmonium mechanically created notes using exact divisions that equated to just intonation, Pierce decided to use three sets of keyboards (two or sometimes four in later models) that allowed for thirty six keys per octave (over the three keyboards) – this meant that instead of the usual black and white key layout, the manual consisted of alternate black and white keys and the player had to learn to play over three manuals to achieve an equal tempered scale. Despite this nightmarish keyboard-complexity the Telharmonium had the unique ability – if required – to play over a variety of intonations.

A unique clutch like device allowed the player to control expression using key velocity as well as with a foot pedal. The resulting sound was fed through the wire network and streamed to the audience through large, six-foot acoustic horns of various designs – Cahill experimented with numerous horn designs using different thicknesses of wood, metal carbon and paper to acquire the right range of tones.

For the Telharmonium to be audible beyond a telephone receiver it needed much more current than the standard telephone; the output power from the Telharmonium's alternators was as much as 15,000 watts and around 1 amp at the receiver – compared to a telephone receiver designed for currents as low as six ten-trillionths of an amp. This power did allow the Telharmonium to be audible to an audience but caused interference with the New York telephone network and needed a huge amount of electricity to keep it running.

The sound of the Telharmonium
The first description of the sound of the Telharmonium was from Ray Stannard Baker writing for McClure's magazine describing a demonstration of the Washington MkI Telharmonium at the Hotel Hamilton;

"The first impression the music makes upon the listener is its singular difference from any music ever heard before: in the fullness, roundness, completeness, of its tones. And truly it is different and more perfect: but strangely enough, while it possesses ranges of tones all its own, it can be made to imitate closely other musical instruments: the flute, oboe, bugle, French horn and cello best of all, the piano and violin not as yet so perfectly. Ask the players for fife music and they play Dixie for you with the squealing of the pipes deceptively perfect. Indeed, the performer upon this marvelous machine, as I shall explain later, can "build up" any sort of tone he wishes: he can produce the perfect note of the flute or the imperfect note of the piano — though the present machine is not adapted to the production of all sorts of music, as future and more extensive machines may be.

After several selections had been given I was conscious of a subtle change in the music. Dr. Cahill said: 'Mr. Harris has taken Mr. Pierce's place.' It is quite as possible, indeed, to distinguish the individuality of the players upon this instrument as it is upon the piano or violin. The machine responds perfectly to the skill and emotion of the player; he gets out of it what he puts into it: so that the music is as much a human production as though the player performed upon a piano. In an hour's time we had many selections, varying all the way from Bach and Schubert to the 'Arkansas Traveler' and a popular Stein song. One duet was played by Mr. Pierce and Mr. Schultz. The present machine is best adapted to the higher class of music. It does not produce with any great success the rattlebang of rag-time which is perhaps an advantage" *–Ray Stannard Baker writing in McClure's Magazine (1903)*

And Thomas Commerford Martin writing in the Outlook on the 5 May;

"A skillful performer upon the telharmonium can make it blare like a trumpet, snarl like a bassoon, warble like a flute, or sing like a violin. Four or five performers, playing in concert, will ultimately be able, it is believed, to produce an effect closely approaching that of a full orchestra; for each bank of keys is furnished with a set of stops somewhat like those of an organ, by means of which it can be made to produce tones almost if not quite identical with those of any family of instruments. At one keyboard one player can play the part of the strings; at another a second player can reproduce the tones of the oboe family; at another a third player can reproduce the tones of the brass; and so on. And each player is able in an instant to modify or transform the quality of tone which he is producing.

Of course there are limitations in this power to imitate instruments. In the violin tone on the telharmonium there is nothing of resin and catgut; in the tone of the French horn there is not the occasional break characteristic of that instrument. On the other hand, the quality of tone in the telharmonium is capable of infinite variation – Instrumental effects are possible on it which have never before been heard."

Established at the Telharmonic Hall, Cahill's New York Electric Music Co. put on several seasons of Telharmonic music from 1906 – including guided tours of the basement machinery. The repertoire consisted of popular light classical works that emphasized the instrument's range and flexibility. The audience listened to the music using a variety of horns and speakers including music fed into a series of carbon arc lamps that oscillated with the electronic signal giving an audio and light show (this phenomena had been explored by the British physicist William Duddell and was used in his 'Singing Arc' instrument of 1899).

Ray Stannard Baker in McClure's magazine in 1903 also contemplated the effect the Telharmonium would have on music and the listener arguing that it would 'democratize' music:

"As the machine is developed, and as the players become more expert, we may enter upon quite a new era of music, what may be called, indeed, the democracy of music. We cannot really herald the complete dominance of democracy until we have good music, great pictures, and the best books at the command of every citizen. Museums, galleries, and process printing have gone far towards bringing that equal opportunity of all citizens for the enjoyment of great pictures, which is the dream of the social philosopher. Free libraries have placed the best and rarest books at the command of any man who wishes to use them. But music, by its nature ephemeral and costly of production, has not so easily submitted itself to such democracy of enjoyment. Poor music may be had anywhere: good music is hived up in grand opera houses, and supported by playing upon the social vanity of the rich. It is a pastime for society. To this fact, indeed, may be traced the slow development, much deplored by critics, of musical taste in this country."

SOURCE: "The 'Telharmonium' or 'Dynamophone' Thaddeus Cahill, USA 1897." 120 Years of Electronic Music, June 7, 2016. http://120years.net/the-telharmonium-thaddeus-cahill-usa-1897/

Document 1D

On March 9, 1913, during our bloody victory over four thousand passé-ists in the Costanzi Theater of Rome, we were fist-and-cane-fighting in defense of your Futurist Music, performed by a powerful orchestra, when suddenly my intuitive mind conceived a new art that only your genius can create: the Art of Noises, logical consequence of your marvelous innovations. In antiquity, life was nothing but silence. Noise was really not born before the 19th century, with the advent of machinery. Today noise reigns supreme over human sensibility. For several centuries, life went on silently, or mutedly. The loudest noises were neither intense, nor prolonged nor varied. In fact, nature is normally silent, except for storms, hurricanes, avalanches, cascades and some exceptional telluric movements. This is why man was thoroughly amazed by the first sounds he obtained out of a hole in reeds or a stretched string.

Primitive people attributed to sound a divine origin. It became surrounded with religious respect, and reserved for the priests, who thereby enriched their rites with a new mystery. Thus was developed the conception of sound as something apart, different from and independent of life. The result of this was music, a fantastic world superimposed upon reality, an inviolable and sacred world. This hieratic atmosphere was bound to slow down the progress of music, so the other arts forged ahead and bypassed it. The Greeks, with their musical theory mathematically determined by Pythagoras, according to which only some consonant intervals were admitted, have limited the domain of music until now and made almost impossible the harmony they were unaware of. In the Middle Ages music did progress through the development and modifications of the Greek tetracord system. But people kept considering sound only in its unfolding through time, a narrow conception so persistent that we still find it in the very complex polyphonies of the Flemish composers. The chord did not yet exist; the development of the different parts was not subordinated to the chord that these parts could produce together; the conception of these parts was not vertical, but merely horizontal. The need for and the search for the simultaneous union of different sounds (that is to say of its complex, the chord), came gradually: the assonant common chord was followed by chords enriched with some random dissonances, to end up with the persistent and complicated dissonances of contemporary music.

First of all, musical art looked for the soft and limpid purity of sound. Then it amalgamated different sounds, intent upon caressing the ear with suave harmonies. Nowadays musical art aims at the shrilliest, strangest and most dissonant amalgams of sound. Thus we are approaching **noise-sound. This revolution of music is paralleled by the increasing proliferation of machinery** sharing in human labor. In the pounding atmosphere of great cities as well as in the formerly silent countryside, machines create today such a large number of varied noises that pure sound, with its littleness and its monotony, now fails to arouse any emotion.

To excite our sensibility, music has developed into a search for a more complex polyphony and a greater variety of instrumental tones and coloring. It has tried to obtain the most complex succession of dissonant chords, thus preparing the ground for **Musical Noise**.

This evolution toward noise-sound is only possible today. The ear of an eighteenth century man never could have withstood the discordant intensity of some of the chords produced by our orchestras (whose performers are three times as numerous); on the other hand our ears rejoice in it, for they are attuned to modern life, rich in all sorts of noises. But our ears far from being satisfied, keep asking for bigger acoustic sensations. However, musical sound is too restricted in the variety and the quality of its tones. The most complicated orchestra can be reduced to four or five categories of instruments with different sound tones: rubbed string instruments, pinched string instruments, metallic wind instruments, wooden wind instruments, and percussion instruments. Music marks time in this small circle and vainly tries to create a new variety of tones. **We must break at all cost from this restrictive circle of pure sounds and conquer the infinite variety of noise-sounds.**

Each sound carries with it a nucleus of foreknown and foregone sensations predisposing the auditor to boredom, in spite of all the efforts of innovating composers. All of us have liked and enjoyed the harmonies of the great masters. For years, Beethoven and Wagner have deliciously shaken our hearts. Now we are fed up with them. **This is why we get infinitely more pleasure imagining combinations of the sounds of trolleys, autos and other vehicles, and loud crowds, than listening once more, for instance, to the heroic or pastoral symphonies.**

It is hardly possible to consider the enormous mobilization of energy that a modern orchestra represents without concluding that the acoustic results are pitiful. Is there anything more ridiculous in the world than twenty men slaving to increase the plaintive meeowing of violins? This plain talk will make all music maniacs jump in their seats, which will stir up a bit the somnolent atmosphere of concert halls. Shall we visit one of them together? Let’s go inside one of these hospitals for anemic sounds. See, the first bar is dripping with boredom stemming from familiarity, and gives you a foretaste of the boredom that will drip from the next bar. In this fashion we sip from bar to bar two or three sorts of boredom and keep waiting for the extraordinary sensation that will never materialize. Meanwhile we witness the brewing of a heartrending mixture composed of the monotony of the sensations and the stupid and religious swooning of the audience, drunk on experiencing for the thousandth time, with almost Bhuddist [sic] patience, with elegant and fashionable ecstasy. **POUAH!** Let’s get out quickly, for I can’t repress much longer the intense desire to create a true musical reality finally by distributing big loud slaps right and left, stepping and pushing over violins and pianos, bassoons and moaning organs! Let’s go out!

Some will object that noise is necessarily unpleasant to the ear. The objection is futile, and I don’t intend to refute it, to enumerate all the delicate noises that give pleasant sensations. To convince you of the surprising variety of noises, I will mention thunder, wind, cascades, rivers, streams, leaves, a horse trotting away, the starts and jumps of a carriage on the pavement, the white solemn breathing of a city at night, all the noises made by feline and domestic animals and all those man’s mouth can make without talking or singing.

Let’s walk together through a great modern capital, with the ear more attentive than the eye, and we will vary the pleasures of our sensibilities by distinguishing among the gurglings of water, air and gas inside metallic pipes, the rumblings and rattlings of engines breathing with obvious animal spirits, the rising and falling of pistons, the stridency of mechanical saws, the loud jumping of trolleys on their rails, the snapping of whips, the whipping of flags. We will have fun imagining our orchestration of department stores’ sliding doors, the hubbub of the crowds, the different roars of railroad stations, iron foundries, textile mills, printing houses, power plants and subways. And we must not forget the very new noises of Modern Warfare. The poet Marinetti, in a letter from the Bulgarian trenches of Adrianople described to me as follows, in his new futurist style, the orchestra of a great battle:

1 2 3 4 5 seconds the siege canons gut the silence by a chord-
Tamtoumb! Immediately echoes, echoes, echoes, all echoes-quick!
take-it-crumble it-spread it-infinite distance to hell. In the center,

center of these flattened **TAMTOUMBS**-width 50 square kilo-
meters-leap 2 3 6 8 splinters-fisticuff-headrammings-rapid fire
batteries **Violence**, ferocity, regularity, pendulum game, fatality
this grave bass apparent slowness-scan the strange madmen
very young-very mad mad mad-very agitated altos of the battle
Fury anguish breathless ears My ears open nasals! beware!
such joy is yours o my people to sense see ear scent drink
everything everything everything….

We want to score and regulate harmonically and rhythmically these most varied noises. Not that we want to destroy the movements and irregular vibrations (of tempo and intensity) of these noises! We wish simply to fix the degree or pitch of the predominant vibration, as noise differs from other sound in its irregular and confuse vibrations (in terms of tempo and intensity).

Each noise possesses a pitch, at times even a chord dominating over the whole of these irregular vibrations. The existence of this predominant pitch offers us the technical means of scoring these noises, that is to say to give to a noise a certain variety of pitches without losing the timbre that characterizes and distinguishes it. Certain noises obtained through a rotating movement can give us a complete ascending or descending scale through the speeding up or slowing down of the movement.

