Immortal Coils – Toiling in Electromagnetic Fields
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There are two things in life that remain interesting from earliest childhood to death: dinosaurs and magnets. In the case of the latter, the spooky action through a distance of levitating magnetic donuts is universally captivating. And, although I am not a man of faith, if a rabbi, an Iman or a priest wanted to convince me of the existence of God all they'd have to do was whisper the word "electromagnetism": the palindromic transformation of magnetic fields into currents, and a currents back into magnetic fields is so clever that sometimes it's hard even for a skeptic like me to believe that it arose by chance during the Big Bang rather than from a very wise mind. Since magnets and electromagnetism are essential to any form of amplified sound, experimental musicians seem especially susceptible to their charms.

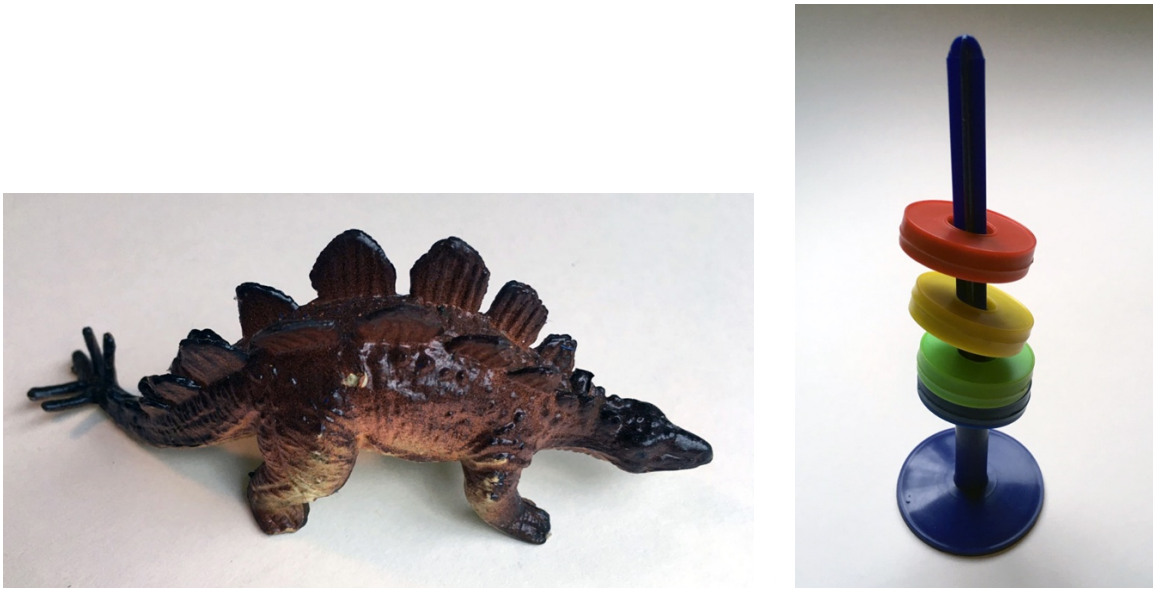

Figure 1: Two interesting things: Stegosaurus (left) and levitating magnets (right).

A dynamic microphone transforms sound into an electrical signal via a thin plastic membrane glued to coil of fine wire encircling a cylindrical magnet: pressure waves jostle the diaphragm, which moves the coil back and forth around the magnetic, inducing a current in the wire. A loudspeaker reverses the process: the amplifier sends current through a coil, inducing a fluctuating electromagnetic field that interacts with the fixed field of a big magnet (think of pushing or pulling a magnet across a tabletop by sliding another one near it); the coil vibrates the paper cone it's glued to, and the resulting waves reach our ears as sound. A microphone and a speaker are built from the same basic parts, only one is usually much smaller than the other. You can verify electromagnetism's reversibility by using your earbuds as a microphone (many a garage band recorded their first demo tape this way), or listening to sounds that come from a dynamic mike when you plug it into a headphone jack.

