

EP. 6:
The Evolution of Audio Production

Trace the remarkable journey of music from prehistoric instruments to modern digital production. In this episode, Aleyna Neivandt-Brown chronicles the technological innovations that transformed the way we create, record, and distribute music — from the telegraph to the telharmonium, vacuum tubes to transistors, tape to digital audio workstations. Discover how inventors, engineers, and composers continually reshaped the audio landscape, and how those same patterns continue to influence today's rapidly evolving industry...

Written and Recorded by
Aleyna Neivandt-Brown

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Hi everyone, welcome to another episode of the Red Pin Podcast. I'm your host, Aleyna Neivandt-Brown, audio engineer, composer, performer, and professor, and the Founder of Red Pin Productions. This podcast serves to enlighten and hopefully entertain you with some science and history, studio stories, and interviews with guests from across the audio industry. Today's episode is just me, walking you through a curated history of audio production, from the earliest developments in telecommunications to electronic instruments and recording technology, all the way to the digital world of MIDI.

[Red Pin Podcast Intro Music]

When I say a curated history, that's because a comprehensive one would take as many years to tell as it covers. Since the beginning of time, humans have been making music and seeking to record it, even if "record" meant something different in the stone age as it does today, the mission has been there. We've been singing, playing instruments, and notating music so that it might outlive its original composers. **With every major discovery or invention, humans immediately apply the breakthrough to make, capture, or share sound.** Travel with me back forty thousand years into prehistoric time. Long before humans could write, they used sharpened stones to work with animal bones, not only for primitive toolmaking, but for music. The earliest known instruments in human history are flutes, with tone holes meticulously carved into hollowed out animal bone. Fast forward thousands of years to the Neolithic Era; as humans domesticated animals and developed agriculture, they learned to process wool, gut, and hair for hunting bows, ropes, and textiles. And immediately, they applied that knowledge to construct early string instruments like the harp and lyre. In Ancient Egypt, developments in high-temperature kilns allowed artisans to design more sophisticated pottery, not only for storage but for art and music. These ceramic designs became some of our earliest idiophones often used in ritual music. In the Bronze Age, when humans learned how to create bronze from copper and tin for stronger weapons and tools, they immediately applied the breakthrough to making instruments like the trumpet and tuned bells. In Ancient Greece, as engineers harnessed the physics of water pressure and pumps, the world's first pipe organ was invented in Alexandria, known as the *hydraulis*, which used water pressure to pump air through tuned pipes. Fast forward to the Middle Ages, around 1000 A.D., a monk named Guido d'Arezzo developed one of history's most influential mnemonic systems for teaching musical notation, the Guidonian Hand, a new way of organizing music on a staff and using the knuckles and fingers on your own hand to represent specific notes. Towards the High Middle Ages, engineers developed crude wooden crank-and-wheel mechanisms for mills and pulleys. Lo and behold, the same

engineering was applied to a string instrument where the bow was mounted on a mechanism that continuously rotated across the strings. This automated instrument is affectionately known as the Hurdy-Gurdy. Moving forward to the Renaissance and the invention of the Gutenberg Printing Press, sure, it revolutionized literacy in the 1400s by mass-producing written text, but it was almost instantly adapted for music publishing. This single technological leap explains the massive explosion of surviving musical scores available for study from the Renaissance compared to any era prior. Fast forward another four hundred years to the Industrial Revolution in the 1800s, we took steel manufacturing and used it to cast iron frames for the modern grand piano, and a guy named Adolphe Sax learned a thing or two from industrial metallurgy, and invented the brand new hybrid metal instrument, the saxophone. Later in the 1800s, as soon as we discovered electricity and the potential of telecommunication, we harnessed it not only to transmit words, but music.

