CHAPTER 10

Electronic Music

Electronic music, like opera, refuses to behave like regular music. Its history intersects with the more general history of music at many points but is conditioned by so many other factors that it begs for independent discussion. Within the tale of electronic music, technological advances have more impact than do beautiful works or widely publicized performances. One could conceivably write a history of electronic music without reference to individual pieces of music; to do so without discussing hardware and software, however, would be impossible. This is also the area most difficult to discuss without bringing European (and Japanese) music into play, since the invention and refinement of electronic devices and techniques has involved much international give-and-take.

To discuss American composers who use electronics in their music would, by the end of the century, include almost everyone. Rare is the 1990s composer who has never used synthesizer, tape, or computer. The term "electronic composer" had fairly specific connotations in the fifties and sixties, because the field was only open to specialists; by the eighties, it had become almost meaningless, except perhaps when applied to those few who never use acoustic instruments. Almost everyone is now an electronic composer. Nor, as electronic composers frequently point out with pride, does the use of electronic technology imply any stylistic preconceptions. The electronic medium embraces minimalists (such as Carl Stone), strict atonalists (Mario Davidovsky), Cagean appreciators of ambient sound (Charles Amirkhanian), improvisers (Richard Teitelbaum), conceptualists (Salvatore Martirano), and composers of every stripe except the most Eurocentrically traditional.

At the same time, however, what electronic music teaches more forcefully than any other genre is that, as Marshall McLuhan said, the medium is the message. Tape-splicing encourages the musical fragmentation of either pointillism or collage. Tape loops lead to repetition and minimalism. Computer algorithms suggest a language-based approach to music. Samplers suggest an imagistic approach grounded in the con-

crete sound-complex. Voltage control and frequency modulation make certain operations easier and more gratifying to work with than others. It is probably moot to ask in each case whether the composer chose the medium because it did what he or she wanted done, or whether the medium sent the composer spinning off in the direction it facilitated. To some extent electronic music has been the voice of the machine, and many pieces have been made more to demonstrate the machinery or software than to express the composer's imagination. This is not to imply a value judgment; if meaningful music may spew forth from a set of *I Ching* operations or a minimalist process, why not from a computer algorithm or piece of circuitry as well? Electronic music took off as it did not only because the gadgets were there but because its potential suited mid-century aesthetics.

Many of the composers who have advanced the field of electronic music are discussed in this book under other auspices: Gordon Mumma and David Behrman under the Sonic Arts Union, Pauline Oliveros and Sal Martirano with the conceptualists, David Tudor with the Cage group, Larry Polansky with the totalists, and so on. This chapter will be devoted to those whose reputation is arguably more related to the development of electronic music itself than to any other movement or scene. I will not defend or even define my criteria for placing a composer here rather than in some other chapter: they are based on the most subjective impressions, such as whether, when a composer comes to my mind, the word "electronic" does as well.

The history of electronic music goes back further than the century. In 1877 Thomas Edison recorded and reproduced, on a tin-foil cylinder, his own voice reciting "Mary Had a Little Lamb." German-born Émile Berliner improved upon Edison by inventing a gramophone with a flat vinyl disc and began marketing the contraption in 1894; the grooved disc was fated to last a little less than a century. Tape was to come along much later. Recording via magnetized particles proved impracticable until 1927, when J. A. O'Neill patented the first magnetic tape. Frequency response was still limited, though, and it took World War II—in which the combatants found tape recording a helpful medium for both espionage and propaganda dispersal—to develop the tape recorder to a level sufficiently sophisticated for musical purposes. The first commercial tape appeared in 1947, and two years later the first stereo tape machine, as well as a little item once ubiquitous in music studios, now obsolete: the splicing block, used to cut and join pieces of tape.

Meanwhile, the search for electronic sound-production instruments kept apace. The first was Thaddeus Cahill's Telharmonium, patented in 1897 and unveiled to the public in New York in 1906; it was a kind of Muzak machine, intended to pipe electronic versions of the

classical literature into restaurants. More successful, and far more lasting in its influence, was the Theremin, first demonstrated in Moscow in 1920, on which one controlled pitch and volume by moving one's arms in space, determining distances from a pair of metal rods. Leon Theremin (1896–1992) interested Lenin in the instrument, toured Russia with it, and then swept across Germany, France, and the U.S. In 1930, ten of his Theremins played at Carnegie Hall, where two years later he returned with an orchestra of fingerboard and keyboard Theremins. In 1938, however, Theremin was abducted by Soviet agents and required to do war work for the KGB. When the fall of Communism in 1989 left him free to travel, he returned to the U.S. for the first time in 1991 for a flurry of homages and emotional reunions. The Theremin remains a popular instrument in downtown music and performance art.

