Bending the Headspace of Electronic Design

chapter 1

My shop teacher in junior high school was a straight-shootin', all-business, dyed-in-the-wool, only-one-way-to-do-it electronics and woodworking professor with whom I'd argue issues in a heartbeat. He was strictly over-the-counter, and I, strictly counter—"counter-culture," that is. He was quick and sharp; it was rare to leave him speechless.

On the day I brought my first circuit-bent instrument to school (a shorted-out amp now built into a wooden box replete with dials, switches, sensors, patch bay, nuts glued on the lid, and more), my shop teacher was already grouchy and looking for an argument. He approached as I had the instrument out on the workbench. All my classmates had gathered around to listen. I was synthesizing birds, helicopters, and police sirens on the instrument, and running electricity through several people at a time so that we could play the device by touching each others' bare flesh.

My teacher assumed that I knew things I'd not let on to in class (we were making a table lamp out of a bowling pin at the moment, and nowhere in the entire school could you learn synthesizer design). He looked at the dials, looked at the switches, looked at the nuts on the lid, leaned forward, looked me in the eye, and said, "Mr. Ghazala, I didn't know you knew anything about electronics." I leaned forward, looked him straight in the eye, and said, "I don't."

That's the beauty of circuit-bending; anyone can do it. You don't need to be an electronics guru or a shop genius. All you need is the ability to solder and to think outside the box.

Why Bend?

In this day of high-tech electronic synthesis and sampling, why are so many people raiding the second-hand shops, buying and bending yesterday's toys? Good question.

in this chapter

Simplicity: Anyone Can Bend

My shop teacher *was* speechless when I told him, quite truthfully, that I didn't know anything about electronics. I really didn't. I knew a little about soldering, but that was it. That's all I knew then, and with the simple approach this book uses for circuit-bending, that's all you need to know now. And soldering is baby-simple.

Circuit-bending is currently being taught all over the world to people of all ages. MIT has a program teaching grade school kids to bend (imagine—kids learning experimental electronic instrument design at the age I was learning in school to play a plastic flute).

So relax. We won't be getting into scary theory here. You don't need it. As far as electronics goes, you'll be finger painting. Nonetheless, you'll be building some of the most interesting music engines on the planet.

Your Immediate Canvas

At one time, painting was, at least technically, far from the relatively easy task it is today. Today's prestretched canvas and premixed paints, accompanied by brushes ready to buy along with assorted gessoes and sealants, make the modern painter's canvas pretty "immediate." You just walk up to it and paint.

But at one time painters had to craft their own pigments and paints and know much more about the actual science involved in their medium before it was even possible to dip a brush. These nature-gathered raw materials resulted in the palette of the Dutch Masters, a rather subdued range centering on dark, warm siennas and umbras. Makes me wonder what these guys would have done with Day-Glo fluorescent paints. Maybe a bad idea.

Many people fear electronics. If you don't electrocute yourself, then certainly the stack of drab theoretical texts to conquer is daunting all in itself. Circuit-bending changes all this: electronic design is now colorful and nearly instantaneous. No, you're not going to get electrocuted. Yes, we'll use the books—if the workbench needs leveling.

Essentially, to bend a circuit you hold one end of a wire to one circuit point and the other end to another point. That's it! Place the wire upon the circuit in an arbitrary fashion, wherever you want, from here to there on the board. This replicates the pure-chance aspect that launched my first instrument as it shorted out in my desk drawer, and it is still the heart of bending. If you hear an interesting sound, you then solder the wire in place, putting a switch in the center of the wire so that the new sound can be turned on and off. That's pretty immediate!

As with the painter who no longer needs to understand the *science* of pigments to create art, circuit-benders no longer need to understand the *theory* of electronics to design instruments. Finally, with electronics, you can just walk up to it and paint.

The Coconut Concept

At first, this free-for-all we're having with circuitry might seem out of place. Fact is, earthlings *musicalize* things. A coconut washed up on the shore could be struck like the wood block of a percussion set. It could become the shell of a drum, the vessel of a flute, or the resonator of a fiddle. Idiophone, membranophone, aerophone, or chordophone, the simple coconut can be modified to fit all the major instrument groups of the orchestra. Add steel strings and magnetic pickup to the coconut fiddle and you've got the electronic group covered, too (Gibson guitars, give me a call).