The pickup in an electric guitar is essentially a microphone whose diaphragm has been replaced by steel strings vibrating above the coil: string movement in the field of the pickup's magnet induces current in the pickup coil. Around 1982 my empirical experience with the microphone<>speaker symmetry of electromagnetism suggested that a guitar pickup connected to the *output* of an amplifier might be able to move the strings, as an alternative to strumming. One cheap pawnshop guitar later I had a radio station vibrating the strings; it sounded like a cross between a reverb and a set of highly resonant filters, or like shouting into a piano with the sustain pedal down. This "backwards electric guitar" provided an opportune bridge between the acoustic experimentation of my mentors like Alvin Lucier[1] and the visceral music that competed for attention in New York's clubs at the time[2]. I built a series of instruments over the next twenty years, and wrote compositions for solo and ensemble settings, as well as incorporating them into sound installations[3]. Radio, tapes, oscillators, hacked toys and live vocals resonated the strings, which were chorded, dampened and retuned[4].

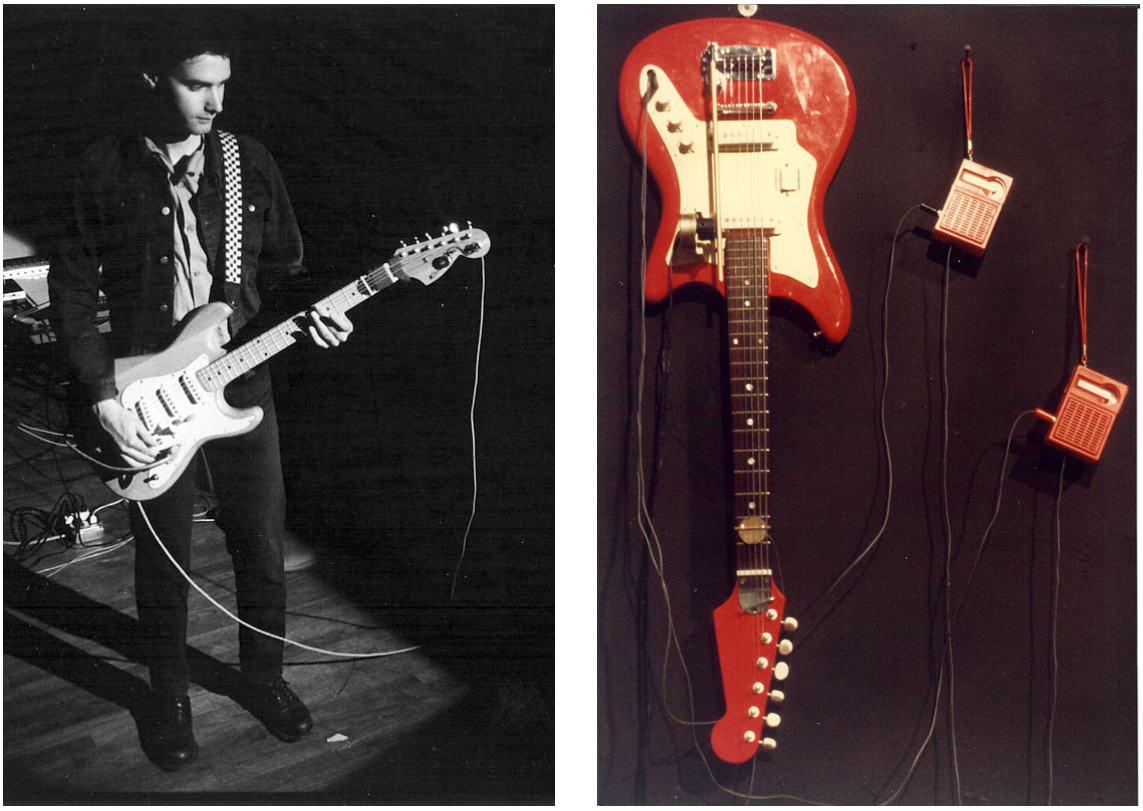

Figure 2: Left: Robert Poss performs *Killed In A Bar When He Was Only Three* at The Kitchen, NYC, 1982 (photo by Paula Court). Right: Installation of *Killed in a Bar* at PS1, Long Island City, 1982 (backwards electric guitar with whammy bar wobbled by clock motor, strings resonated by two radios).