In subsequent years, several electronic instruments were invented, mostly in Europe; the only one to secure a place in musical practice (mostly in French works) was the Ondes Martenot, invented in 1928 by Maurice Martenot, who played it by pulling a ribbon with one hand to vary the pitch and affecting the timbre and loudness with the other. In 1935 the first commercial electronic instrument, the Hammond organ, was manufactured and made its way into the entertainment world. The Canadian electronics pioneer Hugh LeCaine completed, in 1948, an Electronic Sackbut, which allowed the performance of scales and arpeggios as one controlled pitch with one hand and timbre with the other; with it, LeCaine could imitate a cello, a bluesy saxophone, or the clarinet at the beginning of *Rhapsody in Blue* with startling realism.

Since most early electronic instruments were employed to play not new music but electronic renditions of the classics, the real history of electronic music begins in 1942 when Pierre Schaeffer, living in German-occupied Paris, founded the *Studio d'Essai.* He produced his first tape piece, *Etude aux Chemins de Fer* (made from recorded sounds of trains), in 1948, and in 1950 he and Pierre Henry presented the first live concert of what Schaeffer had termed *musique concrète,* music consisting of acoustic sounds recorded on tape and manipulated. The Americans were only a little behind. On May 9, 1952, Vladimir Ussachevsky presented five electronic studies at a Composers' Forum concert at Columbia University. This led to collaborations with Otto Luening and to a more public concert of their tape works in October of that year.

In the next few years electronic music studios sprang up all over the world: the WDR Studio in Cologne (1952), Nippon House Kyokai in Tokyo (1954), Studio di Fonologia Musicale in Milan (1955). Karlheinz Stockhausen's early works at the Cologne studio—*Studie I* (1953), *Studie II* (1954), and especially *Gesang der Jünglinge* (1956)—garnered worldwide attention. The Midwest charged onto the scene in 1953 with a concert at the University of Illinois that included John Cage's tape-splicing extravaganza *Williams Mix* along with works by Stockhausen, Boulez,

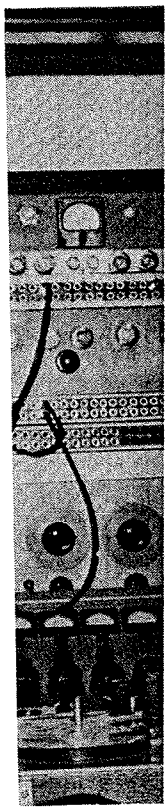
Luening, and Ussachevsky. In 1957 RCA introduced the Mark II Electronic Music Synthesizer, and Milton Babbitt, Ussachevsky, and Luening obtained a Rockefeller grant for Princeton to buy one. Thus one of the two most important American electronic music centers of the sixties was born in 1959. The other, the San Francisco Tape Music Center, opened in 1962. Between them, these two studios defined opposite ends of the American electronic music spectrum.

Luening, Ussachevsky, and the Columbia-Princeton Studio

American electronic music could hardly have picked two more unlikely pioneers than Otto Luening and Vladimir Ussachevsky. Both had claims to being almost as much European composers as American. Luening (1900–1996) had been born to first-generation Americans who returned to Germany in his youth; Ussachevsky (1911–1990) was born in Manchuria to Russian parents. Both, in the first halves of their long lives, had written conservative music of European polish and influences. Luening's style owed much to his teacher Ferruccio Busoni, while Ussachevsky continued the tradition of Tchaikovsky and Rachmaninoff. And both of them, relatively late in life (ages 52 and 41) suddenly found themselves impelled into the most rarefied reaches of the avant-garde by the modest fact that, in 1951, Columbia University acquired its first tape recorder and assigned Ussachevsky, as the junior faculty member, to take care of it.[1]

Both were also from old-world musical families. Luening's was involved in the Milwaukee beer business, but his father had been educated at the Leipzig Conservatory and sang in a performance of Beethoven's Ninth Symphony under the baton of Richard Wagner; thus the Luening family leap-frogged from Wagner to electronic music in one generation. When Luening was twelve his father took the family from Milwaukee to Munich, where Otto was educated as a flutist and composer. After America entered the First World War, he continued study at the Zürich Conservatory. He took private lessons with Busoni, whose groundbreaking *Sketch of a New Aesthetic of Music,* written in 1907, mentioned Thaddeus Cahill's Telharmonium (called at that point a Dynamophone) as a new electronic instrument that would make exploration of microtonal pitch systems possible.