Second-hand shops, where I find most of the circuits I bend, are like high-tide lines on a beach. They're high-tide lines for a different ocean—the ocean of western civilization. Instead of coconuts we find here everything else cast overboard by our throw-away society. Circuit-bending sees its circuits as the island native saw the coconut. In fact, in a very real sense, these things are the coconuts of our island. Adapt the coconut, adapt the circuit (see Figure 1-1).

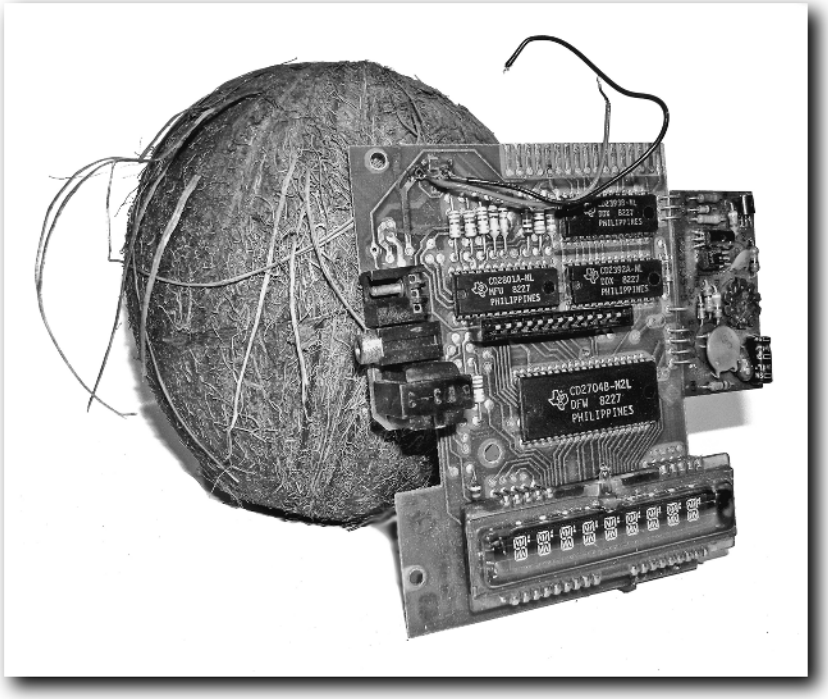

Figure 1-1: Circuit and coconut—one and the same

Taking it a little further, and though not a chance art, the chopping and hot-rodding, repainting, rewiring, and renaming of that '57 Chevy you see at the car show is done in the same vein as circuit-bending. Each effort reflects a desire to push the limits of a thing. I recently spoke at a circuit-bending convention in New York City where, as at the car shows, industry dollars propped up the event!

Bending has come a long way from the night in the 1960s when the band and I had to fist-fight our way out of that performance-gone-bad with the Elvis fans at our heels. I recall that we decided not to play there again.

The Threshold of Invention

That the golden age of invention is dead is a romantic notion at best. True, corporate research and development labs seem to outdo the practical capabilities of garage tinkerers. But the truth is that we live in a rich world of discovery, right here, every day. Just depends on where you look.

There is a principle discussed among all inventors, unnamed heretofore. A principle of simultaneous discovery. I discussed it most recently with blacksmith Howard McDaniels of Lebanon, Ohio, a modern smith whose work spans traditional utilitarian repair and fabrication to artistic ironwork to high-precision pieces for the nuclear industry. Howard's example of this principle was how similar developments in metallurgy occurred, unrelated, in various places around the planet at the same time. I call this technological/sociological time-wave the *threshold of invention*.

Although experimental electronic music labs have been around since the 1950s (Columbia-Princeton being the prime example), the music produced then was appreciated mostly within academic circles. This tradition extended fully into the 1960s, relative not only to appreciation of experimental electronic instruments but to experimental design as well.

Important to us is the period of the mid 1960s. Transistorized, battery-powered electronics were now somewhat commonplace, at least in the form of pocket radios and walkie-talkies. Lots of these circuits were susceptible to interference if the circuits were touched, suiting them aptly for the technological side of the equation. What's still missing is the sociological.

Not that experimental electronic music geared for the general public didn't exist prior to the 1960s. It did! You could hear Bebe Barron's self-destructing circuits bubbling away in the movie *Forbidden Planet*, representing the music of the Krell, an extinct master race (something seems wrong there, eh?). Small-town America's Saturday matinees overflowed into the streets with weird electronic oscillations as the assorted sci-fi "B" movies of the 1950s came and went, their otherworldly music colliding head-on with the real-world cold war headlines boxed next to the ticket window.