As most guitarists know, their instruments sometimes pick up sounds that don't come from the strings: local radio stations, buzz from stage lighting, whining motors, etc. Which brings us to

another spooky feature of electromagnetism: coils of wire, such as the windings in a guitar pickup, will transform any electromagnetic signal into an electrical current. A radio station transmits an electromagnetic wave that has been modulated by an audio signal (music, talk, a telegraph key); a radio receiver detects this wave, demodulates the audio from the carrier, and amplifies it for us to hear. Most electrical devices spill a fair amount of electromagnetic energy -- people assume electricity flows through wires like water through a pipe, but those wire are more like ditches or canals, and they leak along the way. The unwanted noises coming out of your guitar are a function of your pickup acting like a radio antenna detecting that spillage; your Marshall brings it to our ears. If you're curious about the secret life of your household appliances you don't need a guitar, however: almost any coil of wire will suffice. You can buy a standard electronic component called an "inductor" and hook it up to an amplifier, or tune your AM radio to the dead band at either end of the dial. Move your detector as close as possible to your electrical devices, since the strength of a magnetic field follows the beautifully-named "inverse-square law" and the signal weakens rapidly with distance from the source.

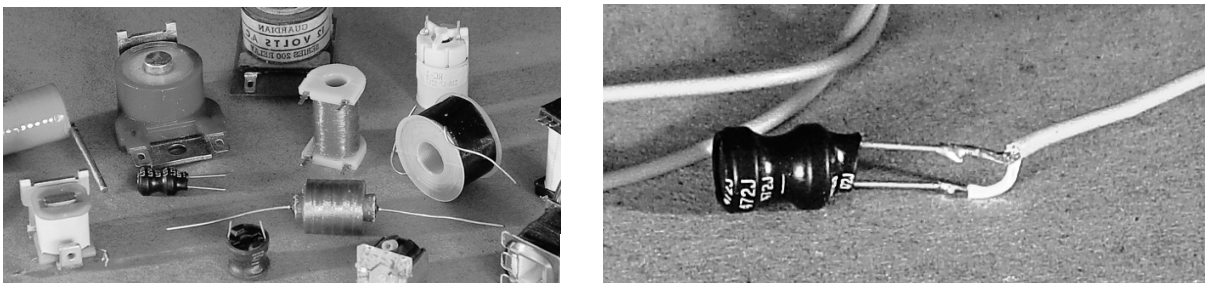

Figure 3: Various coils (left) and an inductor soldered to cable for "circuit sniffing" (right) (photos by Simon Lonergan).

I got interested in "sniffing" electromagnetic fields early in my pursuit of electronic music: the sounds were unexpectedly rich and the coils were cheap. After reading that some of the earliest "computer music" emerged from an AM radio placed on the BINAC mainframe (1949) I slid a transistor radio across the top of my first single-board microcomputer and listened to the melodies in my programs[5]. When portable CD players were introduced in the late 1980s I eavesdropped on the quirky chirping emitted by their motors and servos.

In 2001 backwards guitars and circuit sniffing collided in *Mortal Coil*[6]*.* In one of my periodic fits of shrinking the size and weight of my touring equipment I had built a lap-steel-style backwards guitar with all necessary electronic crammed inside a framework of two Home Dept levels[7]. My tailor sewed inductors onto the fingertips of a glove; the outputs were split between a four-channel PA and six small amplifiers powering driver coils under the guitar strings. As I moved my hand over a variety of objects – my laptop, a CD player, a fan, a plasma light – the sounds of their electromagnetic fields panned amongst the speakers and resonated the guitar strings, which were in turn amplified through the PA.