Luening returned to Chicago in the middle of that city's gangster era and played in theater orchestras, obtaining in 1924 a post as director of the opera department at the Eastman School of Music. This was followed by a series of academic positions, the final one beginning in 1949 at Columbia University.



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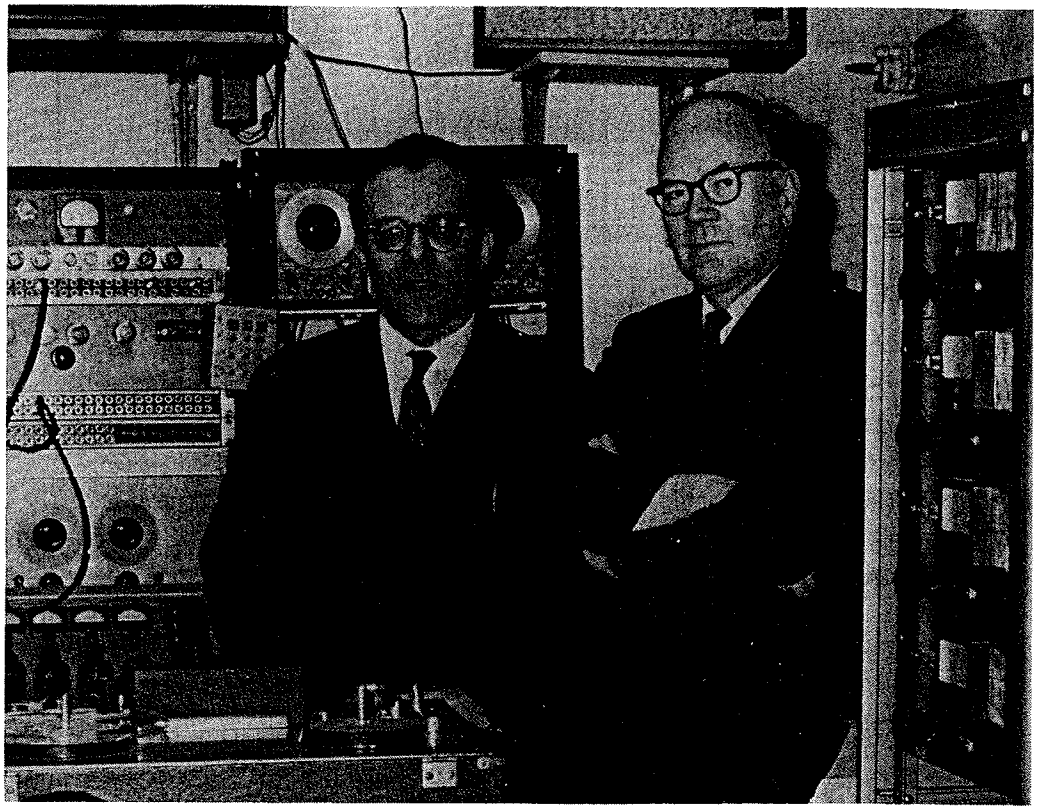


Vladimir Ussachevsky and Otto Luening in the Columbia-Princeton Electronic Music Studio. *Courtesy BMI Archives.*

Meanwhile, Ussachevsky had moved to the U.S. in 1930, studied at Pomona College, and studied in graduate school at Eastman with Howard Hanson and Bernard Rogers. Though he was drafted in 1942, his knowledge of languages, especially Russian and Chinese, won him a position (like Milton Babbitt) in the Intelligence Division. After the war ended, he went to Columbia for postdoctoral work, where he studied with Luening and joined the faculty in 1947. He would remain at Columbia for thirty-three years.

Ussachevsky had been entrusted with not only the Ampex tape recorder but also with a Magnechord tape recorder, a microphone, and a primitive reverb box. With these he began working and, on May 9, 1952, presented five electronic studies at a Composers' Forum concert at Columbia. Henry Cowell reviewed the presentation in *The Musical Quarterly.* Ussachevsky described to the audience his attempts to achieve sounds above and below the ranges of conventional instruments, and Cowell was especially impressed (as he would be, given his overtone-based theories) by the timbre of overtones made by a piano tone transposed downward below the threshold of human hearing. Luening, who

was directing a composers' program at Bennington at the time, convinced his colleague to bring the equipment to Bennington, where they started a primitive studio.[2]

Luening was a flutist, Ussachevsky a pianist, and so they used their own instruments as source material. As Luening later explained:

> We soon saw that the possibilities were endless, and we felt the need to limit ourselves to specific objectives. We had a choice of working with natural and "nonmusical" sounds [as the French musique concrète composers had done] like subway noise and sneezes and coughs, or widening the sound spectrum of existing instruments and bringing out new resonances from the existing world of instruments and voices. We chose the latter. . . .
>
> We used two basic manipulations. Simple as feedback and speed variation in a two-to-one ratio may seem now, their use for artistic purposes was at that time a revelation for both of us.[3]

(By feedback, Luening means here what would later be called tape delay: feeding the output of the tape recorder's playback head back into the record head to get a rapidly deteriorating repetition of the original sound.) The pair were soon invited to present their works at one of Leopold Stokowski's concerts at the Museum of Modern Art. Though skeptical of so much attention so soon, they relocated their studio to Henry Cowell's cottage at Shady Point and went to work. Here they produced four pieces, one by Ussachevsky and three by Luening, that were presented on October 28, 1952, at the Museum of Modern Art along with more conventional works. It was the first true concert of electronic music in America.

Despite the alien nature of the medium, the pieces were "designed to communicate with audiences conditioned to impressionistic, virtuoso, and tonal music in its broadest sense."[4] Ussachevsky's work, *Sonic Contours,* is a mélange of piano tones, metamorphosed into bell-like and harplike tones through artificial cutoff of decays and attacks, speed alteration, and tape echoes. Luening made his *Fantasy in Space* by a technique that would become ubiquitous in popular music: overdubbing. He recorded four flute lines, each time listening to previous lines over headphones. The piece is mellow and atmospheric, ending, for a familiar touch, in a folk-song-like melody. *Low Speed,* as its title suggests, is made up of pulsating flute tones slowed down well below the range of the instrument. *Invention in Twelve Tones* is a set of spare variations on a twelve-tone row, developing into a virtuosic triple canon.

The concert made Luening and Ussachevsky famous. It was broadcast over many radio stations, and soon the pair appeared on a television talk show demonstrating their equipment. By spring of 1953, their music was presented in Paris. Next came a commission from the Louisville Orchestra for the first-ever work for orchestra and tape. The result,

Rhapsodic Variations (1954) was the first of an unusual series of collaborations between Luening and Ussachevsky, followed by *A Poem in Cycles and Bells* (1954) and *Concerted Piece for Tape Recorder and Orchestra* (1960). The unprecedented team became the darlings of all who wanted "weird, spacey" music for their plays and television productions. Meanwhile, their work had sparked Edgard Varèse's long-denied interest in electronic sound, and he came through with his own orchestra-and-tape work—*Deserts*—soon after *Rhapsodic Variations,* followed soon after by the tape work *Poème Electronique.*

Soon Luening and Ussachevsky were able to demand space at Columbia. The next phase was to obtain a synthesizer. Milton Babbitt at Princeton was also interested, so the two schools joined forces on a grant application and in 1959 received funds for the new RCA Mark II Electronic Music Synthesizer. The Columbia-Princeton Electronic Music Center was born. In 1959 the Turkish composer Bulent Arel (born in Istanbul in 1919), who had been making *musique concrète* at Ankara, came to the studio, followed the next year by Argentinean Mario Davidovsky. Pril Smiley (b. 1943) and Alice Shields (also b. 1943) came soon afterwards to complete the Center's staff.

The legendary Mark II filled most of a room and contained 750 vacuum tubes driven by two paper drives and encoded by a series of four-bit binary switches. Its four identical synthesizer units were capable of producing sawtooth waveforms and noise and of controlling the pitch, envelope, volume, and spectrum of the waves produced, as well as possessing controls for tremolo and portamento. Two paper drives—primitive sequencing devices—allowed for a polyphony of four simultaneous voices. "The machine was extremely difficult to operate," Babbitt remembers.

> First of all, it had a paper drive, and getting the paper through the machine and punching the holes was difficult. We were punching in binary. The machine was totally zero, nothing predetermined, and any number we punched could refer to any dimension of the machine. There was an immense number of analog oscillators but the analog sound equipment was constantly causing problems. . . . It was basically just a complex switching device to an enormous and complicated analogue studio hooked to a tape machine. And yet for me it was so wonderful because I could specify something and hear it instantly.[5]

Babbitt created what remain probably the most enduring works from the Columbia-Princeton Center: *Composition for Synthesizer* (1961), *Ensembles* (1964), and especially *Vision and Prayer* (1961, based on a Dylan Thomas poem) and *Philomel* (1984), both of the latter for soprano and tape. On May 9 and 10, 1961, the Center presented its first public concerts, featuring the *Composition for Synthesizer,* Ussachevsky's *Creation-*

Prologue, Luening's *Gargoyles for Violin Solo and Synthesized Sound,* Davidovsky's *Electronic Study #1,* and other works.