Noise accompanies every manifestation of our life. Noise is familiar to us. Noise has the power to bring us back to life. On the other hand, sound, foreign to life, always a musical, outside thing, an occasional element, has come to strike our ears no more than an overly familiar face does our eye. Noise, gushing confusely and irregularly out of life, is never totally revealed to us and it keeps in store innumerable surprises for our benefit. We feel certain that in selecting and coordinating all noises we will enrich men with a voluptuousness they did not suspect.

Although the characteristic of noise is to brutally bring us back to life, **the art of noises must not be limited to a mere imitative reproduction.** The art of noises will extract its main emotive power from the special acoustic pleasure that the inspired artist will obtain in combining noises. Here are the six categories of noises for the futurist orchestra that we intend soon to realize mechanically:

1
roars
claps
noises of falling water
driving noises
bellows

2
whistles
snores
snorts

3
whispers
mutterings
rustlings
grumbles
grunts
gurgles

4
shrill sounds
cracks
buzzings
jingles
shuffles

5
percussive noises using
metal, wood, skin,
stone, baked earth, etc.

6
animal and human voices:
shouts, moans, screams,
laughter, rattlings, sobs

We have included in these 6 categories the most characteristic fundamental noises: the others are hardly more than combinations of them. The rhythmic movements of a noise are infinite. There exists not only a predominant pitch, but as well a predominant rhythm around which more secondary rhythms are equally perceptible.

Conclusions:
1 - We must enlarge and enrich more and more the domain of musical sounds. Our sensibility requires it. In fact it can be noticed that all contemporary composers of genius tend to stress the most complex dissonances. Moving away from pure sound, they nearly reach noise-sound. This need and this tendency can be totally realized only through the joining and substituting of noises to and for musical sounds.

2 - We must replace the limited variety of timbres of orchestral instruments by the infinite variety of timbres of noises obtained through special mechanisms.

3 - The musician's sensibility, once he is rid of facile, traditional rhythms, will find in the domain of noises the means of development and renewal, an easy task, since each noise offers us the union of the most diverse rhythms as well as its dominant one.

4 - Each noise possesses among its irregular vibrations a predominant basic pitch. This will make it easy to obtain, while building instruments meant to produce this sound, a very wide variety of pitches, half-pitches and quarter-pitches. This variety of pitches will not deprive each noise of its characteristic timbre but, rather, increase its range.

5 - The technical difficulties presented by the construction of these instruments are not grave. As soon as we will have found the mechanical principle which produces a certain noise, we will be able to graduate its pitch according to the laws of acoustics. For instance, if the instrument employs a rotating movement, we will speed it up or slow it down. When not dealing with a rotating instrument we will increase or decrease the size or the tension of the sound-making parts.

6 - This new orchestra will produce the most complex and newest sonic emotions, not through a succession of imitative noises reproducing life, but rather through a fantastic association of these varied sounds. For this reason, every instrument must make possible the changing of pitches through a built-in, larger or smaller resonator or other extension.

7 - The variety of noises is infinite. We certainly possess nowadays over a thousand different machines, among whose thousand different noises we can distinguish. With the endless multiplication of machinery, one day we will be able to distinguish among ten, twenty or thirty thousand different noises. We will not have to imitate these noises but rather to combine them according to our artistic fantasy.

8 - We invite all the truly gifted and bold young musicians to analyze all noises so as to understand their different composing rhythms, their main and their secondary pitches. Comparing these noise sounds to other sounds they will realize how the latter are more varied than the former. Thus the comprehension, the taste, and the passion for noises will be developed. Our expanded sensibility will gain futurist ears

as it already has futurist eyes. In a few years, the engines of our industrial cities will be skillfully tuned so that every factory is turned into an intoxicating orchestra of noises.

…I am not a musician, so that I have no acoustic preferences, nor works to defend. I am a futurist painter who projects on a profoundly loved art his will to renew everything. This is why, bolder than the bolder professional musician, totally unpreoccupied with my apparent incompetence, knowing that audacity gives all prerogatives and all possibilities, I have conceived the renovation of music through the Art of Noise.

Luigi Russolo, Painter
Milano, March 11, 1913

SOURCE: Russolo, Luigi. *The Art of Noise: (Futurist Manifesto, 1913) Translated by Robert Filliou* (version Ubu Classics, 2004). New York: Something Else Press, 1967.
http://ubu.com/historical/gb/russolo_noise.pdf

Document 2A

1.2 BIRTH OF THE VACUUM TUBE

The year 1907 saw the invention, by Lee de Forest, of the first electronic device capable of amplification: the triode vacuum tube. Unfortunately, de Forest didn't understand how his invention actually worked, having stumbled upon it by way of a circuitous (and occasionally unethical) route.
The vacuum tube traces its ancestry to the humble incandescent light bulb of Thomas Edison. Edison's bulbs had a problem with progressive darkening caused by the accumulation of soot (given off by the carbon filaments) on the inner surface. In an attempt to cure the problem, he inserted a metal electrode, hoping somehow to attract the soot to this plate rather than to the glass. Ever the experimentalist, he applied both positive and negative voltages (relative to one of the filament connections) to this plate, and noted in 1883 that a current mysteriously flows when the plate is positive but not when negative. Furthermore, the current that flows depends on filament temperature. He had no theory to explain these observations (remember, the word electron wasn't even coined by George Johnstone Stoney until 1891, and the particle itself wasn't unambiguously identified until J. J. Thomson's experiments of 1897), but Edison went ahead and patented in 1884 the first electronic (as opposed to electrical) device, one that exploits the dependence of plate current on filament temperature to measure line voltage indirectly. This instrument never made it into production, given its inferiority to a standard voltmeter; Edison just wanted another patent, that's all (that's one way he ended up with 1093 of them).

At about this time, a consultant to the British Edison Company named John Ambrose Fleming happened to attend a conference in Canada. He took this opportunity to visit both his brother in New Jersey and Edison's lab. He was greatly intrigued by the “Edison effect" (much more so than Edison, who was a bit puzzled by Fleming's excitement over so useless a phenomenon), and eventually he published papers on the effect from 1890 to 1896. Although his experiments created an initial stir, the Edison effect quickly lapsed into obscurity after Röntgen's announcement in January 1896 of the discovery of X-rays as well as the discovery of natural radioactivity later that same year.

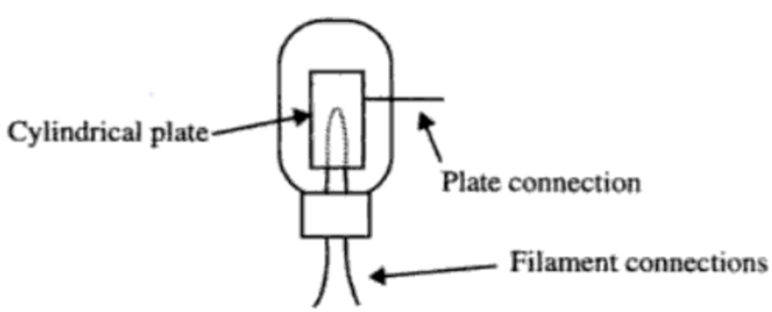


FIGURE 1.10. Fleming valve

Several years later, though, Fleming became a consultant to British Marconi and joined in the search for improved detectors. Recalling the Edison effect, he tested some bulbs, found out that they worked satisfactorily as RF rectifiers, and patented the Fleming valve (vacuum tubes are thus still known as valves in the U.K.) in 1905 (see Figure 1.10). The nearly deaf Fleming used a mirror galvanometer to provide a visual indication of the received signal and included this feature as part of his patent.

While not particularly sensitive, the Fleming valve is at least continually responsive and requires no mechanical adjustments. Various Marconi installations used them (largely out of contractual obligations), but the Fleming valve never was popular - contrary to the assertions of some histories – thanks to its high power, poor filament life, high cost, and low sensitivity when compared with well-made crystal detectors.

De Forest, meanwhile, was busy in America setting up shady wireless companies to compete with Marconi. “Soon, we believe, the suckers will begin to bite," he wrote hopefully in his journal in early 1902. And, indeed, his was soon the largest wireless company in the United States after Marconi Wireless. Never one to pass up an opportunity, de Forest proceeded to steal Fleming's diode and even managed to receive a patent for it in 1906 (#836,070, filed 19 May, granted 13 November). He simply replaced Fleming's mirror galvanometer with a headphone and then added a huge forward bias (thus reducing the sensitivity of an already insensitive detector). Conclusive evidence that de Forest had stolen Fleming's work outright came to light when historian Gerald Tyne obtained the business records of H. W. McCandless, the man who made all of de Forest 's first vacuum tubes (de Forest called them audions). The records clearly show that de Forest had asked McCandless to duplicate some Fleming valves months before he filed his patent. Hence there is no room for a charitable interpretation that de Forest independently invented the vacuum tube diode.

Dual-plate triode used by Armstrong in his regenerative receiver of 1912 (*from the Houck Collection, courtesy Michael Katzdorn*).

FIGURE 1.11. De Forest triode audion

His next achievement was legitimate and important, however. He added a zigzag wire electrode, which he called the grid, between the filament and wing (later known as the plate), and thus the triode was born (see Figure 1.11). This three-element audion was capable of amplification, but de Forest did not realize this fact until years later. In fact, his patent only mentions the triode audion as a detector, not as an amplifier. Motivation for the addition of the grid is thus still curiously unclear. He certainly did not add the grid as the consequence of careful reasoning, as some histories claim. The fact is that he added electrodes all over the place. He even tried "control electrodes" outside of the plate! We must therefore regard his addition of the grid as merely the result of quasirandom but persistent tinkering in his search for a detector to call his own. It would not be inaccurate to say that he stumbled onto the triode, and it is certainly true that others would have to explain its operation to him.

From the available evidence, neither de Forest nor anyone else thought much of the audion for a number of years (annual sales remained below 300 units until 1912). At one point, he had to relinquish interest in all of his inventions following a bankruptcy sale of his company's assets. There was just one exception: the lawyers let him keep the patent for the audion, thinking it worthless. Out of work and broke, he went to work for Fuller at Federal.

Faced with few options, de Forest - along with Federal engineers Herbert van Etten and Charles Logwood - worked to develop the audion and discovered its amplifying potential in late 1912, as did others almost simultaneously including rocket pioneer Robert Goddard. He managed to sell the device to AT&T that year as a telephone repeater amplifier, retaining the rights to wireless in the process, but initially had a tough time because of the erratic behavior of the audion. Reproducibility of device characteristics was rather poor and the tube had a limited dynamic range. It functioned well for small signals but behaved badly upon overload (the residual gas in the tube would ionize, resulting in a blue glow and a frying noise in the output signal). To top things off, the audion filaments (then made of tantalum) had a life of only about 100-200 hours. It would be a while before the vacuum tube could take over the world.

SOURCE: Lee, Thomas H. *Planar Microwave Engineering: a Practical Guide to Theory, Measurement, and Circuits*. Cambridge: Cambridge University Press, 2004.
[**https://books.google.com/books?id=cnhhBAAAQBAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false**](https://books.google.com/books?id=cnhhBAAAQBAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false)

Document 2B

Lee De Forest, the self-styled “Father of Radio” (the title of his 1950 autobiography) inventor and holder of over 300 patents, invented the triode electronic valve or ‘Audion valve’ in 1906 - a much more sensitive development of John A. Fleming’s diode valve.

The immediate application of De Forest’s triode valve was in the emerging radio technology of which De Forest was a tenacious promoter. De Forest also discovered that the valve was capable of creating audible sounds using the heterodyning or beat frequency technique: a way of creating audible sounds by combining two high frequency signals to create a composite lower frequency within audible range – a technique that was used by Leon Termen in his Theremin and Maurice Martenot in the Ondes Martenot some years later. In doing so, De Forest inadvertently invented the first true audio oscillator and paved the way for future electronic instruments and music.

In 1915 De Forest used the discovery of the heterodyning effect in an experimental instrument that he christened the ‘Audion Piano’. This instrument – based on previous experiments as early as 1907 – was the first vacuum tube instrument and established the blueprint for most future electronic instruments until the emergence of transistor technology some fifty year later.

The Audion Piano, controlled by a single keyboard manual, used a single triode valve per octave, controlled by a set of keys allowing one monophonic note to be played per octave. This audio signal could be processed by a series of capacitors and resistors to produce variable and complex timbres and the output of the instrument could be sent to a set of speakers placed around a room giving the sound a novel spatial effect. De Forest planned a later version of the instrument that would have separate valves per key allowing full polyphony - it is not known if this instrument was ever constructed.