[5:39] That brings us to where I want to start with the developments of music technology as it relates to recording and production. But I hope after that whirlwind introduction you can trust that with tens of thousands of years of known human history, there's such a precedent and cultural significance to the fact that our inventions so quickly get applied to our music. But I simply can't cover all of them. So here's where I'll begin. It's 1876, and Professor Elisha Gray just invented the **musical telegraph**, somewhat by accident. You see, in the 1870s, telecommunication lines were congested, creating a demand for the ability to send simultaneous messages on a single wire. Gray had narrowly missed out on beating Alexander Graham Bell in filing a patent for the invention of the telephone. Historians continue to debate who the true "first inventor" was, but I think that shows the effect of the industrial revolution and widespread curiosity for new technology and industry demand, that these two men could've been thinking about and solving essentially the same problem and inventing the same device at the same time. But I digress. My point is, Gray was already an accomplished inventor and had taken to this industry demand for a development in multiple telegraphy. Thomas Edison was able to devise quadruplex telegraphy, sending two signals at the same time in the same direction and the opposite direction on a single wire. But what about further multiplexing? That would've been hugely useful for a hugely expanding telecommunication network across a pretty huge landscape. So where does the musical telegraph come in? In George B. Prescott's "Sketch of Elisha Gray," published in Popular Science Monthly Volume 14 in February of 1879, he writes, "Mr. Gray observed a singular circumstance in connection with the reproduction of electrically transmitted vibrations through the medium of animal tissue. On going into the bath-room he found his nephew playing with a small induction coil—"taking shocks," as he expressed it, for the amusement of the smaller children. He had connected one end of the

secondary coil to the zinc lining of the bath-tub, which was dry at that time. Holding the other end of the coil in his left hand he touched the lining of the tub with the right. In making contact, his hand would glide along the side for a short distance. At these times Mr. Gray noticed a sound proceeding from under his hand at the point of contact, which seemed to have the same pitch and quality as that of the vibrating electrotome, which was within hearing. Mr. Gray immediately took the electrode in his own hand, and, repeating the operation, to his astonishment found that, by rubbing hard and rapidly, he could make a much louder sound than the electrotome was making. He then changed the pitch of the vibration, increasing its rapidity, and found that the pitch of the sound under his hand was also changed, it still agreeing with that of the transmitted vibration. [...] This experiment produced a profound impression upon his mind, and determined him at once to take up the matter in earnest and see what might be in it." (end quote). He did indeed take up the matter. After his bathtub experiments and trials using a violin instead, he eventually developed the musical telegraph as a one-octave keyboard, with each key or note assigned to metal reeds that would vibrate with an electromagnetic current. We know from our understanding of the theory of electromagnetic induction discussed in Episode 5: Inside the Microphone, that that generates a signal that can transmit through a wire. In this case, it transmits to Gray's "Washbasin Receiver" that performs the transduction in reverse—receiving the electrical energy and vibrating it back into acoustic energy, and amplified with the kitchen sink. Pretty creative, you gotta say. He patented the musical telegraph February 15, 1876. He shared the invention with several concerts as well as the 1876 Centennial Exhibition, successfully demonstrating eight simultaneous messages on a single line. It's no coincidence that so many breakthroughs in music technology came from telecommunications research. Companies trying to move voices farther and more clearly kept accidentally giving musicians entirely new ways to create sound. Alexander Graham Bell's telephone invention I mentioned earlier eventually gave rise to Bell Laboratories, which remains today the place of some of the most groundbreaking inventions in electronics of the last hundred years.

[11:18] While Gray's electronic music contributions were considered more technological novelty than art, the musical telegraph did influence later instrumental developments including Thaddeus Cahill's **Telharmonium**… In fact, when Cahill first tried to patent his new instrument, he was rejected from the patent office due to similarities to existing inventions, namely Gray's musical telegraph. Cahill was apparently quite livid about this, resulting in one of my favorite quotes of inventors bashing other inventors, similar to composers bashing other composers, but maybe that'll be another episode. Cahill said that Gray's musical telegraph was (quote) "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." (end quote). Roasted. Anyway, Thaddeus Cahill did go on to design and defend a new invention called the Telharmonium, officially patented in 1897, about twenty years after the musical telegraph. So what actually makes this instrument different and significant in our curated history of music production? Well, the Telharmonium was Cahill's vision of a perfect instrument. Now, if you ask me, an instrument that takes up an entire warehouse, weighs 200 tons, has 36-keys per octave that don't map to any pre-established musical or keyboard-based note system, ten switchboards and almost 2000 switches, requires an insane amount of power to operate and will literally interfere with the New York telephone network, is a little different than what I would call the perfect instrument. Maybe that's just me. Or maybe that's because I play the flute, which as we know, is the longest standing instrument in human history. So what made the Telharmonium so revolutionary that there would even be the support let alone demand for such a massive musical machine? I think it's best summarized by Simon Crab of the "120 Years of Electronic Music" project, a free open-source compendium of research on electronic instrument design initiated in 1995 on 120years.net. It's still going, self-funded and supported by the community, so definitely check it out. And about the Telharmonium, Simon Crab writes, "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 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 chord ability of an organ. Having corrected the 'defects' of these traditional instruments, the superior Telharmonium would render them obsolete." (end quote, again that's published in a great article on the Telharmonium on 120years.net). What a glimpse into the motive behind this development. Do we not also see that in other inventions and developments in technology? This idea that something new will be so much better it will replace everything that came before it. For better, or for worse. Cahill's attempt to render every other instrument and thereby musician on the planet obsolete with an invention of a single instrument that could be played and transmitted over the network instead, honestly makes me pretty glad the 'Telharmonic Hall' business eventually collapsed and he filed for bankruptcy in 1914.