Luening and Ussachevsky were born early enough that their aesthetics were not strongly affected by the mandates of the twelve-tone style. Luening, in particular, produced a lifelong body of chamber music marked by dissonant Romanticism and old-world polish; Ussachevsky has been less well known for his nonelectronic works. In the hands of Babbitt and Davidovsky, however, as in those of Europeans like Stockhausen and Nono as well, the new tape-and-synthesizer medium fused with twelve-tone aesthetics. Tape-splicing (although Babbitt avoided it) was conducive to the pointillism this generation had inherited from Webern, as were the idiomatic noises of the Mark II, as Davidovsky explains:

> I found that it was almost impossible with that technology to produce long sounds that were beautiful—they would tend to become dull. But I found that sounds of short duration and percussive-like sounds were accessible.[6]

Twelve-tone composers saw tape music as the perfect post-Webern medium, allowing total control over musical elements that had been serialized down to the finest detail.

Although he did not employ strict twelve-tone method in his music, Mario Davidovsky, originally from Argentina (born 1934 in Buenos Aires) epitomizes the detailed pointillistic approach to electronics. He is a purist when it comes to electronic sound, disdaining short cuts and building each sound up oscillator-by-oscillator for maximum subtlety. Though trained in Buenos Aires, he studied with Babbitt at Tanglewood and worked at the Columbia-Princeton studio from 1960 to 1964. He thereafter taught at the Manhattan School, Yale, and others before returning to Columbia in 1981 and then moving to Harvard in 1994. Not prolific, Davidovsky is best known for his eight *Synchronisms,* pieces for various solo instruments or ensembles and tape. His chief and oft-noted achievement in these pieces is that the live and taped sounds are so expertly blended that the ear is unable to tell when a tone passes from the instrument to the tape and vice versa. *Synchronisms* No. 1 (1963) is for flute; No. 2 (1964) for flute, clarinet, violin, and cello; No.3 (1965) for cello; No. 4 (1967) for male voices or mixed chorus; No. 5 (1969) for percussion ensemble; No. 6 (1970) for piano; No. 7 (1973) for orchestra; and No. 8 (1974) for woodwind quintet.

Although considerably younger than their male colleagues at the Center, Pril Smiley and Alice Shields maintained independent approaches to electronic composition from the start. Smiley's best-known work, *Kolyosa* (1970—the title means "wheels" in Russian), whirls burbling and rattle sounds through space from speaker to speaker with a pleasure in sustaining sensuous noises more akin to David Tudor than

to Babbitt. Shields is something of a mystic performance artist who uses her voice and texts from Eastern religions in most of her works. Her *The Transformation of Ani* (1970) takes its material almost entirely from her own voice, reading and singing a passage from the *Egyptian Book of the Dead* in both English and Egyptian. Not only has Shields departed from her colleagues in producing long theatrical works—nine operas and music dramas, including electronic operas like *Shaman* (1987), *Mass for the Dead* (1992), and *Apocalypse* (1990–1993, a work based in Indian dance-drama with a libretto in English, classical Greek, Gaelic, and Sanskrit)—she is herself a professional opera singer who has played the role of one of the Valkyries in Wagner's *Ring* at the Kennedy Center.

In the first ten years of its existence the Columbia-Princeton Center produced 225 works by more than sixty composers from eleven countries.[7] In 1976, though, thieves broke into the Center, stole as much as they could, and destroyed the Mark II's wiring. It has never been used since. By the time this vandalism occurred, however, electronic music had already discovered other, more sophisticated methods.

Listening Example: Vladimir Ussachevsky,* Sonic Contours *(1952)

Of the works on the first American electronic music concert, Ussachevsky's *Sonic Contours* is the most complex and also the first to fuse "musical" (piano) with "nonmusical" (spoken conversation) sounds, while its impressionistic atmosphere of repeated notes and melodies anticipated by eight years Terry Riley's work with tape delay. The seven-minute piece begins with the low booming of slowed-down piano notes. After twenty seconds, piano chords enter, sometimes cut off abruptly by tape-splicing. Trickles of notes enter canonically, echoing each other, and at 1:45 (one minute, 45 seconds) a piano chord appears backward. From here on the texture becomes increasingly thick with echoes of tape delay, not only chords and individual notes, but brief motives that turn into ostinatos. At 4:04, a sped-up conversation with "feedback" (tape delay) is heard between Ussachevsky, his wife, Betty, and technician Paul Mauzey. From this humble beginning, the new technology already suggests its own methods of continuity.