De Forest described the Audio Piano as capable of producing:

“Sounds resembling a violin, Cello, Woodwind, muted brass and other sounds resembling nothing ever heard from an orchestra or by the human ear up to that time – of the sort now often heard in nerve racking maniacal cacophonies of a lunatic swing band. Such tones led me to dub my new instrument the ‘Squawk-a-phone’…. The Pitch of the notes is very easily regulated by changing the capacity or the inductance in the circuits, which can be easily effected by a sliding contact or simply by turning the knob of a condenser. In fact, the pitch of the notes can be changed by merely putting the finger on certain parts of the circuit. In this way very weird and beautiful effects can easily be obtained.” *(Lee De Forest’s Autobiography “The Father of Radio”)*

And From a 1915 news story on a concert held for the National Electric Light Association:

“Not only does de Forest detect with the Audion musical sounds silently sent by wireless from great distances, but he creates the music of a flute, a violin or the singing of a bird by pressing button. The tune quality and the intensity are regulated by the resistors and by induction coils…You have doubtless heard the peculiar, plaintive notes of the Hawaiian ukulele, produced by the players sliding their fingers along the strings after they have been put in vibration. Now, this same effect, which can be weirdly pleasing when skillfully made, can be obtained with the musical Audion.”

De Forest, the tireless promoter, demonstrated his electronic instrument around the New York area at public events alongside fund raising spectacles of his radio technology. These events were often criticized and ridiculed by his peers and led to a famous trial where De Forest was accused of misleading the public for his own ends:

“De Forest has said in many newspapers and over his signature that it would be possible to transmit human voice across the Atlantic before many years. Based on these absurd and deliberately misleading statements, the misguided public … has been persuaded to purchase stock in his company. “

De Forest collaborated with a skeptical Thaddeus Cahill in broadcasting early concerts of the Telharmonium using his radio transmitters (1907). Cahill’s insistence on using the telephone wire network to broadcast his electronic music was a major factor in the demise of the Telharmonium. Vacuum tube technology was to dominate electronic instrument design until the invention of transistors in the 1960’s. The Triode amplifier also freed electronic instruments from having to use the telephone system as a means of amplifying the signal.

SOURCE: “The 'Audion Piano' and Audio Oscillator. Lee De Forest. USA, 1915.” 120 Years of Electronic Music, June 17, 2016. http://120years.net/the-audion-pianolee-de-forestusa1915/

Document 2C

This invention relates to sound-generating apparatus or instruments of the type embodying an electrical vibrating system. It aims to provide a novel method of and means for producing sounds in musical tones or notes of variable pitch, volume and timbre in realistic imitation of the human voice and various known musical instruments. One object of the invention is to provide a simple and inexpensive instrument capable of producing musical tones according to the method embodying the same, the pitch, volume and timbre of which sounds may be varied over a wide range, and with delicate graduations.

An instrument embodying the invention comprises a sound reproducer, such as a telephone receiver or loud-speaker, connected to an oscillating system adapted to be controlled or affected by an object or objects, such as the hands or fingers of an operator held in relative position in proximity to an element of the system. For example, an electrical oscillating system including oscillator tubes of the electro-ionic type may be employed, and the circuits of the system may be so correlated that the frequency or frequencies of the electrical oscillations will vary in accordance with the variations in the electrical capacity or other characteristic of the controlling circuit caused by the movements of external objects, such as an operators hand or fingers as above stated. The operator's hands, or the objects moved by him are not required to make physical contact with the instrument, but if the instrument is arranged to permit such contact, the generation or production and control of the sound is not effected directly thereby as is the case with the ordinary musical instruments.

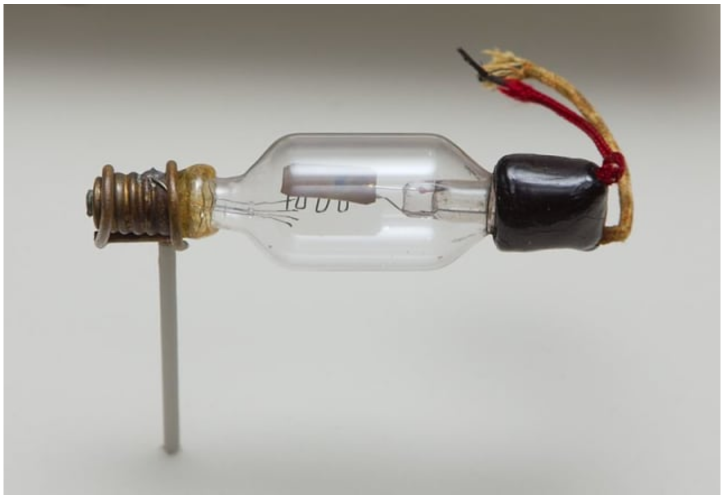
In order to generate clear sound or musical tones and permit ready control thereof, a plurality of oscillators are employed, having a frequency above the audible range but interacting with each other to produce interference or beat-notes of audible frequency. The frequency of one or more of the oscillators is controllable by the operator to produce beat-notes of the desired pitch….

The improved method and means of this invention for producing sound or musical tones possess great advantages over ordinary musical instruments of the prior art. Apart from the simplicity in construction and operation of an instrument embodying the invention, it is capable of producing clear and pure musical tones in realistic imitation of a known instrument, such as the violin for example, and may be so constructed that the characteristics of the sound or music produced thereby may be changed as desired in imitation of various other instruments, whereas the ordinary musical instrument, such as the violin, produces sound tones of fixed and well-known characteristics. The instrument is not limited, however, to the production of music but may be employed to generate Sounds or operate signals for various purposes.

…Various practical embodiments of the invention are herein after described in order to make a full and complete disclosure, but the invention obviously is not limited to the specific arrangements shown and it is to be understood that no limitations thereon are intended beyond those set forth in the appended claims….

SOURCE: “US1661058A - Method of and Apparatus for the Generation of Sounds.” Google Patents. Google, n.d. https://patents.google.com/patent/US1661058A/en

Document 2D



The original triode vacuum tube, the Audion, invented by Lee de Forest in 1906. (Image courtesy of Gregory F. Maxwell.)

In any modern-day electrical device—from alarm clocks to phones to computers to televisions—you'll find a device called a transistor. In fact, you'll find billions of them. Transistors are the atoms of modern-day computing, combining to create the logic gates that enable computation. The invention of the transistor in 1947 opened the door to the information age as we know it.

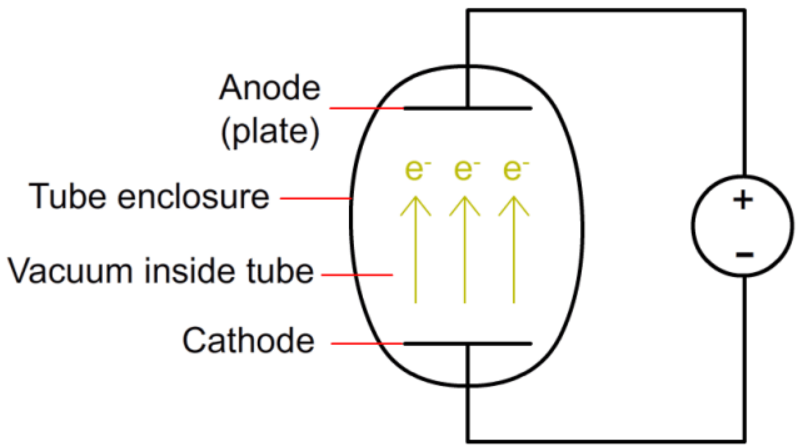
But computers existed before transistors did, albeit in a rather rudimentary form. These massive systems took up entire rooms, weighed thousands of pounds, and for all that, were nowhere near as powerful as the computers that we can fit in our pockets today.

Rather than being built out of transistors, these behemoth computers were made up of something called thermionic valves, aka vacuum tubes. These lightbulb-looking devices are now more or less obsolete (with one or two notable exceptions), but in their heyday, they were critical to the design of many electronic systems, from radios to telephones to computers. In this article, we'll take a look at how vacuum tubes work, why they went away, and why they didn't go away entirely.

Thermionic Emission

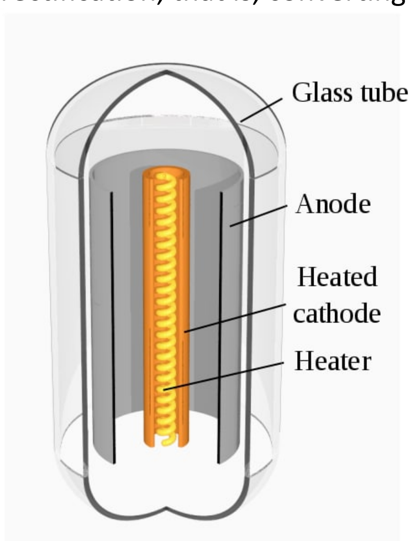
The basic working principle of a vacuum tube is a phenomenon called thermionic emission. It works like this: you heat up a metal, and the thermal energy knocks some electrons loose. In 1904, English physicist John Ambrose Fleming took advantage of this effect to create the first vacuum tube device, which he called an oscillation valve.

Fleming's device consisted of two electrodes, a cathode and an anode, placed on either end of an encapsulated glass tube. When the cathode is heated, it gives off electrons via thermionic emission. Then, by applying a positive voltage to the anode (also called the plate), these electrons are attracted to the plate and can flow across the gap. By removing the air from the tube to create a vacuum, the electrons have a clear path from the anode to the cathode, and a current is created.



A simplified diagram of a vacuum tube diode. When the cathode is heated, and a positive voltage is applied to the anode, electrons can flow from the cathode to the anode. Note: A separate power source (not shown) is required to heat the cathode.

This type of vacuum tube, consisting of only two electrodes, is called a diode. The term diode is still used today to refer to an electrical component that only allows an electric current to flow in one direction, although today these devices are all semiconductor based. In the case of the vacuum tube diode, a current can only flow from the anode to the cathode (though the electrons flow from the cathode to the anode, recall that the direction of conventional current is opposite to the actual movement of electrons—an annoying holdover from electrical engineering history). Diodes are commonly used for rectification, that is, converting from an alternating current (AC) to a direct current (DC).

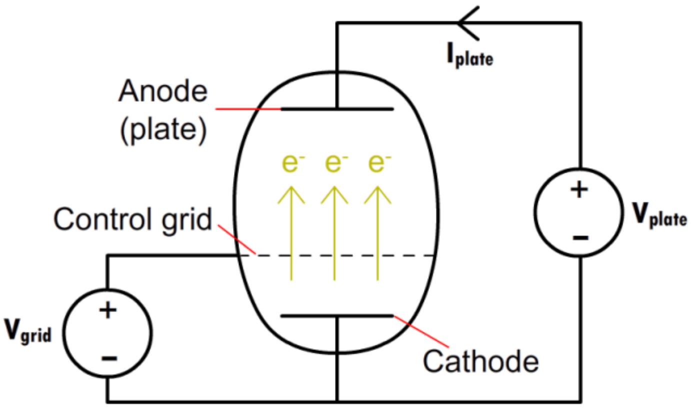


A more realistic representation of a vacuum tube diode. The electrodes are arranged as concentric cylinders within the tube, maximizing the surface area for electrons. Here, the cathode is heated by a separate heating filament, labeled Heater. (Image courtesy of Wikipedia user Svjo.)

Third Electrode's the Charm

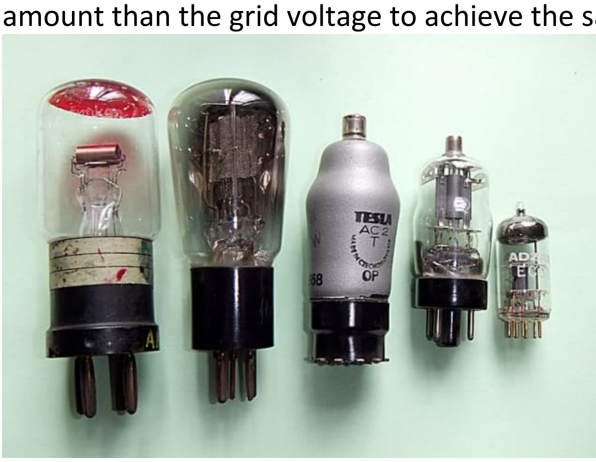
While diodes are quite a handy device to have around, they did not set the limit for vacuum tube functionality. In 1907, American inventor Lee de Forest added a third electrode to the mix, creating the first triode tube. This third electrode, called the control grid, enabled the vacuum tube to be used not just as a rectifier, but as an amplifier of electrical signals.