[15:53] On to the next invention. At this time that the world was more connected than ever via new telecommunications networks, there were still barriers to recording and listening to music on the mass consumer scale, which could be partly why Cahill was still of the mindset that his cumbersome instrument would have a permanent space in a concert hall and a perpetual subscriber base. That's how the public could hear music—in the concert hall. But that was starting to change. Early phonographs had been developed, and in 1906, the Victor Talking Machine Company introduced the **Victrola**. This was a

record player that hid the amplification horn inside a cabinet that looked much more like a statement piece of furniture than a machine. The cabinet doors were kind of like the lid of a grand piano, where open vs. closed served as volume control. With the Victrola becoming more popular, the demand increased for recorded music. At this time, there was only acoustic recording. No microphones, no cables and mixing consoles—musicians would gather round a big horn that channeled the sound into a glass diaphragm attached to a needle. That needle would vibrate with the incoming sound waves and etch grooves onto a spinning wax disc. But if it was becoming popular on a mass market, did the same musicians have to play the same thing for every single disc to be etched? They solved that challenge with electroplating, which allowed factories to essentially stamp identical etchings into thousands of discs. Talk about a supply chain innovation being applied to the music industry—kind of reminiscent of the printing press, no?

[17:54] Soon, inventors would push even this innovation further, out of the mechanical realm of gears and wax and into the age of electronics… Let's talk about the **Audion vacuum tube**. This vacuum tube was a triode, with three internal elements: filament, grid, and plate, that could take a weak electrical signal and boost it into a much stronger signal without distorting the sound. It could also generate pure electronic sounds—synthetic alternating currents. By feeding the output back into its input, it becomes an oscillator. This development in electronic amplification led to the loudspeaker, and this discovery of electronic oscillators led to the development of one of the most iconic and otherworldly electronic instruments… the theremin.

[18:58] The **theremin** was invented by Russian physicist Leon Theremin around 1920. It relied entirely on vacuum tubes as oscillators with antennas to control pitch and volume. How do you play an instrument with an antenna? As crazy as it sounds and as it was, especially at the time, you play this instrument without even touching it. Your hands control the notes in mid-air. Because vacuum tubes are highly sensitive to electrical capacitance, the capacitance of the human body when it gets close actually has an effect on the oscillators. Leon Theremin capitalized on this and designed an antenna that would sense changes in the electrical field based on proximity of the human hand. This gave the performer complete pitch control, not confined to half-steps like a keyboard, but freely gliding between frequencies. The other hand would control volume in a metal loop, again, just by hovering and moving within the electrical field.

[*brief musical transition*]

[20:14] Let's take a break from instruments and talk about microphones and recording technology. In 1928, Neumann came out with the CMV3, the first commercially mass-produced condenser microphone known as "**the bottle**." In 1931, **RCA**, Radio Corporation of America, developed the first ribbon microphones. RCA is going to be a big character moving forward by the way. 1935 saw the development of the first practical commercial **magnetic tape recorder** that allowed for easier and more durable recording, playback, and editing. In 1943, during WWII supply chain shortages of the material used for recorded discs, a new material proved cleaner, lighter-weight and more durable—**vinyl**. In 1948, Ampex mass produced the **commercial tape machine**, the Model 200A. Les Paul was one of the first notable artists to get the full potential from this recorder, experimenting with layered guitar tracks and half-speed recording, resulting in a playback that would've been impossible for one person to play live. Les Paul was also influential in the development of the **8-track** recorder in 1955, establishing a workflow we still use today even on modern technology, **multi-tracking**—the ability to record, isolate, punch-in, and independently mix multiple tracks in sync with one another.