Morton Subotnick and Synthesizers

Without doubt, two signal events of the 1960s jolted public consciousness that electronic music had arrived and was here to stay. One was the 1968 release of a recording called *Switched-On Bach,* a group of compositions by J. S. Bach played on synthesizer. The recording was made by Walter Carlos (born in Pawtucket, R.I., 1939), who had studied music and physics at Brown University before going on to study at Columbia with Luening and Ussachevsky. The record was a tremendous popular suc-

cess, and Carlos followed it up with groundbreaking electronic film scores for *A Clockwork Orange* and *The Shining*. In the seventies, he became the first musical celebrity to undergo a sex-change operation, changing his/her name to Wendy Carlos in 1979. As Wendy, Carlos has remained an important theorist for computerized microtonal tunings.

The other event was also a recording: *Silver Apples of the Moon* (1967), the first synthesizer piece written specifically for recording rather than performance, by Morton Subotnick. In fact, Subotnick has rarely done anything in which he wasn't the first: the first "ghost electronics," the first cross-continental MIDI performances, the first live-conducted computer, the first totally composed CD-ROM. Born in Los Angeles in 1933, Subotnick studied at Mills College and studied with Kirchner and Milhaud. In the late fifties he made his first pieces of *musique concrète* by taping the sounds of an electric piano and junkyard percussion and occasionally running the tape backwards.

San Francisco was an exciting center in the early sixties. Pauline Oliveros and Ramon Sender (born in Spain in 1934, a student of Cowell and Elliott Carter) had gotten together some old equipment and given a concert at the San Francisco Conservatory on December 18, 1961, with fellow composers Terry Riley and Phil Winsor. In their next efforts, Subotnick joined them. The concerts were relentlessly experimental; in Sender's *Tropical Fish Opera* (1962), for example, fish in a tank swam in front of a conceptual score from which the group performed the fish as notes or dynamic indications. The piece that induced the Conservatory to throw the group out was *Smell Opera with Found Tape,* in which dancers went around spraying the audience with perfume as a found tape was played of a woman talking to her minister about her out-of-wedlock baby. Forced to relocate, the composers found an old house scheduled for demolition and turned it into the San Francisco Tape Music Center.

The Center became a hothouse for all kinds of new music, including the latest European electronic music, improvisation, theater pieces, free-for-all happenings, and even minimalism: this is where Riley's *In C* was premiered in 1964. The Center particularly nurtured an approach to homemade circuitry associated with composers that this book has already discussed elsewhere: David Tudor, David Behrman, Gordon Mumma. After a few years, however, the SFTMC ceased to be a breeding ground for experimentalism, and in 1966, Subotnick headed for New York to teach at New York University.

Meanwhile, in 1949 a fifteen-year-old Robert Moog had read an article on how to build Theremins and began building them. Within five years he and his father had formed the R. A. Moog Co., and Robert had to interrupt his studies to keep up with the growing demand. Moog began researching voltage-controlled oscillators and amplifiers, and by 1965 began selling his modules; in 1967 he began advertising them as "synthesizers" (a word that, before this point, had only been applied

specifically to the RCA Mark II). A huge, imposing black box dotted with knobs and holes for cables, the Moog Synthesizer was the beginning of an apparently endless series of electronic sound-generation machines.