Little kids were considered as good a target as adults for experimental electronic music in the 1950s. I had a recording that I listened to as a young child, a kid's 45 rpm record, called "Omicron Visits Earth." In this comical fable of a crashed spaceship, Rege Cordic and Co.'s weird electronic oscillator music bridges the story's chapters.

But it was not until the Beach Boys' "Good Vibrations" that a large popular audience had to deal with experimental electronic instrumentation. Musically set as it was, within the Beach Boys record-selling surf-board-rock style, the theremin struck a wavering note with the public, and the electronic instrument stage was set for bigger and better, not to forget louder, things.

Actually, the instrument heard on "Good Vibrations" (and two or three other Beach Boys songs) was not a theremin at all. Instead of being "space controlled" (played without touching) like a real theremin, Bob Whitsell's "Electro-Theremin" was a *mechanically controlled* oscillator. For accuracy's sake, this instrument might be better named the Mechano-Theremin. But then, that wouldn't be a theremin at all, would it? The Electro-Theremin heard on the Beach Boys' hit was hospitalized at the end of its career. It was then the elderly, not beach bunnies, "pickin' up good vibrations" from the instrument: In the hospital wards the Electro-Theremin was used to test the hearing of cranky oldsters, many of whom, no doubt, had heard it in earlier days and promptly turned their radios off.

The 1960s public was ready, as Bob Moog would discover, for electronic synthesizers. Things were happening within corporations and universities—research teams were designing both musical as well as purely experimental electronic instruments (the latter wonderfully exemplified by the Michel Waisvisz/Geert Hamelberg "crackle box" of the late 1960s, an instrument later developed at Steim in Amsterdam that, although from the start designed to do what it does and therefore not a circuit-bent or chance-designed instrument, still uses body contacts for control).

But something very important—more important to us, in fact—was also happening outside the theory-guided teams and institutions. It was happening way down at street level. A totally new approach to design was being launched. Renegade electronics' insurgence was at hand.

The threshold of invention, placing susceptible mid-1960s electronic circuits and music-curious humans upon the stage simultaneously, was at work creating its usual synchronicity of planet-wide discovery. All over the world, lone wolves like me were discovering that the accidental howling one encountered upon touching the live circuits of battery-powered audio electronics was musical.

Where Did Circuit-Bending Start?

Probes are sent into deep space to listen to alien worlds, but alien worlds aren't always that far away. For me, in fact, a portal to an alien world was hidden in my childhood home, right at my fingertips. Here's what happened.

I'd always been interested in unusual sounds and music. I even awoke once actually singing along with an otherworldly choir I was dreaming of, startling my mother awake in the next room. Five-year-olds singing in foreign tongues from somewhere in dreamland? I was delighted, my mother a little less so.

This was the mid-to-late 1950s, the same period in which I was tuning between FM stations to hear the strange squeals, touching the glowing tubes to listen to the weird buzzes, and fingering my walkie-talkie circuits to get that loud and nasty "WAAAA!" sound.

A "Girder and Panel Hydrodynamic Building Set" had me constructing plug-in circuits when I was eight or so, after building electric motors for plastic models for a few years prior. I became enamored enough with electricity to necessitate the safety capping of all unused wall outlets lest I repeat my paper clip stunt, which I was, luckily, caught at while performing its debut.

I spent my best moments during these years whistling through vacuum cleaner hoses and talking through spinning fans, hitting telephone poles with hammers (press your ear to the pole right after—try it!), and all the other noisy stuff kids do in their off-time, all day long. And I

listened to the distant world through my "Big Ear," an electrified parabolic sound dish, always pointed toward the future, toward what the 1960s was about to bring.

Synthesizer music, in the mid-to-late 1960s, was all the rage. It was new to most people and very, very cool—especially if you were a 15-year-old hippie-musician, as was I! However, my friends and I were all penniless, and the possibility of our getting hold of a synthesizer was certainly remote.

So we listened to the oddball electronics of Silver Apples, Aorta's "special effects," Joseph Byrd and Gordon Marron's electronics on the seminal *United States of America* album, plus *Switched on Bach's* new Moogs as well as the earlier music of such experimental electronic composers as Bülent Arel, Mario Davidovsky, and Vladimir Ussachevsky working out of the Columbia-Princeton Electronic Music Center. And we wished we had a synth.