The control grid is placed between the cathode and anode, and is in the shape of a mesh (the holes allow electrons to pass through it). By adjusting the voltage applied to the grid, you can control the number of electrons flowing from the cathode to the anode. If the grid is given a strong negative voltage, it repels the electrons from the cathode and chokes the flow of current. The more you increase the grid voltage, the more electrons can pass through it, and the higher your current. In this way, the triode can serve as an on/off switch for an electrical current, as well as a signal amplifier.



A simplified diagram of a vacuum tube triode. A minute adjustment to the grid voltage has a comparatively large effect on the plate current, allowing the triode to be used for amplification.

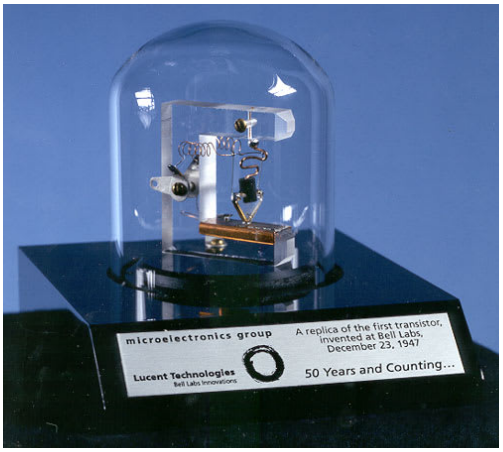
The triode is useful for amplifying signals because a small change in the control grid voltage leads to a large change in the plate current. In this way, a small signal at the grid (like a radio wave) can be converted into a much larger signal, with the same exact waveform, at the plate. Note that you could also increase the plate current by increasing the plate voltage, but you'd have to change it by a greater amount than the grid voltage to achieve the same amplification of current.



The evolution of triode vacuum tubes from a 1916 model (left) to one from the 1960s. (Image courtesy of Wikipedia user RJB1.)

But why stop at three electrodes when you could have four? Or five, for that matter? Further enhancements of vacuum tubes placed an additional grid (called the screen grid) and yet another (called the suppressor grid) even closer to the anode, creating a type of vacuum tube called a tetrode and a pentode, respectively. These extra grids solve some stability problems and address other limitations with the triode design, but the function remains largely the same.

The Transistor Is Born, but the Tube Lives On



A replica of the first transistor created in 1947.

In 1947, the trio of physicists William Shockley, Walter Brattain and John Bardeen created the world's first transistor, and marked the beginning of the end for the vacuum tube. The transistor could replicate all the functions of tubes, like switching and amplification, but was made out of semiconductor materials.

Once the transistor cat was let out of the bag, vacuum tubes were on their way to extinction in all but the most specific of applications. Transistors are much more durable (vacuum tubes, like light bulbs, will eventually need to be replaced), much smaller (imagine fitting 2 billion tubes inside an iPhone), and require much less voltage than tubes in order to function (for one thing, transistors don't have a filament that needs heating).

Despite the emergence of the transistor, vacuum tubes aren't completely extinct, and they remain useful in a handful of niche applications. For example, vacuum tubes are still used in high power RF transmitters, as they can generate more power than modern semiconductor equivalents. For this reason, you'll find vacuum tubes in particle accelerators, MRI scanners, and even microwave ovens.

But perhaps the most charming modern application of vacuum tubes is in the musical community. Audiophiles swear by the quality of vacuum tube amplifiers, preferring their sound to semiconductor amps, and many professional musicians won't consider using anything in their place. Whether there's any merit to this preference is a matter of some debate, but you can dive more into the fascinating world of tube sound in this thorough IEEE Spectrum article.

Vacuum tubes had their day, and now the world is powered by transistors. But what does the future hold for electronics? With Moore's Law reaching its limits, and quantum computing looming tantalizingly on the horizon, it's anybody's guess where the wave of technological advancement will bring us next.

SOURCE: Alba, Michael. "Vacuum Tubes: The World Before Transistors." Engineering.com, n.d. https://www.engineering.com/ElectronicsDesign/ElectronicsDesignArticles/ArticleID/16337/Vacuum-Tubes-The-World-Before-Transistors.aspx

Document 3A

In 1957 a 30-year-old engineer named Max Mathews got an I.B.M. 704 mainframe computer at the Bell Telephone Laboratories in Murray Hill, N. J., to generate 17 seconds of music, then recorded the result for posterity. While not the first person to make sound with a computer, Max was the first one to do so with a replicable combination of hardware and software that allowed the user to specify what tones he wanted to hear. This piece of music, called "The Silver Scale" and composed by a colleague at Bell Labs named Newman Guttman, was never intended to be a masterpiece. It was a proof-of-concept, and it laid the groundwork for a revolutionary advancement in music, the reverberations of which are felt everywhere today.

When Max died in April at the age of 84 he left a world where the idea that computers make sound is noncontroversial; even banal. In 2011, musicians make their recordings using digital audio workstations, and perform with synthesizers, drum machines and laptop computers. As listeners, we tune in to digital broadcasts from satellite radio or the Internet, and as consumers, we download small digital files of music and experience them on portable music players that are, in essence, small computers. Sound recording, developed as a practical invention by Edison in the 1870s, was a technological revolution that forever transformed our relationship to music….

In comparison, the contributions of Max Mathews may seem inevitable. Just as so much of our life has become "digitized," so it seems that sooner or later, sound would become the domain of computers. But the way in which Max opened up this world of possibilities makes him a singular genius, without whom I, and many people over the last six decades, would have led very different lives.

As an engineer, Max had extremely diverse interests, all of which he pursued with a great deal of energy. He provided the initial research for virtually every aspect of computer music, from his early work with programming languages for synthesis and composition (the MUSIC-N family of software) to foundational research in real-time performance (the GROOVE system and RTSKED, the first real-time event scheduler). Max also helped start the conversation about how humans were meant to interact with computers by developing everything from modified violins to idiosyncratic control systems such as the Radio Baton. Marvin Minsky, a pioneer in the field of artificial intelligence and one of Max's peers, said that Max "wrote the first beautiful examples of how to do things and then he moved on to something else," leaving it to colleagues, students and other creative minds to pick up where he left off. Along the way, his fluency in human cognition, acoustics, computer science and electrical engineering allowed him to always keep in mind the big picture: that computers were meant to empower humans to make music, not the other way around.

Back in 1957, none of these ideas were self-evident. Rebecca Fiebrink, an assistant professor of computer science at Princeton University, says of Max: "Max had this vision of the computer as being something that is creatively empowering to people, even in the 1950s, when the words 'empower' and 'creativity' were not part of the vocabulary."

Max's early experiments with sound and the digital computer were made possible by a fortunate combination of factors, including a community of supportive colleagues led by his supervisor, John R. Pierce. Bell Labs, for whom he worked as an engineer, had a vested interest in Max's research: as the practical demands of telecommunications in the United States broadened after the Second World War, a melding of analog telephony and digital computing was inevitable. Max's initial mandate was to research the problem of getting computers to listen and speak. The fact that he interpreted his research agenda in the broadest possible terms, giving us not Moviefone, but music, is amusingly subversive; the fact that he got away with it, was encouraged to keep going, and created an entire world of possibility along the way, is astounding.

Max's research was first published for a wider audience in an article, titled "The Digital Computer as a Musical Instrument" in the November 1963 issue of Science. He explained the language he created to work with sound digitally, wherein the user creates two sets of instructions. The first, an "instrument," defines what the sound should be, in terms of waveforms, amplitude curves, filters and how these components should be connected to one another. The second set of instructions, the "score," contain the musical notes, rhythms and durations with which the instrument will sound. This simple conceptual distinction between the instrument and the actions it performs to make music is still the norm today.

This article prompted two other computer music pioneers, John Chowning and Jean-Claude Risset, among others, to come to Bell Labs to work with Max. They found themselves in a community made up of a seemingly peculiar pairing of Bell Labs scientists and avantgarde musicians. Risset, finishing his doctorate in Paris, came to Bell Labs and began working with Max on new possibilities for synthesizing the timbre of existing instruments.

"Max was very generous about sharing," Risset recalled. "At that time, Bell Labs was almost a public service. They had the feeling that there was a commitment and duty to make the research available to the general public, including artists, in terms of new possibilities. In fact, they felt the artists were also doing research, so that science and technology could both benefit."

Chowning, in his second year as a graduate student in composition at Stanford, was experimenting with electronic sound and multiple loudspeakers. He recalled Max's Science article well: "I had never seen a computer, so when I read this article and realized what this meant, it defined the possibilities of music in a wholly new way. So I decided to investigate. The first thing I did was to take a programming course, and convince myself that as a musician that I could learn to program. I then contacted Max."

Speech (and speech synthesis) was of particular interest to what was rapidly becoming Max's lab, and he and his colleagues John Kelly, Jr., who would go on to propose the Kelly criterion in economic investment theory, and Carol Lockbaum used the I.B.M. to generate perhaps the ultimate cover song. If "The Silver Scale" was a proof-of-concept, the 1961 speech synthesis rendering of "Bicycle Built for Two" is a tour-de-force of the new digital musicality possible with computer programming. In the man-versus-machine standoff in Stanley Kubrick's 1968 film "2001: A Space Odyssey," Douglas Rain's HAL 9000 begins to sing the tune wistfully as astronaut David Bowman disengages its memory, regressing the homicidal machine back to its infancy as it fondly remembers a Mr. Langley, who taught it to sing a song.

By the early 1970s, Max's lab at Bell, the Acoustic and Behavioral Research Center, was doing research in literally every possible aspect of sound in which a computer could provide assistance, all under the auspices of a company ostensibly committed to the comparatively modest goal of providing Americans with better telephone service. He was also becoming increasingly engaged in getting computers into the act of performance, something that was only just becoming possible. His first foray into the problem was a project he called GROOVE, a hybrid project wherein a computer controlled a large analog modular synthesizer.

Laurie Spiegel, a composer who at the time had been working with analog synthesizers, met Max through Rhys Chatham, who programmed a performance by Max and Emmanuel Ghent for a music series at the Mercer Arts Center, a venue that would evolve into the Chelsea arts space many of my friends and I perform in today.

Spiegel, excited by the possibilities of the GROOVE system, asked Max if she could join him in his endeavors at Bell Labs: “Being a woman with no technological credentials at the time, I doubt I would have been granted access to then-scarce powerful computer systems in any other lab. But Max didn’t go by credentials or background or identity. He took every instance in as its unique self, responding to each thing on its own terms.”

A life-long violinist, Max also began experimenting with electric instruments using custom circuitry. He created a series of twelve electric violins containing custom circuitry. Laurie Anderson recalls receiving one to work with, beginning a 30-year friendship with Max: “He gave me a violin that I used for a while. The violin itself was really beautiful. The way he talked about strings was amazing. Like everyone, I lost touch with him and got back in touch with him all the time. But no matter what, as soon as I would see him again we were right in the middle of the conversation. Max was one of those friends.”

“The Sequential Drum,” an article Max published with Curtis Abbott in 1980, saw Max’s research taking a new, significant turn, as he began to outline the idea of an intelligent musical instrument, leveraging the power of the computer to generate sound and assist in musical performance. This work involved not only a computer program but also a physical device that enabled a performer to control the timing of a musical sequence stored on a computer by beating a “drum” (in actuality an electrical trigger). Three years later, Max published an article in the Journal of the Acoustical Society of America titled “RTSKED: a real-time scheduled language for controlling a music synthesizer.” In the article, Max explains a basic system for getting a computer to schedule musical events in real time, either on its own or in response to commands from a live performer. This system, which outlined a simple, efficient mechanism for human-computer interactivity, started an avalanche of innovation in computers that could finally perform alongside us.

I was 8 years old when Max described RTSKED. Nearly every day for the last 15 years, I’ve opened up my computer and double-clicked an icon to launch a program called Max. Max the program, named after Max the man, was developed in the late 1980s by Miller Puckette, an American computer scientist working at IRCAM, the Institute for the Research and Coordination of Acoustics and Music in Paris. Influenced by Max’s research thus far, the program allows for the creation of a visual graph, or “patcher,” representing a process that can generate and respond to sounds, images or any other input and output one can imagine to the computer. Puckette first heard Max speak at an International Computer Music Conference in the early 1980s presenting RTSKED: “I didn’t actually talk to him, but the thing I noticed was, unlike all the other speakers who got up, when Max showed up at the lectern the entire audience gave him a standing ovation before they allowed him to say a word. I was 22 at the time, so I paid some attention to what he said after that, and it was a good thing I did, because I trace a large part of what I did in Max to RTSKED.”

