MUSIC

Coaxing Sounds from Circuits

Tod Machover

A remarkable review appeared in the December 1968 issue of *Saturday Night* magazine, a review that declared "It's a bit surprising that the record of the year (no, let's go all the way—the decade!) is an unembarrassed compote of Bach's greatest hits…that not even the *Reader's Digest* could have topped…The whole record, in fact, is one of the most startling achievements of the recording industry in this generation, certainly one of the great feats in the history of 'keyboard' performance, and the surest evidence, if evidence be needed, that live music never was best." (*1*) The reviewer was the great pianist and incisive wit Glenn Gould (then in the process himself of retreating from the concert stage to the recording studio). The "keyboardist-composer" who created this performance—note by note, splice by splice, layer upon layer—was physicist and studio engineer Walter Carlos (then in the middle of a sex change that would turn him into Wendy Carlos). The record was, of course, *Switched-On Bach*, the album that did more than anything else to bring electronic music, and specifically the Moog synthesizer, into the very center of the music business and of popular consciousness.

Analog Days
The Invention and Impact of the Moog Synthesizer
by Trevor Pinch and Frank Trocco

Harvard University Press, Cambridge, MA, 2002. 384 pp. $29.95. ISBN 0-674-00889-8.

In *Analog Days*, Trevor Pinch (the head of Science and Technology Studies at Cornell University) and Frank Trocco (a professor at Lesley University) tell the story of how the Moog synthesizer came about. They discuss how synthesizers reflected and reinforced cultural aspirations for transformation and transcendence, which were so prevalent in the 1960s. And they explore how this particular synthesizer—developed by Robert Moog and colleagues in a funky storefront in Trumansburg, New York, a backwater not far from Cornell University and adjacent to (believe it or not) the village of Podunk—managed to beat out a host of competitors for commercial success and popular acceptance. The authors do not tell the whole story of electronic music, nor of the many other innovative instruments created before and since the Moog. [Readers can find an excellent overview of that material in Joel Chadabe's *Electric Sound* (*2*).] Nevertheless, Pinch and Trocco have crafted an informative and entertaining account of the complex process by which new instruments and inventions come about, and they analyze the relationship among inventor, user, and general public that leads to widespread acceptance of a new medium or tool. Although not particularly thorough in technical or musical description, the book is crammed with wonderful stories and details about the many colorful scientists, musicians, salesmen, and cult figures (such as The Beatles; Stevie Wonder; and band leader, composer of cartoon and ad music, and inventor Raymond Scott) whose lives intersected through the lure of new musical possibilities.

In many ways, the Moog synthesizer was a very conservative device, one wedged in time between the visionary electronic experiments of Edgar Varèse, Karlheinz Stockhausen, John Cage, and Iannis Xenakis and the more commercial MIDI-based (Musical Instrument Digital Interface standard) computer-music electronics that have become ubiquitous over the past 20 years. But Bob Moog managed to integrate new sounds and techniques, relative ease of use, physical and gestural control, and a genuine concern for his customers' needs. This proved to be a winning combination.

Born in 1934 in Queens, New York, Moog was a classic tinkerer. He specialized in electronics and became enamored of the theremin, one of the first truly original electronic instruments. Designed by Russian physicist Leon Theremin (also a celebrity, Russian spy, inventor of electronic bugging, and eventual Gulag resident), the theremin was a sensation in the United States during the late 1920s (and was popularized again in the 1960s through songs such as the Beach Boys' "Good Vibrations"). Moog figured out how Theremin used the electrical capacitance of the hands to control the pitch and volume of a pair of coupled oscillators. While still in high school, he started to make and sell his own theremins. His passion for electronic music instruments grew through his years as a physics graduate student at Cornell, and it soon replaced his purely scientific work. Pinch and Trocco tell how Moog, a very mild-mannered and somewhat absent-minded fellow, was riding the elevator at Cornell on the way to his own Ph.D. defense: "He was not thinking about solid state physics, the topic of his dissertation [but] about sound and what the resonant frequency of the elevator was…Bob started jumping up and down on the floor [and] somewhere between the fourth and fifth floors he hit the right frequency. The elevator suddenly started bouncing alarmingly in time with his jumps and ground to a halt. Four hours later he was rescued." He did pass his defense but soon moved permanently away from pure physics and toward the exploration of sound.