At some point in the development of this piece my gloved hand passed near the strings and started to feed back with the driver coils. As for many composers of my generation, feedback

was one of my first tools for musical experimentation: on a student budget in the era of expensive analog synthesizers (1970s), its cheapness was as significant a factor as its sound and responsiveness[8]. Discovering a new order of feedback three decades after my first encounter with the phenomenon was the kind of fortuitous surprise that periodically reinvigorates my music. In *Mortal Coil* the interaction of the multiple pickup and driver coils generate a polyphony of rhythmic pulses and Theremin-like swoops, inducing ethereal washes of harmonics in the strings; adding distortion to the guitar output pushes the texture into the domain of Metal excess.

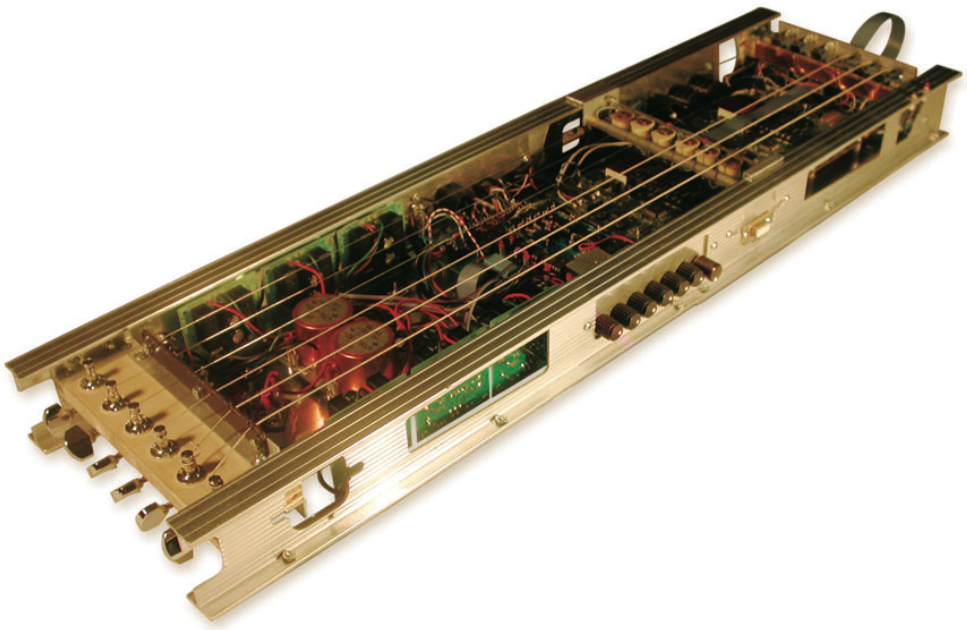

Figure 4: "Level Guitar" for *Mortal Coil*: backwards electric guitar with a driver coil under each string, piezo bridge pickup, driver amplifiers and associated electronics embedded in frame of aluminum levels (it also still works as a level) (photo by Simon Lonergan).

Both for their sonic possibilities and their pedagogic value in demonstrating electromagnetism, coils have figured prominently in my book *Handmade Electronic Music – The Art of Hardware Hacking* and in my teaching over the past two decades[9]. Recently, in workshops and concerts around the world, I have noticed a surge of interest in the sounds of electromagnetic fields, which prompted me to re-examine the material of *Mortal Coil*. I stripped away the guitar, motivated (again) in part by a desire to reduce the mass of my concert tech, but also to foreground the electromagnetic sounds over the more familiar texture of the strings. I retained the glove. The signal from each fingertip pickup is split. One half passes through an amplifier to a pair of coils on the table-top. These driver coils include inductors, transformers, relays, solenoids, tactile transducers and small speakers. As the hand nears the table the pickups and

drivers feed back with one another; the pitch, rhythm and phrasing are affected by the location, shape and movement of the hand, as well as the electrical characteristics of each driver.