Nearly a quarter-century old, Max, the software, is currently developed by a software company in San Francisco called Cycling’74, founded by David Zicarelli. Zicarelli met Max, the person, as a graduate student at Stanford University’s Center for Computer Research in Music and Acoustics (CCRMA), where Max began teaching upon retiring from Bell Labs in 1987: “He had this way of characterizing it, which is that pitch is not expressive, in comparison to rhythm and other aspects of performance. If you store the pitches and let people focus their performance expressivity on rhythm and legato and that kind of thing, you don't have to worry about staying in tune, or playing the wrong note at the wrong time, and you can actually be really musical. He saw this drum both as an interesting sensor technology, but also as an egalitarian musical vision. That this is a way to open up music performance to a wide audience." If you've ever played Guitar Hero, or Rock Band, you've experienced making music through the legacy of Max's ideas about democratizing musical performance.

Throughout the 1980s and 1990s Max continued his research in expressivity in computer music performance, embarking on research that would culminate in the Radio Baton, a musical controller that allowed for the three-dimensional control of sonic parameters, and Scanned Synthesis, a paradigm for computer sound generation. The Radio Baton, which provided the missing link between the Theremin and the Nintendo Wii game controller, allows for smooth, expressive control of multiple musical parameters without being tied to such things as musical keyboards, faders and buttons.

In the 2000's, Max began having breakfast every Thursday with a group of electronic and computer music pioneers from both academia and the commercial music industry. Max attended the group's meetings religiously.

Up until the end of his life, Max continued to work on innumerable projects with computation and music. Richard Boulanger, who worked with Max extensively on the Radio Baton, tells me: "Even to the last days of his incredibly full life, he was learning, teaching, writing, coding, performing, and even now 'remixing' his classics."

I met Max a handful of times, and sat across from him once in graduate school at one of those interminable dinners academics like to have at conferences. He was warm, funny, and had the grace not to let on to the kid at the table that he was the smartest man in the room. Bell Labs was several decades and many miles away, described in hindsight, and with certain nostalgia, as a magical place where artists and engineers were one and the same. We don't really have those places anymore, which is a shame. Our new century, this century of data, is built on work done by the unassuming geniuses like Max who worked in the liminal spaces between science and art. On the telephone from Paris on Easter Sunday, Risset told me "in America, the phone company is very important." It made me laugh, but he was right.

In February of 1972 Max wrote a short story and sent it to a few friends and colleagues, including Vladimir Ussachevsky, then director of the Columbia-Princeton Electronic Music Center. I found it in Max's file in the Columbia archives, with a cover letter that reads "Attached is the result of a momentary madness which you might enjoy." The story, set in 2165, concerns an astronaut wielding a 1704 Stradivarius violin, who returns after nearly two hundred years in hibernation to a planet Earth in which music is very different than it was when he left. On the one hand, there is a monastic society of musicians clad in the formal tails of concert soloists, virtuosi who perform canonized music for "perfect" digital recordings controlled by special stewards within their order. On the other hand, there are participatory mass-improvisations mediated by computers, called "Audances," where players interface with digital machines creating work using all manner of joysticks, knobs and TV screens, all happening inside a specially built room, with no audience and no possibility for error. The story's protagonist reminisces, in his last will and testament, on the world he left behind, where music was a physical act as well as a social one, involving physical instruments performed from the stage.

I didn't know Max well enough to be certain, but I suspect that these two scenarios were his bêtes noires, worlds where music ceased to be live, immediate and accessible. As the potential for making music by computer grew, Max saw the oncoming ubiquity of the digital world, and he embraced it, fostering a spirit of inquiry, openness and experimentation among his colleagues and students. At the same time, it was vitally important to him that we, the musicians of the computer age, understood the computer for what it was: an instrument for enabling our creative acts, not replacing them.

The history of music is the history of technology. Unless you are improvising, acapella outdoors with your own singing voice, you are making music with technology, be it the technology of writing, architecture, instrument design, electric amplification, electronic reproduction, or digital synthesis. Musicians intuit this, and can easily weather massive shifts in how we relate to new technologies in the human experience because we integrate our future seamlessly with our past. We understand that every human culture will use the maximum level of technology available to it to make art. It's natural, and everything Max gave us flows from that, because he understood. He was a musician, too.

For Max V. Mathews, the computer was the Stradivarius of the 20th Century.

He was our first virtuoso.

SOURCE: Dubois, R. Luke. "The First Computer Musician." The New York Times. The New York Times, June 9, 2011. https://opinionator.blogs.nytimes.com/2011/06/08/the-first-computer-musician/

Document 3B

Mister-X will never forget the day he became a mod tracker. It happened shortly after his brother first showed him “Scream Tracker” — a music-making program created by the legendary Finnish “demo group” Future Crew.

“It was love at first sight,” says Mister-X, who now operates a major Website devoted to mod tracking. “I knew that computers could be used to create music, but I had no idea that they could create this level of quality. I had been using computers like the TI 99/4A, and the Tandy 1000EX, and was used to the ‘dinkety-dink’ type of music that these computers produced.”

Goodbye to dinkety-dink. After becoming a mod tracker, Mister-X could use his personal computer to create music with sophisticated production values, without having to invest in expensive musical equipment or recording hardware. All he needed was a PC with a sound card and a few shareware or freeware software programs.

A tracker is a program that allows would-be composers to create mod files. The word “mod” is short for “module” — a digital music file constructed out of samples, along with the encoding information that determines how those samples sound (pitch, tone, special effects). The samples can be taken from anything — from a snare drum to an answering machine message. They can even be “ripped” right from a commercial CD or from an already existing mod, although tracker veterans generally frown on such practices. Unlike the MP3 scene, tracking is focused primarily on creating original music, rather than the distribution of already recorded music.

Straddled right across the intersection of the art of music composition and the science of computer programming, mod tracking is hailed by its small but thriving band of practitioners as the digital embodiment of the idea of accessibility. Free to all comers, facilitated by the growth of the Internet, mod tracking offers a gateway into the world of professional-quality music production that anyone can pass through. And even though mod tracking is no magic wand — it won’t automatically transform musical dunces into sublime songwriters — it does remove key obstacles along the road to self-expression.

“The thing that scares many people off from becoming musicians is the economics of being a modern musician,” says Dan Nicholson, aka “Maelcum,” the founder of the tracker group Kosmic Free Music Foundation: “$1,000 for a keyboard, $5,000 in samplers and synth modules! It’s a shame – who knows, the [next] Beethoven, John Lennon or Orbital might be out there, and we may never get to hear their great music. Tracking breaks down this barrier — I got started on a hand-me-down PC, and current software runs just fine on a $300-400 non-state of the art PC. It gives anyone the tools they need to make great music, and it’s practically free.”

But the tools aren’t just those that remove financial barriers. By allowing composers to “see the music” — to take apart a module and understand exactly how a particular sound is created — mod tracking puts the techniques behind creativity into plain view. The age of the hacker musician is at hand.

“The ability to see the music, to know how an author succeeded in creating this and that sound,” says tracker Jesper Petersen, “is how we learn stuff in the end. There is a great portion of trackers that have no musical background whatsoever and that still do amazing stuff when they’re put in charge of a tracker. Of course talent plays a huge role, but it is also very much a simple matter of watching and learning. And being persistent as hell — no one makes a decent first track; we all suck to start out with."

"A typical talented 15-year-old can now explode his imagination into a song, and not waste his time in front of a TV observing an input others have control over," says Michael Lazarev, aka "Kosmos," the founder of the tracking clearinghouse United Trackers. "I heard a track written by a 13-year-old once, and it was a hundred times better then the garbage they play on the radio. The scene is great. No one has to know anyone to be in it. No one needs connections, and no strings need to be pulled. You want to make your music, and have the world hear it? You got it! Need support? You got it! No money? No problem! … It's all about love for music, and not its commercial aspect."

Tracking is an evolutionary outgrowth of the once-thriving Commodore Amiga "demo scene." In the late '80s and very early '90s, the superior sound and graphics production qualities of the Amiga computer encouraged the growth of an underground subculture devoted to the creation of "demos" – homegrown 3D graphics productions that emphasized clever coding. The Amiga was one of the first computers with digital audio capability, and the first tracking programs allowed Amiga users to sequence samples on the Amiga's four digital audio channels.

During the early '90s, most demo scene activity occurred in Europe. But the death of the Amiga, the emergence of more powerful personal computers and, most importantly, the explosion of the Internet spread mod tracking around the world. The Internet, with its native ability to connect like-minded people, has long been a friend to subcultures of all kinds. But when the subculture is one built around digital software, the Net's influence is especially dramatic. Most observers and veterans of the tracker scene say the number of people creating and listening to mods has surged dramatically over the past few years.

Future Crew may have disbanded, and Scream Tracker may have given way to newer, more powerful tracking tools — such as FastTracker II and Impulse Tracker — but most trackers assert that the scene is still suffused with the same sense of joyful creativity that the early demo scenesters exhibited as their calling card. Fueling that creativity is the potent merging of two sensibilities: the desire to become a musician and the passion to fiddle with something that looks a lot like code.

In one sense, a mod is the code for a musical composition, as well as the composition itself. It's as if a pop song you might hear on the radio came in a package that included its sheet music and guitar tablature.

"[A tracked] piece is not a recording," says Gene Hsi Wie, an undergraduate computer science student at the University of California at Irvine, and a longtime chronicler of the tracker scene in the now extinct zine TraxWeekly. "Rather it is like the 'code' for a piece that is interpreted by a player for output. When listening to a tracked piece, many players have a display that shows the parsing of the piece line by line, vertically by track, showing the progression of the piece as the line-by-line reader translates the numbers and effects into notes and music."

Some trackers argue that the coding analogy is overdone. Andrew Sega, a now-retired tracking star (under the nom de tracker plume of "Necros"), says it's not as if trackers need to know how to hack C++.

“In a tracker you manipulate the sequenced data in a very basic form — you specify exactly when notes will trigger, what ‘effects’ will be applied, etc.,” says Sega. “It is however a bit of a myth that tracking is like ‘coding’ per se. Most current trackers force you to work in the raw data format of the .MOD. You’ll enter a sequence of data such as this: ‘C-4 05040 D0F,’ which sounds very complicated and technical until you know what it actually is: Play a middle C, with instrument number 5, at full volume, and ramp the volume down quickly after it’s played. It’s more a problem of most trackers not having good user interfaces. However for the little ‘hacker musician’ kids, it’s perfect.”

Sega provides a perfect example of how tracking technology can help bootstrap a tracker up onto bigger and better things. He describes himself as someone who “didn’t have the big professional tools and opportunity to express themselves musically. [But] if used correctly, you can coax a tracker into producing some very professional-sounding output, comparable to stuff that you would hear on CD.”

After making a name for himself in the tracking world, Sega started producing music for computer games, most recently as part of the team that created the music for Unreal, the first-person shooter computer game.

“Tracking, at least for a while, was a very attractive way to get high-quality music into computer games,” says Sega, who now works as a 3D-graphics programmer for Digital Anvil. “It used far less memory than the typical CD-audio soundtrack, sounded better than MIDI, and allowed simple interactivity — by changing patterns around. This may no longer be the case, now that fast MP3 decoders exist, but it did serve to link the tracking and computer game worlds.”

Whether or not tracking requires programming chops, some trackers still see an affinity between the “seeing the music” aspect of tracking and the code accessibility of open-source software.

Says Steve Gilmore, a tracker and the most recent maintainer of the alt.binaries.sounds.mods frequently asked questions file: “When I look around today it absolutely defies the imagination how big it’s grown, while still maintaining a lot of the original ethos — i.e., free music, free software, free advice. I think it’s a close cousin of the Linux scene. The parallels are striking.”

“The ‘open source’ analogy is pretty much on the money,” says Sega. “You get to see exactly how the song was put together: what samples were used, how they were played, what instruments worked together to create certain sections. One would think that this would lead to a rash of ‘imitation’ music — where people change out a few notes or samples here and there, and redistribute it as their own — but that really hasn’t happened. The scene very much frowns on rippers, copycats and the like. I’ve learned a lot about how certain styles of music work by looking at other people’s tracked work.”

Is Sega the musician of tomorrow? Dan Nicholson says that the emergence of what he calls “zero equipment musicians” — people who do all their musical composition on the computer — is a sign that the electronic music business now has a level playing field.

“There are people at the top of the industry doing almost everything in the PC or Mac,” says Nicholson. “The radical thing is that unlike the garage band vs. ‘big producer in a loaded studio’ concept, these people all have access to virtually the same tools when it’s all software.”

In that sense, the growth of the PC into a truly powerful audio platform is having the same effect on music production that it has already had on the graphics business — it's eliminating the advantage held by people who have access to top-of-the-line equipment. Ultimately, however, there's one advantage that tracking can't eliminate, and that's the upper hand held by people who have actual talent — however one measures it.