[21:59] That brings us back around to the next instrument I want to highlight on our journey through early electronic music and audio production, and that is the **synthesizer**. The **Columbia-Princeton Electronic Music Center**, which now operates as the Columbia Computer Music Center, was co-founded by Vladimir Ussachevsky and Otto Luening and became the creative home to many great composers and innovators during the 50s and 60s. These included Milton Babbitt, Mario Davidovsky, Alice Shields, Pril Smiley, and Wendy Carlos just to name a few of my favorites. I want to focus on Milton Babbitt for a moment to highlight his mastery of the innovative **RCA Mark II synthesizer**. The RCA Mark I synthesizer was invented in 1951, quickly replaced with the Mark II, so in our timeline I'll refer to both models together as the RCA Mark II. RCA's goal for this instrument was actually to make music recording more efficient by being able to program in arrangements of "hits" to crank out more hits without the time, errors, or labor of union musicians. What resulted was a machine that could play back electronically generated sounds determined by a score that was fed to the machine on paper. On this paper score, there would be holes punched for pitch, timbre, volume, and envelope for each note. The sound was generated again by vacuum tube oscillators, 1,700 of them. The thing is, the RCA Mark II synthesizer took up a whole room and required such a complex understanding to use that only highly specialized composers sought to use it, and certainly not for commercial music. So instead of becoming a mainstream music production tool in every studio, this invention lent itself more to the avant-garde composers of the time. This is quite unlike the instruments I've talked about so far. The musical telegraph, the telharmonium, the theremin, all used innovative new technology and applied it to familiar

tunes and genres for public enjoyment. The early synthesizer went a different direction, furthering the 20th century departure or divide between high art music and popular music—that is, music composed inside the highly-educated rooms of music academia versus music playing on the bandstand or concert halls or radios in living rooms. The 20th century was ripe with both the rebellion against mainstream music and the introduction of such intellectual music that the regular person probably wouldn't even describe it as such. Take for example the riot that happened in 1913 with Stravinsky's radical Rite of Spring ballet, or when 12-tone serialism arose from the Second Viennese School of Schoenberg, Webern, and Berg, refuting the very tonality holding our classical music theory together! Add technological developments in instruments creating sounds no one had ever heard before, to a group of composers seeking to write music no one had ever heard before, you end up with the case of **Milton Babbitt**. In fact, Babbitt wrote an essay in 1958 called, "The Composer as Specialist," which was actually retitled by the magazine's editor without his permission to something much more provocative: "Who Cares if You Listen?" In this essay Babbitt calls for a separation of commercial popular music and intellectual modern composition and experimental music. He advocates for universities to really be the sanctuary for that pursuit, because it's not something the average person can be expected to understand, let alone support. Let me read to you a selection from his essay, [quote] "Advanced music, to the extent that it reflects the knowledge and originality of the informed composer, scarcely can be expected to appear more intelligible than these arts and sciences to the person whose musical education usually has been even less extensive than his background in other fields. I dare suggest that the composer would do himself and his music an immediate and eventual service by total, resolute, and voluntary withdrawal from this public world to one of private performance and electronic media, with its very real possibility of complete elimination of the public and social aspects of musical composition. By so doing, the separation between the domains would be defined beyond any possibility of confusion of categories, and the composer would be free to pursue a private life of professional achievement, as opposed to a public life of unprofessional compromise and exhibitionism. But how, it may be asked, will this serve to secure the means of survival for the composer and his music? One answer is that, after all, such a private life is what the university provides the scholar and the scientist. It is only proper that the university which–significantly–has provided so many contemporary composers with their professional training and general education, should provide a home for the 'complex,' 'difficult,' and 'problematical' in music." [end quote] Feel free to rewind and listen again, because, wow, what a hot take. Written in 1958 and it's still a hot take. The ivory tower vs. music for the masses, it's an ongoing debate. One even I have struggled with as someone on "both sides" if you will. I have a Masters in Composition with a

specialization in Computer Music from the University of North Texas, an incredibly specialized and advanced program that encourages one to experiment with new technology and avant-garde compositional techniques, really not intended for an audience outside our niche community it can be said. At least I'll say it! It's for us. It's not for someone's commute or background music for a dinner party. It's not the kind of concert you go to sit back and enjoy. It's music that shocks or evokes a thought or feeling you've never had by giving you sound in combinations you've never heard. It invites deep listening, observing, questioning, and even yes, reacting, be that positively or negatively. And to Babbitt's point, it can't be expected to be immediately understood. So when the RCA Mark II synthesizer came along, Babbitt had the bravery to dive in and explore the endless combinations of parameters, not confining himself to any musical scales or tonality or form, let alone what would sell at the record store. Instead, he invented new music for this new machine. And he didn't expect the public to join him. But that doesn't really make for a marketable machine for RCA, and a guy named Bob Moog was about to come along and make another synthesizer much more accessible.