By the time Moog set up his Trumansburg factory in 1964, electronic music was very much in the air. Moog's big innovations were to design modules specifically for producing musical sounds (instead of co-opting radio test equipment), to provide a technique—a bird's nest of wires and patch chords—for connecting these modules in any combination, and to invent circuits for shaping and modifying electronic signals in musically satisfying and intuitively understandable ways (most notably through the use of electronic control voltages). Moog's individual components were robust, and they sounded great. He continued to invent new circuits and modules and to pull them together into a coherent environment, and in 1966 he coined the word "synthesizer" to describe the system.

Music machinery (1965). One of Moog's first three customers, commercial musician Eric Siday installed a synthesizer in his home studio, where he created electronic jingles, sound signatures, and sound logos.

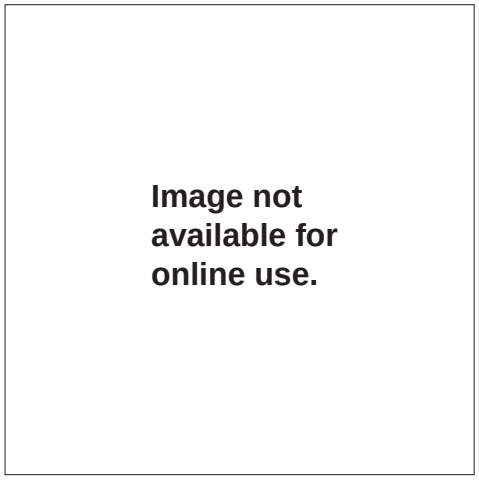
The time was ripe for musical experimentation as well as for cross-fertilization between music of different genres. In London, The Beatles and Karlheinz Stockhausen listened to each others' music; in New York, Leonard Bernstein attended synthesizer concerts at Carnegie Hall and the Museum of Modern Art; and in San Francisco, avant-garde composers such as Morton Subotnick, Steve Reich, and Terry Riley

The author is a composer, inventor, and musician at the MIT Media Lab, Cambridge, MA 02139, USA. E-mail: tod@media.mit.edu

CREDIT: COURTESY ROGER LUTHER OF MOOGARCHIVES.COM

hung out at the all-night "Trips Festivals" organized by Ken Kesey and the Merry Pranksters. Many of the Haight-Ashbury rock musicians had studied "classical" electronic music with celebrated composers like Luciano Berio (then at Mills College). They wanted to fuse the new soundscapes with lightshows and drugs to lead initiates into a new, "other" world. Don Buchla (a brilliant young Berkeley engineering student) became the electronic instrument manufacturer for the hippie generation, and the contrast painted between his synthesizers and Moog's is one of the most telling and poignant episodes in *Analog Days*.

Buchla was the more radical designer. He imagined a totally new kind of music, one based on gesture and texture, generally improvised with complex bursts of sound and



Cult classic. Red letters on the cover of Elektra Record's *The Zodiac Cosmic Sounds* stipulated "must be played in the dark."

little repetition of pitch or rhythm. He favored noninstrumental, purely electronic sounds, the processing and manipulation of live playing or singing, and a total break from the playing technique of traditional instruments. Therefore no keyboard for Buchla, although he did provide a strip of key-like metal pads that measured velocity and heat (the latter used for continuous control effects). Not surprisingly, Buchla's synthesizers attracted radical musicians. One of the most prominent of these was Subotnick, who used expressive vocal sounds as control gestures to shape a complex web of radical, space-age, yet vibrantly human music. His *Silver Apples of the Moon* (1967)—produced entirely on a Buchla 100 synthesizer, and released on Nonesuch as the first composition commissioned specifically for the recording medium—is a masterpiece. Well received by critics at the time, it has endured and is currently enjoying a renaissance of appreciation from a younger generation brought up on techno, trance, and hip-hop.

Soon afterward, *Switched-On Bach* arrived, about as different from Subotnick's composition as any music could be, and its influence proved to be far greater. Walter Carlos had studied music composition at Columbia University, but he felt alienated from the complex, nontonal music then in fashion there. Despite becoming interested in electronics (and completing a joint degree in physics), he had no interest in the avant-garde sounds coming out of the so-called Columbia-Princeton studio. But he became acquainted with Bob Moog and provided informal advice on how to improve the synthesizers. As Pinch and Trocco write, "Bob's detailed knowledge of electronic musical instruments and Carlos's own increasingly refined sense of what he wanted from the new medium made a perfect pair." Carlos desired better tonal quality, more reliable tuning, a portamento control for expressive melodies, and, especially, a touch-sensitive keyboard. Whereas Buchla was a stubborn individualist (and true visionary), Moog took his cues from trusted musicians. The keyboard was added, Carlos acquired a Moog, and the rest is history.