"Newer software has made it a lot easier to get a better-sounding result," says Jeffrey Lim, the author of the popular Impulse Tracker program. "But in the end, it is the composer that will make the difference."

"This is not the market for people who own a toy such as a Roland MC-303 Groovebox," says Lazarev. "Nothing is pre-programmed for you. You can't select a stored arpeggio and simply sit there and tweak the knobs, thinking that you're producing music. This is actual composing. And everything has to come from within you."

But if you've got it, tracking allows you to flaunt it, more easily than ever before.

"One of the greatest things about tracking is that it gives people with little or no music training the ability to output decent-sounding tunes," says Gene Hsi Wie. "The world is filled with people who probably will never realize the incredible symphonies that they hear in their heads because … the complex theories surrounding music notation and harmonic structure are not in their educational background. Tracking lets us 'compose by ear' and produces instant results, letting us know if a particular idea sounds good or bad to our own personal standards."

Does every one of us have an incredible symphony, all our own, reverberating inside our heads? Perhaps — perhaps not. But for anyone who does, and wants to bring that music forth into the world, the tools are out there.

SOURCE: Leonard, Andrew. "Mod Love." Saloncom RSS, April 29, 1999.
https://web.archive.org/web/20121025040018/http:/www.salon.com/1999/04/29/mod_trackers/

Document 3C

Few producers within dance music have made a greater impact than Juan Atkins. A funk musician from an early age, Atkins' life changed when he discovered synthesizers and electronic music. He began making his own electronic demos, joining forces with college classmate Rik Davis to found electro outfit Cybotron in 1981.

It was when Atkins began making solo records under the Model 500 alias in 1985 that a new style of music, later dubbed techno, started to take shape. Alongside the other two members of the "Belleville Three" – friends Derrick May and Kevin Saunderson – Atkins laid down the blueprint for techno, coming up with the name for the style in 1988. Initially, his records were largely ignored in the Motor City, instead becoming popular in Chicago and Europe.

Back in 2010, Atkins sat down with DJ History's Ben Ferguson to discuss his journey in music, from playing bass in garage funk bands as a 13-year-old, to techno taking the UK by storm at the tail end of the 1980s.

You moved to Belleville when your parents split. What was suburbia like?
We were about to move to California but then my father's ma, my grandmother, called us at the last minute and said, "They're building a new house down the road from me." She talked him into it. It was very, very different from inner city life. We lived in Detroit before that.

How old were you?
Like 14 or 15.

Were you already listening to music?
Yeah. I'd always listened to music. In Detroit I was playing in funk bands, garage bands with friends of mine off the street and around the block. I played bass guitar and some lead guitar. This was when I was 12 or 13….

Did you carry on playing funk?
Yeah. Well, that was the era. It was the funk era – and a little disco. But then funk became disco, then disco became new wave, then new wave and disco became house and techno.

But techno didn't just happen. You moved to Belleville with your Dad who was a concert promoter, right?
Yeah, he'd run people like Norman Connors, Michael Henderson, Barry White; he did a big Barry White show down at Cobo Hall….

But the shows must have been good.
Yeah, I remember Michael Henderson particularly because I liked the "Wide Receiver." That was a big track for me in high school, so it was memorable for that one track.

Did you ever consider stardom of this sort?
You know, we were just having fun, we didn't think about stardom or being famous. We were just kids doing what we liked to do…. When you pick up an instrument, there's a bit of you that definitely dreams of being a superstar. That goes without saying. We wouldn't get around in a group discussion and say,

"Hey, let's try to be superstars." It was just something that was an unspoken rule. Unspoken rule to be famous basically, like how nobody is allowed to admit that they want to make money. We didn't think about stardom or being famous. We didn't have aspirations.

Well, not everybody. Your brother was living with you as well. By the sound of it, he made a big impression on Derrick May, especially the day when he rolled up in his Cadillac with Parliament pumping out of the speakers.
[Laughs] Well, my brother was a year younger than me. He and Derrick were in the same class because Derrick is a year younger than me too. He would prowl around with my brother before we became friends.

How was your relationship with him?
He's my younger brother. I love him, we're one of the same. But the funny thing is back then I'd hang out with an older crowd. We didn't hang out with the same sort of people….

But it wasn't long before you put down the bass and picked up the synth.
When I moved to Belleville I started playing the keyboard. My grandmother owned an organ, this hammered old B3 thing. She'd go into the music shop Brunel's for this organ. And right at this time they'd introduced the MiniKorg-700S and the Korg MS10. These were small, smart, monophonic synthesizers. I'd go into the back room and play these synthesizers and eventually I was able to talk her into buying me one. And the rest was kinda history. I was so wrapped up in this sound and with playing around with these synthesizers. I made drum sounds, drum kicks, everything all on this one synthesizer. That's how I started doing my demos and my electronic music demos. By the time I got to college I had full-blown demos that I played for classmates.

How old were you then?
Around 15 or 16….

One difference between playing in bands and using a synth is that music could be made alone. All you needed was your bedroom, yourself and the machine.
Yeah. Well the thing is, being in Belleville the next person I could play with was ten miles away. You know it was hard for me to get together with other musicians. I was very innovative when I was young.

So were there lots of guys just playing around in their bedrooms, trying to make stuff alone?
No, there weren't too many other people doing that. I was very innovative when I was young.

And did you know this back then?
Pretty much. I more or less knew I was doing stuff that was not the normal thing to do….

What did you think?
It was great. All the pretty girls were there.

Did you find out about music from there as well?
Well I grew up with funk on the radio where Electrifying Mojo was playing a lot of stuff that influenced my early years. Sometimes I'd just go in the record store and buy stuff based on what the album looked like.

Electrifying Mojo inspired a lot of people. What made him different?
He owned his own show, he was in control of whatever he wanted to play. He didn't have a format imposed on him by the program director. He was an individual, a personality – and quite a personality he was. He played a huge variety of music and exposed a people in Detroit to a lot of different things that they probably wouldn't have otherwise heard.

Like what?
He would play half an hour of James Brown, play half an hour of Jimi Hendrix and then turn around and play half an hour of Peter Frampton. He also played a lot of Parliament and Funkadelic. You name it. He brought Prince here. First place I heard Kraftwerk. Believe it or not, he'd play America "A Horse With No Name." Yeah [laughs]. He'd play "A Horse With No Name." Stuff like that.

Where did his style come from?
Mojo was in Vietnam or something. Mojo was on the radio in Vietnam and, when you asked him, he'd say that's where he got his eclectic format. He had to play a variety of stuff to the soldiers in Vietnam. I can't remember what city he was in, but it had something to do with that. In fact, he was in the Philippines. It must have been playing to all soldiers where he got his strong love of Hendrix, Frampton and America.

Another guy who's famously a Vietnam vet is Rik Davis. How did you meet him?
I met him in my first year at community college in one of my music courses. I brought my electronic demos to school and when I played them to my students, everybody wanted to hook up with me because they were so different. They were so wild. Rik wanted to hook up with me and play music because he was an electronic musician like myself….

Was there something that made you click with one another?
I'm sure there was. There must have been for us to come together and put Cybotron together, but what that thing was I can't quite put my finger on. There was definitely something. I was a kid though – 17. He was like a father figure to me. He taught me a lot. We didn't have so much in common. I was in awe of him. My father was in jail at the time.

Cybotron was an early drop in the techno ocean that sent waves throughout Europe, Canada and Russia. It has been picked up by so many white kids that some people talk about techno as white music. Did you and Rik ever talk about race in relation to your music?
No. Why would we talk about race? We talked about music and race didn't come into it. I mean, we knew we were black, and we were in America. There was nothing to talk about – those were our circumstances. We had a white guy in the band [called Jon-5], in fact. He played guitar, controlling the synth with his guitar. But if you listen to records like "The Line," "Industrial Lies" and "Enter," all of that guitar work was Jon-5. A lot of my core persuasion was funk music. That could be considered to be black music but we never said, "Hey, we're making black music." We were making electronic music.

But how did you feel about "Clear" spending nine weeks on the black music chart?
OK, well, we knew we weren't making rock & roll. We were playing in someone's church and it wasn't rock & roll.

I guess that's where you and Rik went your separate ways, when he wanted to take it in a rock & roll direction?

I think that that was where his mind was. He was heavily influenced by Jimi Hendrix. You could call him Jimi Hendrix on the synthesizer. I think that was where he wanted to be, in that album-orientated rock [scene].

Meanwhile you had these bubbling aspirations for Metroplex.
Yeah. I started Metroplex in order to release my sound. It was a continuation of the more funk and bass heavy electro tracks.

You knew you were going to do that from a young age?
Yeah.

Did Cybotron help you realize Metroplex?
For sure.

Hopping back a little bit, I think it's worth talking about your relationship with Derrick May.
OK, well, he came to live with us after high school, after "Alleys Of Your Mind" and "Cosmic Cars." Right around that time Derrick was very instrumental in helping me promote the records. I was living in Detroit with my grandmother and Derrick was living with us there.

Tell me how Deep Space came about.
It was the label that Rik and I released Cybotron on, but then Derrick and I took the name and it became the sound company that we did parties under. It worked well for me and Derrick….

Did you play your own music?
Yeah. We played "Alleys Of Your Mind" and "Cosmic Cars" and got a great response. Those records were huge. By then Mojo was playing the records, we were famous in Detroit.

How did Mojo get your records?
We gave them to him. He heard the demos of our stuff and liked them. The fact that Mojo liked the records was what really prompted us to play them. He was like, "I like it," and we went away and pressed it, took it back and he kept his word and played the records.

Did you know from then on things had changed?
No, but I loved the music. I was very confident, but where we were going was a mystery to me. The thing is, just because I liked it didn't mean that another person on the planet had to like it. So I didn't know. I figured it was going to be good. I don't think the record ["Alleys Of Your Mind"] got the recognition it should have got. Because of radio politics and the politics of distribution, it was hard to get a record distributed nationally in different cities in the States. It's not like the UK where you've got Radio 1 and everybody hears everything all at the same time, especially during the early '80s when radio was fragmented. Now it's more across the board; if a record is big in New York, it gets passed across the cities. Back then you had more personality style DJs and radio would sound different from city to city. It was hard to distribute or market a record across the country because a record that was popular in Detroit might not necessarily even be heard in Chicago or Cleveland and visa versa. If you went on a road trip to Chicago you might hear something and be like, "Wow, I've never heard this record," simply because it never made it Detroit.

That sounds like another world now.

Yeah. Even before the internet, in the last ten years I mean, radio had become more centralized but back then it was more fragmented.

Had you ever left Detroit by then?
Well, what happened was this: Derrick's parents had moved to Chicago, but he was still in high school so he had to stay here to finish up. But he would go there and he would tell these stories about the clubs, who he'd met and radio shows he'd heard. That was my first introduction to Chicago. When I started Metroplex he took some of my first records down there, my first copies of "No UFO's." He gave a copy to Farley Jackmaster Funk and he broke that record over there. Farley made it the biggest record in Chicago. He made it bigger than it was in Detroit.

Did you know about Chicago house?
Well, there wasn't any house at that time. There was nobody making records in Chicago. When Derrick went down there and gave it some of the guys like Jesse Saunders – who kinda made the first house record – and Chip E, these guys more or less started coming out with records around the same time as Metroplex started. It was like a cultural exchange between Detroit and Chicago.

Clubs in Chicago were playing disco weren't they?
Yeah, mainly disco. I mean if you listen to some of the early Hot Mix 5 [radio shows] it was just a continuation of disco. When disco came to an end in the United States, Italians were still making disco records, so a lot of the Hot Mix 5 mixes featured Italo disco tracks. Italians kept making disco records after 1981, and that was the stuff the Chicago boys were playing. Ultimately, after that, they started making their own stuff. But when you started listening to the Hot Mix 5 mixes, 80% of the tracks were Italo disco records.

So it was way more Italo than in New York?
Well, New York was earlier. When disco died, New York died more or less. New York was West End, Prelude and Salsoul. All of that stuff fell to the wayside when disco left. They were the disco kings….

You opened up for radio visionary Ken Collier at one party.
Yeah, that was very enlightening because he was the king. We learned a lot from Ken.

Did it seem like a big deal?
Yeah, there were stints when he had mixes on the radio during the disco era, but when disco died they didn't want mixes anymore. Ken was a main guy when they did have the mixes. He was an icon. We were honored to play with him; we were glad that he wanted to play with a couple of unknown DJs….

What happened when you started to focus on producing music as Model 500?
I took a step back from DJing for a while. Derrick continued to DJ because he wasn't making music, but when I started Metroplex I did take a step back for a few years. And then the records got exported to the UK so I started back up, so I could go to Europe.