[30:34] **Bob Moog** learned electrical engineering from his father at a young age, building radios and other hobby projects as young as ten years old. In 1952 he started a dual degree in electrical engineering and physics at Queens College and Columbia University. Yes, young Bob and the likes of Milton Babbitt did indeed overlap at Columbia, however their studies and goals were so different. While Babbitt was experimenting with electronic music serialism and distancing himself purposely from the public, Bob Moog was much more focused on the electronics themselves. An engineer first and foremost, he applied his innovations to making musical instruments that were accessible, affordable, and—get this—portable. One summer, home from college, Bob built his own theremin in his father's basement. He continued working on developing commercial theremins for several years all the while continuing his education with a PhD at Cornell, receiving the RCA Fellowship. Yes, that's the same RCA, lots of little connections here. Here's another one, when Bob presented his new voltage-controlled modules at the Audio Engineering Society convention in 1964, he met Wendy Carlos, one of the composers I mentioned working out of the Columbia-Princeton Electronic Music Center. They would go on to collaborate on Bob's Synthesizer, with a demo record in 1967, and the "Switched-On Bach" album in 1968 which won two Grammys. The Moog synthesizers had modular controls for a lot of the parameters we've talked about on the early RCA synth, but instead of feeding this room-sized machine rolls of hole-punched paper, the Moog synth was smaller. It used solid-state electronics instead of vacuum tubes, and it had a keyboard attached. Yes, like a piano keyboard. Now you're probably starting to envision the synthesizer as we know it, an electronic keyboard that can sound like anything and be

played like a piano on stage, in the studio, on tour. And you're right, that's what happened. In 1967, the Moog synth was used in the production of two major albums, one by The Doors and one by the Monkees. It really started to get some attention when it was used in the 1969 *Abbey Road* by The Beatles. In 1970, a simplified and smaller keyboard synth was released, The Minimoog, advertised as "compact, moderately priced miniature synthesizer designed and built especially for live performance." What a difference in not only the philosophies but the resulting application of the new technology to music, between the RCA Mark II and the Moog synthesizers. Both vital to the development of electronic music and production, it must be said. But interestingly, only one survived the developments that came next. A New York Times article in 1968 said it best, "Mark II Is Dead, Long Live the Moog!"

[*brief musical transition*]

[34:17] Before we leave the midcentury modern era, let's go back into the studio and talk about some recording and playback techniques using tape that created a whole new genre of music. In the 50s and 60s music composed not for instruments to play, but exclusively in the recorded medium using pre-recorded sounds as raw material was coined the term **Musique concrète**, by French composer and theorist Pierre Schaeffer. Everyday real-world sounds would be recorded, and the piece of music created would lie in the tape editing techniques—looping, splicing, reversing, or speeding up, slowing down which would raise or lower the pitch. Musique concrete paved the way for practically all of the effects you hear in today's DJ sets. Take a clip of audio and loop it, speed it up, change the pitch, splice it into smaller and smaller clips leading into the bass drop. You know it, you've heard it. [Audio example of time/pitch-shifted effects using words from the previous sentence.] They were doing it in 1948. As this genre developed and more composers explored its techniques, a new branch of musique concrète emerged that would transcend the tape medium. These looped tape pieces invited such deep listening with their mesmerizing techniques. One composer, **Steve Reich**, applied these techniques to recorded speech. His piece "It's Gonna Rain" in 1965 utilized musique concrète, and from it emerged minimalism. The recorded raw material that he used was a street preacher warning people about the rapture, shouting passionately from the story of Noah and the flood, "He began to warn the people. He said 'it's gonna rain after a while; for forty days and for forty nights, and the people didn't believe him. And they begin to laugh at him. And they begin to mock him. And they begin to say 'It ain't gonna rain.'" Reich captured the rhythm of his cadence and isolated specific words and phrases, and with it, created a tape piece. With two tape recorders playing back the same speech, Reich let one play back at a slightly different speed, eventually the words getting out of sync in a technique known as **phasing**. The way it

was repeated so long meant the words became sounds, and the sounds became rhythms, and the rhythms were hypnotic. And it was all an intentional process. This process-based composing became known as **minimalism**, and would be used not only in tape music but in acoustic music composed by Reich along with many others like Philip Glass, Terry Riley, La Monte Young. I always find this relationship between audio production and music composition really interesting, because so far, we've seen it go the other way around in terms of influence. Acoustic music influences the kind of music created and recorded in the studio. But in the case of minimalism, it really grew out of the studio and into the concert hall.