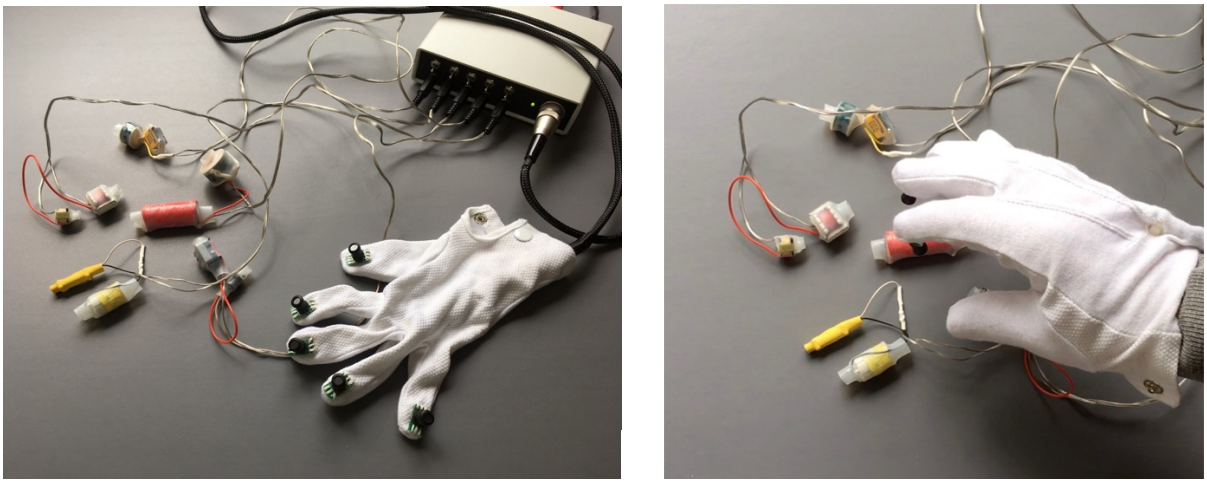

Figure 5: Left: technology for *Immortal Coil*: driver coils at left, glove with pickup coils at right, circuitry at rear. Right: *Immortal Coil* performance gesture.

The bandwidth of feedback between a microphone and speaker is constrained by the frequency response of those two devices: since both are intended for use in the range of human hearing, the sound is usually limited to the audible range. Electromagnetic feedback between coils is not similarly restricted, and extends far beyond pitches we can hear. Curious about what was taking place, unheard, in the infrasonic and ultrasonic regions, I sent the pickup outputs into my laptop, on which I run a simple program (in Max/MSP) that divides the signal from each of the four fingers into three bands: those within the range of human hearing (c. 20Hz to 15kHz) pass through unprocessed; those above 15kHz are frequency-shifted down into hearing range; those below 30Hz are shifted up. The performer has the option of toggling on and off each of these bands with keys on the laptop, varying the density of the sound.

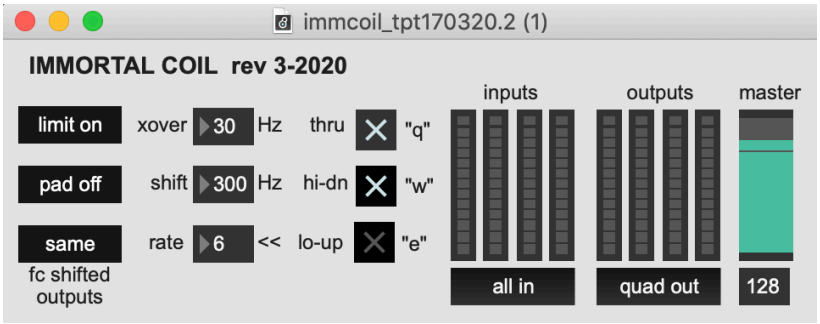

Figure 6: Max patch for *Immortal Coil*, controlling band-split frequency shifting.