So to have been inspired by a band from Europe, Kraftwerk, you then found yourself going back over there.
Yeah, but you've got to remember that the electro thing had kicked off in Europe. "Clear" and "Techno City" were included on a set of essential electro compilations, so it wasn't like it was the first time I was exposed to Europe.

But Europe had grown up on Manuel Göttsching and Kraftwerk. Electro wasn't new to them. Did you think about "Techno City" as a Detroit export?
No, we didn't know it was going to be exported then. I had no idea that it was as big in the UK as it was.

Europe was maybe a bit more open to experimental electro. Do you think you added some soul to it?
I guess you could say that.

But is that what you'd say?
Erm, I guess you could say that.

Had you heard Göttsching?
"E2-E4" was great. It was more on an ambient vibe, like a summer breeze.

Not dance music.
No.

There was something about your four-to-the-floor beat that turned this style into dance music.
My style was always dance music. I think that from the beginning everything I had done was very danceable. My first record "Alleys Of Your Mind" was very danceable.

Did you always want to make dance music?
That's my forte.

This interview was carried out in April 2010. A version was featured in Bill Brewster and Frank Broughton's book The Record Players © DJ History

SOURCE: Ferguson, Ben. "Interview: Juan Atkins." Red Bull Music Academy Daily, May 23, 2017.
https://daily.redbullmusicacademy.com/2017/05/interview-juan-atkins

Document 4A

INTRODUCTION

The Internet has changed the traditional supply chain of the music industry. The formatting of music into the Moving Picture Experts Group Audio layer 3 (MPEG-3) de-facto standard has resulted in the global sharing of digital music online. This type of sharing potentially causes the disintermediation of record companies and retailers from the traditional supply chain and allows artists and consumers to be directly connected through websites and peer-to-peer (P2P) technology. As a result, stakeholders are currently uncertain of their role in the emerging music-on-demand model of purchase. The aim of this paper is to investigate the dynamics between stakeholders in the music industry supply chain and to retrace the cumulative changes that took place as a direct consequence of technological innovation. The cases of MP3.com, Napster and Kazaa will be used to provide evidence for the hypothesis that new technologies were the catalysts for the demise of the traditional music industry. In effect, this paper is retelling the story of not only the impact of the Internet on the music industry but of the potential for the Internet to displace traditional members of the supply chain across vertical industries.

MULTIPLE CASE STUDIES

Although all three cases share the common characteristic of having been a market leader, each differed in structure and operation. Moreover, each of the three cases represented an alternate method of downloading music from the Internet. Napster, a P2P program designed predominantly for MP3 downloads, began as a free service providing a central server that indexed the songs contained on its users hard drives. After legal proceedings Napster was shutdown and relaunched as a legal PPD service where users paid for the rights to download music. MP3.com represented a different type of distribution service being a website where artists could post there music for download, offering both free and PPD services to its users. The final case of Kazaa, a newer brand of P2P, is a decentralized file sharing program that allows its users to share a variety of different file formats for free across millions of anonymous super nodes.

The main unit of analysis is the online music distribution company. The sub-unit of analysis is the stakeholders that interact with the online music company. There are three major stakeholders in the supply chain – the artist, the record company and the consumer/user. At the first level the technology is considered independently; at the second level the different perspectives of the individual stakeholders are considered and then related back to the main unit of analysis.

LITERATURE REVIEW

The Economics of Digital Music Distribution

The economics of digital music distribution are critical to understanding a shift in power in the music industry. According to qualitative research conducted by Lam and Tan the traditional distribution channel of music involved the following steps:

1. artists sign contract with record label;
2. artists record the album, record company produces the album on some type of media, e.g. CDs;
3. retailers purchase the CDs and other media from the record label;
4. and consumers buy the CDs and other media from retailers.

As a result of the arrival of the Internet and P2P technology to support file sharing, this model of distribution was no longer the only way consumers could acquire music. Lam and Tan argue that “the threat to the music industry is not MP3s, but the arrival of a consumer distribution channel that is not controlled by the music industry". Quantitative data presented by Easely, Michel and Deveraj further supports this notion identifying that a shift in power to the consumers poses both challenges and great opportunities for those setting strategy in this domain.

THE INTERPLAY OF DIMENSIONS IN THE INNOVATION PROCESS

Does Technology Shape Society or Society Shape Technology?

The MP3.com, Napster and Kazaa cases provide evidence showing that when a technology is released into the market it first impacts on social attitudes and behaviors. In the music industry, technology gave consumers availability to more music, and artists the means to distribute their music worldwide. The technology was unleashed without too much thought about the consequences of its widespread use. The technologies were then attributed to a devaluation of music as they taught users that it was okay to get their music for free. This had economic implications as the users who were once purchasing music from physical retail stores began to rely on online offerings. The changes in spending by consumers drained revenue from the traditional supply chain. It is at this point, that large record companies took notice, using the law to protect their business interests. The record companies moved to try and reshape consumer attitudes and behavior by showing that the MP3.com and Napster technologies were illegal. When this failed the law was used against individuals to try and deter others from downloading. Unfortunately by this time it was too late, word of the technology had spread worldwide, and as one technology was shutdown new variations were born. This has resulted in a display of force where record companies who have the economical power are moving to buy and takeover new online music distributors. However, social behaviors and attitudes were altered so much since the inception of free music download capabilities, that warnings from the record corporations and law courts have done little to abate consumer practices.

The historical evidence confirms that technology does shape society. In the digital music domain, a pattern emerges – a technology is released, it changes social behavior, which has an economic impact, law moves in to try and control or even reverse the economic effect by attempting to change social attitudes, but just as law seems to appear the victor, technology evolves and society follows the technology. It is at this stage that we find that society begins to shape technology by demanding the services that they have always been accustomed. In the online file-sharing community the technology implementation that allows the greatest diversity for file sharing and which offers advanced anonymity will survive as the market leader, despite the call that illegal activities may be taking place in the use of those operations.

Typical Product Life Cycle in Online Distribution Services

MP3.com, Napster and Kazaa reveal a distinct pattern of innovation in the creation of digital music distribution services…. This is referred to as the technology-push effect. Technology identified to impact on the rate of adoption includes the rise in the awareness of the MP3 standard, the increase in unlimited Internet access and broadband and the growth in MP3 devices. Even those record companies fighting to close MP3.com, Napster and Kazaa have invested into the MP3 market through the creation of MP3 players and related devices. However, the mere release of such technology raises ethical questions. For instance, is it wrong to use a paid download service together with the free services offered by Kazaa? Why release the device if it can be used for illegal downloads when claiming that free downloads will lead to the music industry's demise? By creating MP3 technology record companies are effectively encouraging the adoption of all MP3 technologies, not just those that are legal. The MP3.com, Napster and Kazaa life cycles demonstrate that free digital music distribution services will always exist. Kazaa has been able to maintain a large user base even with the legal action brought against it. However, in accordance with the product life cycle trend and with court proceedings still underway in the Kazaa case, consumers have already turned to another technology called eDonkey/Overnet, making it currently the largest file-sharing network on the Internet. The technology is out and has emerged beyond the control of law and consumers are sending an obvious message that they want to use it.

PATTERNS OF DISINTERMEDIATION AND REINTERMEDIATION

The creation of digital music distribution services has changed the music industry supply chain. Traditionally the supply chain was sequential in nature whereby artists sold the rights to their music to record companies who then distributed the music through physical retail stores. In this type of model the five major record companies enjoyed control and managed not only the dissemination but also the pricing of music. This allowed the record companies to exercise power over the other stakeholders of the music industry. The Internet changed this by allowing other players to establish themselves in the supply chain as key members. A variety of different digital music distribution service technologies soon began to appear giving consumers an alternative means of acquiring music. Digital music distribution services removed intermediaries, namely the record companies and retailers, and allowed artists and consumers to be connected directly. In this type of supply chain consumers and artists become the distributors, though maybe not aware of it, by sharing each other's music collections. The P2P technology sits at the middle only facilitating the transfer, at no point is music stored on the servers.

The record companies reacted to this transformation by moving to close MP3.com, Napster, Kazaa and other digital music distribution services in an attempt to preserve the traditional supply chain. This move was driven by the concern that new technology would replace the record companies or take some of the market which they previously owned. The move to close MP3.com and Napster was successful; both services were shutdown and eventually purchased by different record companies. This allowed for the reintermediation of record companies online. The MP3.com and Napster mergers with the record companies proved unsuccessful and both companies were later sold off. However, other free digital music distribution services like Kazaa soon appeared making it clear that the technology is here to stay. Online legal music retailers choose to take advantage of downloading, rather than fight it, by trying to capture a share of the online music market. One such example is Apple's iTunes which achieved instant success and allowed for the reintermediation of retailers. These companies are often referred to as e-tailers…. While the record companies still enjoy the majority share of the music industry in this new supply chain, developments in technology have shown them that they must be content to allow other players to exist in order to meet consumer needs.

The restructuring of the supply chain in the music industry demonstrates how technology facilitates reverse markets in which the definition of stakeholder roles change. The Internet and digital music distribution technologies are allowing consumers to take over the packaging and marketing of music where online communities partake in the duplication, broadcasting and distribution of digital music once facilitated by artists and record companies. In this emerging market, consumers could potentially have more information and power than artists and intermediaries as technology available enables the creation of music sharing services free from those restrictions of the offline music industry. Furthermore, the cost of entry and investment into an online market is relatively low compared to the investment made by record companies and retailers in the offline music industry, thus further enabling the formation of such large-scale communities online.

CONCLUSION

The principal conclusion of this paper is that digital music distribution services will not lead to the demise of the music industry. Evidence from the three cases shows that the online music industry is growing and that consumers have simply shifted their spending rather than stopped purchasing music altogether. Furthermore, the three cases of MP3.com, Napster and Kazaa reveal how technology can shape society's behaviors. The paper also showed that powerful members of the traditional supply chain seek to maintain their power in newer supply chain models in a bid to protect their own interests. These stakeholders will assert their position in the supply chain by either attacking new members by force (e.g. legal court battles which smaller members cannot afford), or by mimicking their opposition (e.g. in the case of the music industry, becoming a legitimate e-tailer). In any case, conflicts of interest will always be present as members of supply chain seek to continue their operations.

SOURCE: Alves, K. and K. Michael. "The Rise and Fall of Digital Music Distribution Services: a Cross-Case Comparison of MP3.com, Napster and Kazaa." Research Online. 2005.
http://ro.uow.edu.au/infopapers/379

Document 4B

Sales of CDs in the UK in 2018 amounted to 32 million units, that's some 100 million fewer discs than were selling just 10 years ago in 2008, and a drop of 9.6 million year-on-year, according to a report from BBC.

The lack of space being given over to CDs in retail outlets, such as supermarkets, is partly to blame for the fall. Also, the decision by the UK's main music and video retailer, HMV, to call in administrators just after the Christmas break, is a sign that the physical media industry is really hurting.

Consumers, particularly millennials, are shunning physical media and opting for streaming services such as Apple Music, Spotify, Tidal, and Qobuz. One of the reasons for this disenchantment with physical media is perhaps the drop in homeownership and affordability among young people. It's much harder to drag around a large CD or vinyl music collection if you find yourself moving apartments annually, plus younger people are spending more of their money on experiences such as live concerts, movies as well as subscriptions for things like music streaming and software.

One physical media that has bucked the trend in falling UK sales is vinyl LPs, which sold 4.2 million units in 2018. Last year's figures for vinyl appear to have stalled slightly with 2018 showing a modest 1.6, according to BPI, the organization that represents the UK's recorded music industry.

However, all is not completely lost for the CD, and reports of its death may be a little premature. The silver discs that are still selling tend to be music that appeals to older purchasers who to still value owning physical media or who enjoy the higher audio quality of the CD format, which is still far better than MP3s. Only higher-quality streaming services such as TIDAL or Qobuz are offering the quality of streaming that audiophiles want.

The UK's physical media market is also mirrored in the experience of the USA market, where sales of CDs have fallen by 80% over the last ten years, from 450 million units to just 89 million.

According to the BBC, two of the recordings nominated for Album Of The Year at the Grammys (H.E.R.'s self-titled debut and Cardi B's Invasion of Privacy) haven't even been pressed as a CD in the US. That's the first time that's happened since 1984 when vinyl was king and not all music releases were on CD.

Despite the slump in sales of CDs, the business of selling the silver discs is still a market in the UK that's worth £2bn in 2018, and the troubled retailer HMV sells £250m of those discs, so it may be a while before we see the CD completely disappearing from UK shopping baskets.