[37:59] Let's stick to the studio for a moment, because this era of technological development in solid-state components enabled so many of these corresponding developments in music production. The **transistor** was invented at **Bell Laboratories** in 1947. Yes, the same Bell Laboratories I mentioned before, and we're not done yet. This solid-state component was smaller and more reliable and more powerful than bulky, fragile vacuum tubes. These components directly influenced the studio workflow as we know it, the center of the room, the star of the studio… the **console**! I want to highlight two major audio engineers who were making strides in consoles in the 60s and 70s, Rupert Neve and Colin Sanders. Neve, of course, the namesake of the iconic **Neve** consoles and preamps we know and love, famous for their saturation and warmth, the purity of their Class-A amplifiers. And Sanders, the founder of Solid State Logic, **SSL**, known for their routing flexibility and Total Recall automation. Both Neve and SSL consoles were able to house many channel strips each with preamps as well as equalizers and compressors, because the semiconductor components were getting smaller and smaller, packing more control and more power into less space, making a truly ergonomic mixing desk with more precision at the engineer's fingertips than ever before. And while I'm on the topic of studio workflow, remember the 1955 advent of the 8-track recorder? Well, the 60s saw the 16-track become standard, only for the 70s to replace it with 24-track. This meant engineers didn't have to record the whole band in one room in one take with just a couple microphones. Instead, they had such precise multitracking—new drum miking techniques, honing in on every single drum and multiple overheads and room mics, new techniques for miking amps, and overdubbing layer upon layer until it was perfect, because the consoles had plenty of channels and now the tape did too. Some iconic microphones came onto the scene during these two decades as well – the **Neumann U67** tube condenser and the solid-state **U87** which replaced the tube with a Field Effect Transistor. New dynamic mics that could handle these new drum and amp placement techniques included the **Sennheiser MD 421** (which I'm using right now), the **Electro-Voice RE20**, and the **Shure SM57**. And new **outboard gear** for effects like reverb, delay, compression, and EQ thrived because of the

routing flexibility of these new consoles and the high-speed, high quality signal flow in this new era of the recording studio.

The distribution of music was also undergoing some change at this point. Vinyl records were overtaken by the 8-track tape player, which became the first factory-installed personal music player in vehicles when Ford added it as an option to their 1966 Thunderbird. Radio had been in cars for quite some time, but for the driver to be able to choose their own music was a new and exciting feature. 8-track players soon got overtaken by **cassette tapes**. In 1979 Sony introduced the **Walkman**, meaning you could take your music with you anywhere. By 1980 cassettes were outselling 8-tracks, and between '84 and '89 cassettes had majority market share as the most sold physical medium of recorded music. But I'm sure you can guess what happens next… the rise of digital music. However, before there were CDs, MP3s, streaming services, or DAWs like Pro Tools and Logic on a laptop, someone had to figure out how to make a computer create sound at all…

[*brief musical transition*]

[42:46] So far, a lot of our instruments and technological advancements in music production have been in the analog realm—generating a signal and manipulating it, or recording it, and playing it back. Whether that's from a telegraph using electromagnetism or the RCA Mark II vacuum tube oscillators, we've been harnessing electricity and using it to generate an analog signal, a real wave, real electrical energy. But at Bell Labs in 1957, someone was asking a completely different question. Known as the Father of Computer Music, **Max Mathews** developed a programming language on an IBM 704 **computer** that could actually generate sound from numbers. **MUSIC I**, his pioneering program, could convert numbers into sound. Not by vibrating reeds or oscillating vacuum tubes, but by computing the waveform mathematically. Mathews continued developing the software throughout the 50s and 60s, each upgraded capabilities getting an upgraded number to its name. By MUSIC III, you could patch together unit generators, basic building blocks of music and their parameters like waveform type, filters, and envelopes, just like we saw with the modular synthesizers, but this time, digital! In 1968 Mathews released MUSIC V, this time programmed in FORTRAN, a universal programming language that made it accessible to other software engineers and computer music researchers around the world. Mathews' developments in computer music directly led to the programs and languages of **Csound** and **MaxMSP**, MaxMSP actually named in his honor. I used both Csound and MaxMSP throughout my degrees in composition. My album *Recitations* from 2025 actually features a live instrument plus MaxMSP patch. And in my Master's Thesis on expanding femininity into computer music spaces, I created a #pinkcode