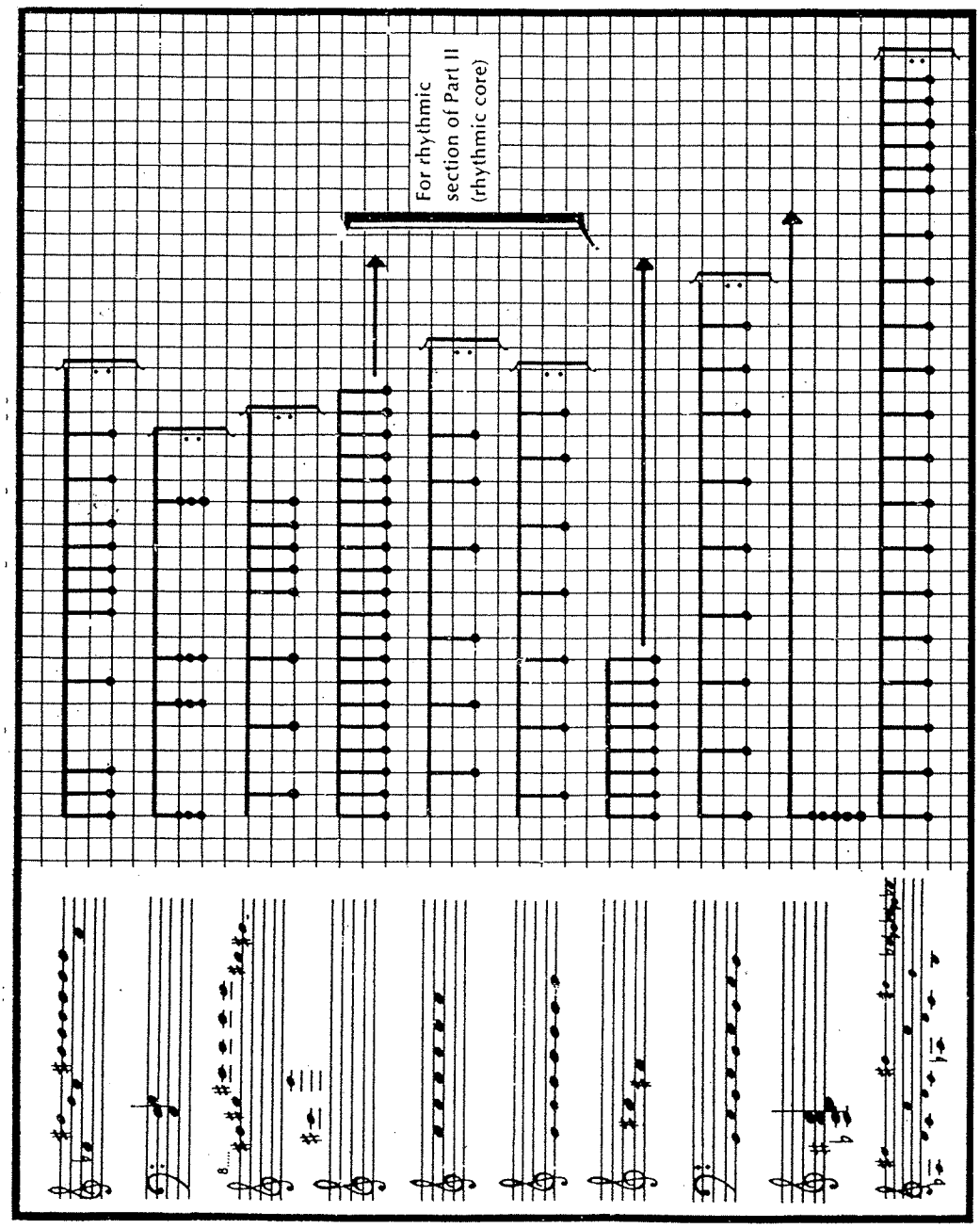
Improvements followed quickly. In 1963 Donald Buchla (born 1937) began working at the San Francisco Tape Music Center on an oscillator controller of his own, adding a pressure-sensitive keyboard and a built-in sequencer—an automation device with which a composer could store a sequence of notes or pieces of information. The latter device freed composers from having to splice a new piece of tape for every note and allowed them to work in larger musical units. The "Buchla Box" premiered in 1966. By the late sixties, rock groups had begun to see synthesizers as a glamorous addition to their acts. Keith Emerson bought a Moog to use with Emerson, Lake, and Palmer, Pink Floyd incorporated one in their album *Dark Side of the Moon,* and a sudden commercial market led to a series of analog synthesizers: the Minimoog, ARP, Oberheim, Prophet-5.

In 1966, Nonesuch Records offered Subotnick a $1000 advance on an electronic piece for a recording. The result was a series of works made on the Buchla synthesizer, starting with *Silver Apples of the Moon.* The piece's burbles, glissandos, and rhythmicized hisses, and its wild dance of looping ostinatos on side two, sounded like moon-music indeed, much more detached from conventional musical possibilities than the *musique concrète* produced by the earlier Luening-Ussachevsky experiments. As the then-mind-blowing liner notes about the Buchla Synthesizer read,

> It is possible to produce a specific predetermined sound event . . . and it is also possible to produce sound events that are predetermined only in generalities . . . this means that one can "tell" the machine what kind of event you want without deciding on the specific details of the event. . . . This gives the flexibility to score sections of the piece in the traditional sense . . . and to mold other sections (from graphic and verbal notes) like a piece of sculpture.[8]

The sense of sculpture was reinforced by a diagram for the gentle bird-like tweeps that ended Part II, "A single silver child-angel in a glittering garden of silver star-fruit" (example 10.1).