The signals from each of the four fingers are routed to one channel of a quad PA system. The output of the thumb pickup is sent directly to the subwoofer only, with no processing -- we

hear very low frequency feedback only, un-transposed, a thunderous rumbling. The performance of this new piece, *Immortal Coil*, begins with sniffing the emissions of various electronic objects on the table before moving on to raucous feedback; the sounds pan dramatically in four-channel space as the hand moves through the electromagnetic fields[10].

I have been making music with software almost as long as with circuits, since the early (pre-Apple) days of affordable microcomputers. I am in awe of the evolution of ever more powerful digital platforms and programming tools, their liberation of my work from earlier constraints, and their opening of new creative pathways. Yet I keep my soldering iron warm. "History is a spiral, like the groove on a record," Robert Poss (founder of Band of Susans) once told me, echoing the 19th Century Swiss cultural historian Jacob Burckhardt. Sometimes old ideas (like feedback) return, displaced slightly but significantly, and new work arises. Immortal coils[11].

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[1] See Alvin Lucier. *Music on a Long Thin Wire.* Lovely Music LP, 1980. When I demonstrated my first backwards guitar to Doug Simon, a former student of Lucier's and the interviewer for the material in *Chambers* (Wesleyan Press, 1980), he commented, "music on six short thin wires".

[2] Rhys Chatham similarly chose the electric guitar to connect lessons from his mentors LaMonte Young and Marianne Amacher to the visceral excitement of The Ramones– see *Guitar Trio* (1978).

[3] The first of these pieces actually got me onto the stage at CBGB: *Killed in a Bar When He Was Only Three* (1982) (http://www.nicolascollins.com/music/killedinabar.mp3).

[4] See http://www.nicolascollins.com/texts/BackwardsElectricGuitar.pdf.

[5] *Little Spiders* (1981) (http://www.nicolascollins.com/music/littlespiders.mp3). My first computer was a Synertek Vim, recommended by colleagues in the early microcomputer music movement as the "next generation Kim". We typically sandwiched the circuit board (about the size of an A4 sheet of paper)) between two layers of acrylic plastic, providing a smooth surface on which the radio would slide like the planchette on a séance table. For more information see "Before There Was Apple There Was Kim -- the Microcomputer, Music and Me" (http://www.nicolascollins.com/texts/microcomputermusic.pdf) and

[6] On *Feedback – Order From* Noise. Mikrotone Records (Moscow) CD/DVD, 2014. A different performance can be heard here: http://www.nicolascollins.com/music/ueamortalcoil.mp3.

[7] This instrument grew out of a discussion with Ed Osborn during a soundcheck in Dortmund. Of the five composer-performers on the program, both Ed and I were using Hawaiian guitars as tabletop instruments. We commiserated on the weight of the wood body. Ed was a Formula 1 fan and suggested one might construct a guitar with a monocoque frame, like in an F1 car, rather than a plank, and install all the necessary circuitry inside the frame, instead of carrying it in a separate suitcase. I don't know if Ed ever followed up his own suggestion, but I began work on the Level Guitar as soon as I returned home from the tour.

[8] See "All This and Brains Too". *Resonance* Magazine, Vo. 9 No. 2, 2002. And "Improvising with Architecture – *Pea Soup* and Related Work with Audio Feedback", http://www.nicolascollins.com/texts/peasouphistory.pdf.

[9] Nicolas Collins. *Handmade Electronic Music – The Art of Hardware Hacking* (3rd edition). Routledge 2020

[10] A short demonstration video of the feedback section of *Immortal Coil* can be found here: https://www.youtube.com/watch?v=6bCB4yFJ5MA&t=73s

[11] For more on the different creative implications of hardware and software see Nicolas Collins, "What to Ware? A Guide to Today's Technological Wardrobe". *New Music Box*, March 9, 2016. https://nmbx.newmusicusa.org/what-to-ware-a-guide-to-todays-technological-wardrobe/ (retrieved 10/27/2020).

Photos by Nicolas Collins except where noted.