exhibit featuring a Csound program on FM, AM, and RM synthesis. It's kind of surreal to trace that software all the way back to a Bell Labs programmer writing Music I on an IBM computer 70 years ago.

[*brief musical transition*]

[45:34] So we've seen how telecommunications companies like RCA and Bell Labs drove the technological developments that at times inadvertently led to the biggest strides in electronic music. These inventions from the telephone to the musical telegraph, the transistor to the synthesizer, continue to prove that long-standing powerful correlation between innovation and its immediate application to music. Such is our human motivation, our obsession with telling our story through art. One place we've talked about so far, truly dedicated to the advancement of musical creativity was the Columbia-Princeton Electronic Music Center. But there's one more I need to mention, especially for its contributions to our journey through music production history, after Max Mathews launched us into a whole new world of digital music. **IRCAM**. I-R-C-A-M. IRCAM is an acronym, originally in French, which translates to the Institute for Research and Coordination in Acoustics/Music. IRCAM opened in 1977 in Paris as an incredibly well-funded institution and continues to this day to be one of the great creative hubs in the world. With RCA and Bell Labs driving the technological inventions, places like the Columbia-Princeton Electronic Music Center and IRCAM were the creative hubs for composers to harness these new tools. IRCAM in the 70s was the stomping ground of many modern music pioneers including Pierre Boulez. But these pioneers weren't dealing in room-sized vacuum tube-powered switchboard organs. No, the frontier had changed. Computers changed the language. Transistors changed the tools. And there, in the middle of a bustling Paris, IRCAM sat underground—the studios caves full of composers experimenting with sound in this new age. In a 1982 article by Stewart McBride in The Christian Science Monitor, IRCAM was described as a "subterranean kingdom of absolute silence and infinite sound… the world's largest and best-endowed electronic and computer music center." And rather than replace real-life musicians or acoustic sounds entirely, as was the mission of Thaddeus Cahill and the belief system behind the RCA Mark II, IRCAM was a unique place where digital music and acoustical studies combined. Boulez himself created one of the first prominent electroacoustic compositions, a combination of technology and live musicians. His 1981 piece *Repons* combined an ensemble of 21 musicians, 6 soloists, and a computer. In its performance, the soloists were recorded, processed by the computer, and projected back into the hall along with the live performance of the orchestral musicians. It was a true fusion of acoustic and electronic sound in one piece. Even IRCAM's performance hall itself is fluid in its

design, able to lower the ceiling and rotate the walls to different acoustical surfaces to suit the piece. If you think that's neat, just wait until the next episode where I talk all about acoustics and reverb!

[*brief musical transition*]

[49:40] The technological boom of the second half of the 20th century connected the world like never before. We had all these researchers and creators trying to use these new tools to create new genres and techniques in music production. There came a point at which digital music developments needed to share a common language to promote compatibility, synchronization, and collaboration. In 1981 a new protocol emerged to standardize communication between devices so everyone's music equipment worked together. Allow me to introduce you to… **MIDI**. M-I-D-I, an acronym for Musical Instrument Digital Interface. Rather than sending an analog waveform as an electrical signal through an XLR cable from your mic to your interface, MIDI comes in the form of data messages. It's a digital language. Fast, efficient, and detailed. MIDI messages contain instructions about musical events that your computer or synthesizer will follow. For example, if you tell a musician to play a C, it's a simple task, yes, but your musician would have several questions about that task like: in which octave? For how long? How loudly? All of those questions are answered in a packet of MIDI data: pitch, note on, note off, velocity. Even musical expressions like crescendo, diminuendo, vibrato, glissando. They all map to MIDI messages. And because we can strip back a melody into its most basic building blocks and map it using MIDI data, that means it can be easily edited, played back on any virtual instrument, copied/pasted, layered, the opportunities are limitless. Today we work with MIDI all the time inside of **Digital Audio Workstations** like Logic and Pro Tools. Digital music producers, composers, and orchestrators will often use a MIDI keyboard that is, in essence, a digital piano, that has sensors and programming built-in to generate MIDI data from what they play on the keyboard. It gets mapped out in block-like notes and then they assign it to different **virtual instruments** like sampled strings, woodwinds, percussion, or completely new digitally synthesized sounds, blending soundscapes of MIDI tracks and recorded audio all within one program. Such is the power of the Digital Audio Workstation—which developed alongside MIDI in the late 70s and 80s. It really started to become the software we recognize today when Digidesign introduced **Pro Tools** in 1991.