SOURCE: Sparrow, Mark. "Sales of Physical Music Media Slump As Consumers Move To Streaming Services." Forbes. Forbes Magazine, January 4, 2019.
https://www.forbes.com/sites/marksparrow/2019/01/03/sales-of-physical-music-media-slump-as-consumers-move-to-streaming-services/#219473fd2255

Document 4C

Streaming has been blamed for killing off the CD, but industry experts agree it's helping bolster the growth and quality of another physical music format: vinyl. Since 2015, streaming income has eclipsed CD sales, and the likes of Apple Music and Spotify have become major players in the music industry. This year the Recording Industry Association of America reported that 75 percent of music revenue in the United States came from streaming services. In the past three years, vinyl sales in the US have steadily risen about $2 million annually.

On paper, it doesn't make sense. Why would anyone buy an album they can only listen to in one specific environment, when for half the price of a new record, they can put it and millions of others in their pocket and listen anywhere?

"It's a completely inconvenient way to listen to music, it really is," Caren Kelleher, founder and president of Gold Rush Vinyl, said. Before starting her own pressing factory in Austin, Texas, Kelleher was the head of music-app partnerships at Google and a band manager.

Kelleher and other experts at the recent Making Vinyl conference in Detroit agreed that streaming and vinyl are complementary rather than competitive. As a consumer, it's a lot harder to take a risk on a $30 record you think you might like when a Spotify subscription costs $10 per month.

"Vinyl is not a discovery format," Jessa-Zapor Gray, vice president of marketing for Intervention Records, said.

Comparatively, the most expensive streaming subscription -- Tidal HiFi -- costs $20 per month. For the price of one record, you get access to some 60 million songs in Tidal's catalog and high-res streams. That value proposition is hard to ignore, more so if you opt for a lower-cost service like Spotify or Apple Music. No one likes wasting money, and even when vinyl was the dominant format, not every album was worth buying. Chances are, if you form a connection with an artist you happened upon via streaming, you're more likely to buy a physical version of their music.

Log in to Spotify and you're immediately presented with music you might not have heard. There's no risk rolling the dice on the album that surprise dropped this week and your social feeds are raving about -- even if you don't typically listen to Lil Wayne.

Vinyl Me, Please

"The best discoveries come from the unexpected," Matthew Fiedler, CEO of record-of-the-month club Vinyl Me, Please, said during a panel at the event. The problem is that algorithms by design deliver things you probably already will like. Conversely, a friend or record-store clerk will offer personal recommendations out of left field you'd never have heard otherwise.

Fiedler, along with musician/Third Man Records founder Jack White and many others, feels the formats are mutually beneficial: Streaming is a good method for discovery while vinyl is for investing in the artists and albums you love. The unfortunate side effect is that streaming has commoditized music. Every music app more or less looks the same, and you pick tunes much like you would scan your inbox, by dragging your finger through a list of data. But it fills a vacuum in an era when terrestrial radio is no longer a reliable way to discover new music.

During vinyl's heyday, 45RPM singles were everywhere. Artists would put out three of them, then a full-length album. They didn't sound great, but they were cheap and used to drive full-album sales.

Now many major labels intensely focus on streaming because it means bigger profits for them, less risk and no costs from producing vinyl. Bruce Ogilvie, the chairman of physical-media distributor Alliance Entertainment, mentioned the lack of vinyl releases for some of this year's biggest albums like Drake's *Scorpion* and Cardi B's *Invasion of Privacy* as examples of the music industry prioritizing streaming.

Before leaving Google, Kelleher gave a presentation about why artists were frustrated with low royalty payments. One slide, in particular, caused a stir: the payout difference between physical and streaming. Her data showed that the average independent artist needed 2.5 million YouTube views or 368,000 Spotify streams to make the same amount as selling 100 vinyl records.

"Their eyes just popped out of their heads," she recalled. "I tried to [illustrate the data] as an infographic, and I couldn't fit it all on one slide."

Without knowing how much the artists charge for the records or the quantities they're buying, it's hard to verify that claim. For 300 black, standard-weight, 12-inch records with a standard jacket, plain sleeve and shrink-wrap, Universal Record Pressing quotes the job at just over $2,000. Each record costs about $6.91 to make, and bands typically charge $25 at the merch table. That's $5,427 profit on the batch or $1,809 per 100.

According to Kelleher's data, Spotify pays artists $.007 per stream (the reality can be more or less, depending on whether someone is a paid vs. an ad-supported listener), which equals around 260,000 streams to hit the $1,809. So the figures don't quite add up, but that doesn't matter. Spotify pays less per stream than Apple, and Pandora pays less than Spotify. Likewise, if you double the order size, the per-unit cost of vinyl drops by more than 60 percent. The point is, selling a few hundred records per month can keep an artist afloat, and you can't say that about a few hundred streams.

Unfortunately, albums leak. The three-month gap between a record's journey from studio to retail only allows more time for that. It's why Eminem's *Kamikaze* or Kanye West's *Ye* were released to fans via Apple Music and Spotify by surprise, mere hours after they were finalized. That couldn't happen in a physical-only era. Until we get to the point where every new album arrives in record stores at the same time as the digital version comes online (a lofty ambition), don't expect big labels to prioritize vinyl even though it'd benefit their bank accounts.

Vinyl may make an artist more money than streaming, but that's because vinyl costs so much more; it's a luxury item. Citing an industry poll, The Guardian wrote in 2016 that almost half of record buyers own a turntable they never use. Instead, they're making purchases dependent on packaging they can display in their home. That, in turn, is pushing boutique labels like Mondo and others to embellish their album design.

"We've got a lot of labels now that are doing a lot to sell a package," Rob Maushund of Stoughton Printing told Engadget during a panel on the importance of packaging. The production planner described a recent reissue of Ennio Morricone's score for John Carpenter's horror classic *The Thing*. Waxworks

Records asked for a slipcase that resembled an iceberg you'd have to "break open" to access the records. Try doing that with your iPhone.

The package was a very limited run, and fan response was frenzied. Waxworks' co-owner told Maushund he'd gotten death threats because the pressing sold out so quickly. What was originally a $32 record resells for as much as $250 on eBay. Maushund said this is evidence that specialty packaging makes physical media more attractive to buyers than digital music.

"It's making customers want more and buy more," Gray said.

Ogilvie concurred. He mentioned K-pop group BTS as an example. Several of the Korean boy band's recent albums were released with bespoke physical CD editions packed with stationery, stickers, photos and even a diary. "Nobody's cracking them open and listening to the CD -- they just want the artwork. It's always been that way," he said.

Fiedler said if labels rush to put out vinyl and don't take the time to assemble a package worthy of a new record's high price, customers feel shortchanged -- specifically if a label or artist charges $30 or more and cuts corners by not mastering an album for vinyl and ships it with a flimsy slipcase.

"If you have a subpar product with vinyl, then it's gonna be hard to have that complementary experience," he said. While vinyl can make more money for musicians, it isn't always a consumer-friendly format. Used albums are one thing, but a new single-LP album costs $20, on average. Add in fancy gatefold packing or multiple discs and the price climbs.

Streaming and vinyl each has benefits. Streaming gets music into your ears faster and is ridiculously convenient while vinyl gives superfans something tangible to showcase their love for an artist. It also gives them a chance to hear it without the compression of typical streaming bitrates. While 160Kbps streams might not be the best fidelity, their lack of pops and scratches has had an impact on the ears of two generations -- millennials and those under 25 -- kids who grew up in the era of digital remasters, with CDs and MP3s as the dominant formats. In turn, that's driven innovation within the vinyl industry.

When she was managing musicians, there wasn't much Kelleher could do if her client got a bad-sounding record. The plants were operating at capacity, and the alternative was to wait another six months. Now production time has halved, and thanks to competition and demand, it's getting more efficient every year. These days, record-pressing factories and equipment manufacturers are striving to create cleaner-sounding records as a direct result.

"Digital music, in general, has led people to certain expectations about what music should sound like: clean and pop-less," Gray said. She said people are comfortable with the sound of an older, used record when they typically cost $10 or less. "But when you're getting new vinyl, you want something quieter," she said.

The desire for something more is what's driving the music industry as a whole. Streaming revenues are up, and the value proposition of paying for a subscription will likely never disappear. The price for new records won't drop anytime soon either. Streaming was the byproduct of Napster. Now it's the predominant format and is helping musicians get paid for their work.

It's no coincidence that vinyl's upswing charts a similar course with paying Spotify customers. Digital left a void, and superfans wanted to start reconnecting with the music they loved. Its homogenization of the art form unexpectedly pushed vinyl back into the zeitgeist and forced the aging industry to adapt to modern ears. You can bet Sean Fanning and Sean Parker never saw that coming.

SOURCE: Seppala, Timothy J. "Music Streaming Is Fueling Vinyl's Resurgence." Engadget, December 4, 2018. https://www.engadget.com/2018/12/04/music-streaming-is-fueling-vinyls-resurgence/

Document 4D

Sophomore Collin Flynn has promised his parents he won't drop out of UNC to pursue SoundCloud rapping — "over and over and over again."

Flynn began uploading his music to the free music platform last semester under the name "Karma," and already his first song, "Ride," has over 8,000 plays. Flynn is one of millions who post music on SoundCloud, including college-age rappers looking to get famous.

Flynn said part of SoundCloud's appeal is that anyone can post music and potentially "blow up." Rappers such as Lil Pump and Sheck Wes got their start on the platform before going on to achieve record deals and Billboard hits.

"All you have to do is have a mic, a computer and a place to record, and you can be the next Lil Pump — theoretically," Flynn said.

Sophomore Shawn Duncan, who posts music under the name "~ssion," said SoundCloud is especially popular with college students because it is free to post and listen to music, providing accessibility students may not have to other platforms such as iTunes and Apple Music.

Duncan, like Flynn, considers himself a student before a SoundCloud musician and is not planning to pursue music as a career. He said he is not seeking a huge following, but rather posts music for people to enjoy.

Local Hits

Community was central to "watchu_meen!!??," a song that orientation leaders Vance Stiles, Excellence Perry and Smit Mehta wrote and posted this summer to play for their orientation groups. The song was based on Mehta's catchphrase and caught on with the orientation staff and students.

The song, which is Stiles' most viewed, features Mehta saying "watchu mean" as the chorus. Perry said it became iconic during orientation — so much so that they performed it in a mini concert during Rise Against Hunger.

"We would hear students at the orientation session humming it, and some of them would ask for the SoundCloud link," Perry said. "And with that link, it spreads like wildfire."

Stiles said SoundCloud is area-focused, allowing rappers in small areas to produce music and listeners to hear music by artists near them. He compared rappers posting music on SoundCloud to people selling their mixtapes on street corners in the past but with greater circulation.

Though Stiles has considered pursuing music production as a career and is interested in the field, he said it will probably always be a hobby for him because it is such a competitive industry and Chapel Hill is not a central location for trap or rap.

"We wish it were Trap-el Hill, but it's really just Chapel Hill," Perry said.

Cheap Thrills

Perry also uses SoundCloud to make joke tracks with his sister, including one they created about Crocs and socks after he bought her Crocs for Christmas. He said they are able to create a fully produced song in under 30 minutes by making beats on GarageBand, giving them an opportunity to be their own musical group.

Stiles said GarageBand is one of many factors that has made music recording cheaper, along with the availability of more inexpensive "daws", which are digital audio workstations. Because anyone can make music with cheap equipment, artists can start producing music without large amounts of money.

“Now anyone can make music,” Stiles said. “That doesn’t mean it has to be good music, but anyone can make music, which is empowering.”

Underground Sound

With so many artists posting on SoundCloud, both Duncan and Flynn said it is important for rappers to find a unique sound to differentiate themselves. Duncan said SoundCloud attracts an “underground sound,” which makes its way into the mainstream as songs like “Mo Bamba” by Sheck Wes go viral.

“SoundCloud has changed (the music scene) because it’s easier for underground artists and underground sound to come to light,” Duncan said.

Stiles and Perry said the sound is characterized by being rawer and less processed than most mainstream music because it is not as controlled by record labels. Electronic mashups also have a role on SoundCloud, whereas Perry said they are not as prevalent on platforms like Spotify that focus more on the biggest hits.

Another trend Stiles and Perry said they see is that listeners focus less on lyrics and more on melody, in SoundCloud rap and beyond. They also said rap is more popular than other genres both on SoundCloud and the top charts, which they said indicates that rap is the new pop in the music world — especially on college campuses.

“Look at the airwaves now,” Stiles said. “It’s covered in rap. 21 Savage, 10 years ago, would not have had a name for himself. Now everyone’s rapping him and Post Malone all the time.”

SOURCE: Sheehy, Maeve. “Now That You're Here, Check out My SoundCloud.” The Daily Tar Heel, January 20, 2019. https://www.dailytarheel.com/article/2019/01/soundcloud-rappers-0120