Switched-On Bach was a runaway success, stimulating in its new sounds but reassuring in its presentation of familiar music. Although it is difficult today to listen to the recording (reissued on CD in 2000) with fresh ears, one can admire the audacity with which Carlos recreates the excitement and refinement of Bach's scores. Rather than imitating acoustic sounds or human performance gestures, Carlos replaced these with synthetic re-imaginings, audacious and exaggerated, that more than compensate for the loss of the familiar (and of the vitality and unpredictability of acoustic sounds and natural playing) with a kaleidoscope of sonic details and previously unavailable parameter modifications that make the music sound alive, vivid, and contemporary. As Gould sensed only weeks after the record was released, Carlos had created something totally synthetic that felt more "natural" than a typical "live" performance captured and frozen on long-playing albums (or, more recently, CDs).

From 1968 on, the strands of electronic music diverged even further. Inventors like Buchla developed ever more radical interfaces and controllers that required new playing techniques and musical languages, while Moog became ever more mainstream. (In this he was helped by the easy-to-use and portable Minimoog, as well as the marketing genius, well documented by Pinch and Trocco, of David Van Koevering.) Much of the sound of the 1970s was defined, for better or worse, by the Moog synthesizer: from Stevie Wonder to Emerson, Lake and Palmer; from Pink Floyd to Miles Davis (of that period); from Stanley Kubrick (Carlos did the scores for *A Clockwork Orange* and *The Shining*) to Steven Spielberg; and basically all of disco. Moog synthesizers were so hip that George Harrison not only bought his own in late 1968, he also took lessons with Moog expert Bernie Krause, recorded Krause's pedagogical diddlings without informing him, and released the results, complemented by a whole side of Harrison's even more stupefying meanderings, as *Electronic Sounds* (1969). Luckily Harrison mastered the Moog later in 1969, when he laid down many synthesizer tracks for *Abbey Road*—most notably, those for his own "Here Comes the Sun," perhaps the most beautifully appropriate use of electronic sound in all of pop music.

But even this widespread success for the Moog was dwarfed by the next revolution in music technology. That occurred in 1983, when three events surprisingly coincided: personal computers were introduced; computerized—rather than analog—synthesizers (notably the Yamaha DX-7) became available; and the adoption of a standardized protocol, MIDI, allowed musical information to be sent between any computer and any sound producing or processing device. All of a sudden, electronic instruments were precise. Sounds and "patches" could be stored and recalled. The neutrality of computer processing opened up virtually limitless possibilities for sound design. And with "computer intelligence" in the loop, instruments could interpret and draw conclusions from user performance or sonic history and expectation.

Although I have always felt more comfortable with computer-based music systems than with analog synthesizers, reading *Analog Days* gave me a new appreciation for the true innovations of the great analog-synthesizer designers. It reminded me how many of their ideas have been adapted into current music-tech terminology, and it increased my respect for the odds that these inventors and designers had to overcome in order to have their new instruments become more than curiosities. I do not agree with the authors' claim that the development of the analog synthesizer is "one of the most significant musical moments in the 20th century." (The noise music of Varèse; the prepared and mechanical pianos of Henry Cowell, Cage, and Conlon Nancarrow; the tape recorder; musique concrete and sampling; Stockhausen's elektronische musik; the studio magic of The Beatles and Frank Zappa; Steve Reich's minimalism; Pierre Boulez's Institut de Recherche et de Coordination Acoustique/Musique and computer music; MIDI and interactivity—all these developments, to name but a few, seem more significant.) But I do think that this is a story well worth telling, and Pinch and Trocco tell it well.

References
1. G. Gould, *Saturday Night* **83** (12), 52 (1968).
2. J. Chadabe, *Electric Sound: The Past and Promise of Electronic Music* (Prentice Hall, Upper Saddle River, NJ, 1997).

Science
AAAS

Coaxing Sounds from Circuits

Tod Machover (February 21, 2003)

Science **299** (5610), 1185-1186. [doi: 10.1126/science.1080788]

Editor's Summary