With MIDI, Digital Audio Workstations, and the continued revolutionary strides in computer processing with ever-shrinking semiconductor components, the average laptop today has more music production capabilities than even RCA's room-sized Mark II synthesizer. Not to mention, we're carrying a phone in our pocket with a more sophisticated microphone than the entire first half of the 20th century.

We're seeing a rise in **home studios** as these technological developments make production more accessible, and as **digital streaming platforms** make the global audience more accessible too. We're still inventing instruments—get this, the **EWI**, electronic wind instrument, is a MIDI controller that a woodwind musician can play, using the same breath and key control as one would play a flute, clarinet, or saxophone. The sensors inside map the articulation, air movement and pressure, and key combinations into MIDI data. That MIDI data can be assigned to any virtual instrument and effects you want. It plays out the sound via a built-in speaker or you can record directly into your DAW. I haven't personally had the opportunity to play a EWI, but I do have one in my shopping cart as we speak…

[*brief musical transition*]

[54:27] Now that we've gone through an extensive history, we can reflect on the fact that not many of the early electronic instruments have stuck around, especially not on the world-changing scale they were designed to be. From the musical telegraph to the telharmonium to the theremin, they aren't household instruments, and they certainly didn't replace acoustic instruments or musicians. But they laid the foundation upon which synthesizers, computer music, and eventually digital audio and MIDI would be built. In terms of music distribution methods, in the 20th century we saw wax discs get overtaken by vinyl to get overtaken by cassettes to get overtaken by CDs that, in the turn of the century, were overtaken by handheld music devices like iPods, only to be yet again overtaken with internet music streaming. In terms of recording methods, developments in microphones coincided with developments in the telecommunications industry, and the push for precision, quality and flexibility in recording led to developments in consoles and tape machines. Digital Audio Workstations led the way to new production techniques with less equipment and more collaboration. Some producers are working entirely in-the-box, no console or analog outboard gear required. Just a mic, a preamp, and a DAW. But we're not done. **Emerging technologies** continue to shape the industry and market, which drives demand in certain areas and skills. It's our job as audio engineers and producers to continue to meet the needs of our artists and fans, and push the boundaries with each new stride in technology. We're on the cutting edge of some, kind of scary directions, relying arguably too much on not just plugin presets but full-on AI production tools, maybe to the point of it not being a creative tool or time-saving technology anymore, but a takeover. That's a nuanced subject that deserves its own episode. This episode is about history. But if I've made one thing clear it's that we've been here before. With every new stride in human innovation, comes an immediate application to music. And still, every generation thinks it's living through the biggest technological disruption in music history. Gray thought so. Cahill thought so. Babbitt thought so. Moog

thought so. Max Mathews certainly thought so. Maybe AI really is different. Or maybe history is reminding us that musicians ultimately decide how to put new technologies to use, and it's okay if we don't agree. We saw factions arise between classical and commercial music throughout the 20th century. Today we face divisions between the ivory towers of avant-garde computer music to the bedroom studios of indie pop stars. But we all have a choice: How to use new technology in music. And I have a feeling it will be another tick on our timeline that another podcast writer 50 years from now will yap about like I have the last hour. Thanks for coming on this journey with me. From forty-thousand-year-old bone flutes to the electronic wind instrument, we've come a long way. And there's still so much more we can cover, but I'll save that for another time…

[Red Pin Podcast Outro Music begins in the background]

Up next is Sound in Space: a scientific and creative look at reverb and acoustics. As always, check out redpinproductions.com for more information. Consider becoming a sponsor to get special shout-outs, early access, and behind-the-scenes content. I'm Aleyna Neivandt-Brown. Thanks for listening.

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