My high school desk drawer, circa 1967, was my junkyard. In it I had a wrecked Radio Shack mini amp. This was a nine-volt, battery-powered transistor amp containing no integrated circuits (ICs) at all. Inside were just a few small transformers, transistors, resistors, and capacitors, all gathered around a small central speaker. The gray plastic case was no larger than the palm of your hand and looked as uneventful as a gray, overcast sky.

With the muses of blind luck on my side I'd left the battery in, the back off, and the power on. In pursuit of some other item in the drawer, for a project now lost in time, I'd pulled the drawer open to rummage around. All my cool stuff was in there, nestled around the little gray amplifier that was about to change my world, just as it is about to change yours.

I closed the drawer and was immediately in the midst of some of the most unusual sounds I'd ever heard. Why? By pure accident, some unknown metal object had fallen against the exposed circuitry of the amp, shorting-out the electronics.

Of course, I didn't know this at first as I looked at the stereo system (it was turned off) and then all around the room to try to figure out what could possibly be making the extraordinary noises. A "flanged" pitch was sweeping upward to a higher frequency, over and over again, sounding like a miniature version of the massive Columbia-Princeton synthesizers. But I didn't own a synthesizer! Or did I?

Finally opening the drawer and realizing that fate had created for me a mini synth from my toy transistorized amplifier, two thoughts immediately struck. First, if this can happen by means of an accidental short circuit, what might happen by shorting things on purpose? And second, if this can happen to an amplifier, a circuit not meant to create a sound on its own, what might happen if you shorted circuits designed to create their own sounds already, such as toy keyboards and electronic games? Though I didn't name the design concept of the found-by-chance creative short circuit until 25 years later, "circuit-bending" was born.

I soon discovered many different creative short circuits within the mini amp's circuitry by using a hair pin to span the circuit, point to point. Additionally I found that all kinds of interesting variations in sound would occur when I ran these new circuits through various electronic components, things such as potentiometers, photo cells, and capacitors. A series of instruments resulted as this original circuit was rebuilt into various configurations to allow more room for these electronic modifications.

The first was the most unusual. Designed and redesigned during the period of late 1966 through early 1967, it settled into an aluminum foil body-contact and patch-bay instrument. Yes, with spinning speakers (see Figure 1-2).

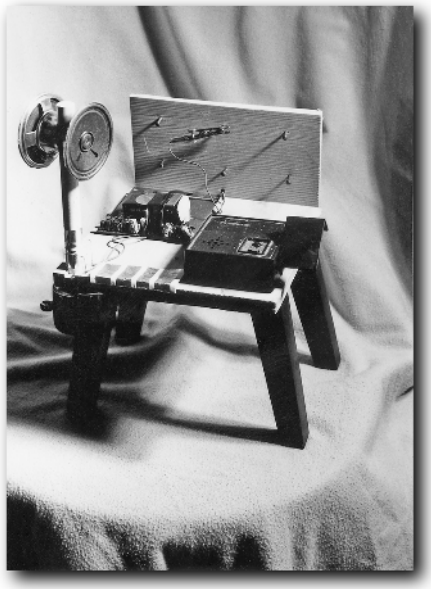

Figure 1-2: Ghazala's first circuit-bent instrument, c. 1967–1968 (mock-up; the original was destroyed by an irate audience)

I'd found that simply by touching the bare circuit with my fingers, I could get it to squeal, and even—with careful adjustment of finger pressure—actually sweep the pitch with a degree of control. By soldering wires to these body-contact points, I extended them to aluminum foil pads on the instrument's front control surface so that they could be touched with ease.

Then, I implemented all the interesting point-to-point short circuits I'd discovered in a patch-bay fashion using a backboard on the instrument. Nails were driven through the backboard. A wire was then soldered to the extending tip of each nail, behind the backboard, and these wires were then soldered to sensitive circuit points.

Another wire was then soldered to a final point on the circuit, a point that when connected to any of the other points, which were now extended to the nail heads on the patch bay backboard, would result in new sounds. To this lone wire I soldered an alligator clip, enabling the wire to be clipped to any nail head on the patch bay, thereby making the circuit-bending connection and creating the new sound.

The amp's original speaker was replaced by a pair of similar speakers, now attached to opposite sides of a wooden dowel. Mounted onto the axle of a powerful slot car motor, the speakers could be spun using the slot car's original motor and accelerator pedal, mounted now on the instrument's playing surface.

In my neck of the woods, in the late 1960s, a 15-year-old hippie kid playing a prototype synthesizer with tiny spinning speakers was not always embraced with critical enthusiasm. Especially if playing in a neighborhood church to rowdy Elvis fans. The resulting tussle damaged this fragile instrument to the point that all I could salvage was the circuit.

Certainly not recognizing this as a classic incident of experimental music–meets–John Doe, instead thinking practicality, I simply redesigned the circuit into an irate public–resistant case. And so it survives to this day.

The new instrument, finished in 1968, was housed within a lidded cedar box. I'd glued whole nuts, in the shell, inside the lid to accommodate the patch cords that could, in one way or another, be wrapped around the nuts to keep them close at hand while still out of the way. (Well, you work with what ya got, right?) Thanks to a friend who enjoys surrealism as much as boysenberry juice, this instrument became known as "The Odor Box" (see Figure 1-3).

Figure 1-3: The Odor Box containing the original bent circuit, now audience-proof, c.1968

The patch bay was now implemented with ⅛" audio jacks on short cords instead of with the alligator clip and nail system. No, they didn't carry audio, just the shorts I'd discovered. Also new to this circuit was a rotary switch allowing the shorts to be sent through a collection of resistors and potentiometers as well as a photo cell. The aluminum foil body contacts were now

replaced with solid metal domes. I added a separate toy organ circuit to experiment with polyphony and beat notes (the pulsing you hear when two frequencies are close to the same).

Also added were a separate amp and line outputs for recording and amplification. Later I added light-emitting diodes (LEDs) as soon as they hit the consumer marketplace.

Yet another version from the same time period was my portable body-contact-only model. Containing eight foil contacts, it could make all kinds of bird and insect noises (see Figure 1-4).

Figure 1-4: The Cat Box, a slimmed-down, meowing and chirping, all-body-contact instrument, c. 1968

Because it was simply unheard of back then, in the 1960s, to carry around pocket-size electronic bird synthesizers, holding the instrument under a restaurant counter and making it chirp like a song sparrow produced a fine audience. Especially if you pointed up toward the light fixtures at the same time and said things like "There he is!"

Technology produced more and more complex sound circuits, and my orchestra grew and became diversified. Alone in my suburban basement, I relentlessly experimented in my ad-hoc sound lab. I made *working* science fiction instruments while *Star Trek* debuted on TV, and while *Lost in Space, The Jetsons, 2001: A Space Odyssey*, *Close Encounters of the Third Kind*, *Star Wars*, and so many other sci-fi episodes special-effected instruments into existence. And I listened, often amazed, to what seemed to be a new, alien world of music.

Here in the United States, along with myself, John Hajeski had also fallen down the same 1960s rabbit hole. Admiring the ghost in the machine, John created his "portable anarchy" instrument: a suitcase of circuit-bent radios that, via body-contacts, like my first instruments of the same era, could make experimental electronic music with the touch of a finger to the circuit. John and I weren't aware of our similar experiments. As with us and so many others who certainly heard and recognized the creative short circuit back then, the threshold of invention swept us all along like so many voided warranties in the wind.

Enter EMI

It was in *Experimental Musical Instruments* magazine, in 1992, that I first published the term "circuit-bending" in an attempt to help identify the emerging art, open it to discussion, and differentiate it from the more expected and theory-true design processes. Ever since then, the art has been gaining momentum and demanding clarification while spreading, like alien musical bacteria, throughout the planet's circuitry. The result is at least a design revolution in electronics if not, as the press has responded, "the planet's first electronic art movement," the "first electronic art-object movement," or even the "first grassroots electronic music movement."

Doesn't really matter. What matters is that you're here, as was the EMI audience before the art was afforded any major press at all, and that we're at the beginning of the era of circuit-bending. As did the school of impressionism, bending will branch and produce numerous artists who will work in varied styles. Most of the new music and instruments still await discovery. The field is *exceptionally* wide open.

Think about it. In one easy evening you can discover and build an instrument capable of making sounds and music no one else has ever yet heard, an instrument that exists nowhere else in the universe. Within circuit-bending's threshold of invention, the golden age of discovery is not dead at all! In fact, you're about to learn enough about circuit-bending to do some inventing of your own. The following chapter explores circuit-bending's new instruments and their often unbelievable behavior. You'll be introduced to the concept of *chance* electronics, the mechanics of *clear illogic*, and how you yourself can become a new species by actually melding your body with the electronics of the circuit. You'll discover a new way to look at the lifespan not only of bent instrumemts but also all musical instruments. Most important, the next chapter takes you inside circuit-bending's garden, an electronic zoological garden where you'll meet the creature instruments you're about to design.