Like his fellow Californian Henry Cowell before him, Subotnick felt that records demanded a new repertoire and that there was something dishonest about putting on discs experiences that were meant to be heard live; his intimate electronic works intended for records were "a kind of chamber music 20th-century style." He followed up *Silver Apples* with *The Wild Bull* (1968), *Touch* (1969), *Sidewinder* (1971), *Four Butterflies* (1973), *Until Spring* (1975), and *A Sky of Cloudless Sulphur* (1978). *Sidewinder* grew from a crescendoing, rattly click that sounded like a rattlesnake; *Four Butterflies* structured quiet pings in energy-envelopes that reflected the tripartite structure of both the butterfly's life and its body.

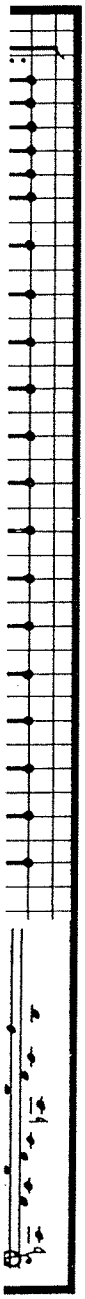


EXAMPLE 10.1 Morton Subotnick, *Silver Apples of the Moon.*

In 1969 Subotnick left New York to teach at the California Institute for the Arts, and in 1979 he married the singer-composer Joan LaBarbara.

By 1977, starting with *Liquid Strata* for piano, Subotnick had returned to live instruments, now modified to the point of unrecognizability by what he calls "ghost electronics." In these, sounds played by the musicians are picked up by microphones, modified by the composer, and then redirected through loudspeakers scattered around the hall. Next, he began working with computer systems capable of following the performer's tempo, so that predetermined computer sounds and ensembles could coexist in flexible give-and-take. The most engaging result of this research is *The Key to Songs* (1992) for two pianos, three mallet instruments, viola, cello, and computer, which spins the mournful melody of Schubert's song *Erlkönig* over a riveting pulse of repeated drone notes. With its virtuoso hairpin turns, *The Key to Songs* is possibly Subotnick's most unforgettable work.

The list of Subotnick's innovations continues. His *Return* (1986), intended as background for a planetarium exhibit, documented the cyclic reappearance of Halley's Comet through a series of computer-modulated quotations of plainchant, Scarlatti, Mozart, Liszt, and so on. In his *Angel Concerto* (1994), he depicted angels by having a MIDI piano played by computer, the piano's keys depressed by an invisible hand; at one Electronic Café performance at the Kitchen in New York, he played the piano long-distance from Santa Monica, California, over the phone lines. And, just as Subotnick had made the first composition specifically for record, he also produced, in 1993, the first composition specifically for CD-ROM, *All My Hummingbirds Have Alibis*. Some of Subotnick's compositions have seemed profoundly attuned to our times, others seemed merely to push the technology ahead for the sake of doing so. But he has always been out in front.



EXAMPLE 10.1 Morton Subotnick, *Silver Apples of the Moon.*

The Origins of Computer Music

Computer music was arguably the first musical technology ever in which the Americans led the rest of the world. An interest in computer-generated sound began at Bell Telephone Laboratories in Murray Hill, New Jersey, in the late 1950s. The electrical engineer Max V. Mathews (born 1926 in Columbus, Nebraska) joined the acoustic research department of Bell Labs in 1955, hired to help develop computer equipment to study ways to improve telephone sound. In the course of his work, he invented a converter that could refigure sound as digital information for computer use and then refigure it back. He quickly realized that his converter made it possible to generate music on the computer. Mathews interested John Pierce (coiner of the word "transistor") and Newman Guttman in the project, and together they created

the first computer-generated sounds in 1957. Mathews wrote a sound-generating program called Music I, a program he later described as "terrible—it had only one voice, one waveform, a triangular wave, no attack, no decay, and the only expressive parameters you could control were pitch, loudness, and duration."[9]

Equally terrible, and produced via Music I, was the first piece of computer music, credited to Guttman, a linguist and acoustician: *In the Silver Scale* (first heard May 17, 1957), a nineteen-second melody leaping through diminished-seventh chords before a quick tonal cadence. The first dozen computer works were by computer technicians and have mainly historical interest. From the beginning, though, Mathews experimented with the computer's ability to effortlessly transform one sound into another via algorithms. His *Numerology* (1960) features the gradual change of a timbre from piano to bowed string, and a finale in which the notes accelerate, Nancarrow-like, to the point of unintelligibility. Mathews also computer-synthesized a version of the old song "Bicycle Built for Two" in which the computer sings over a honky-tonk accompaniment; the piece was later used in Stanley Kubrick's 1968 film *2001, A Space Odyssey.*

The first works to possess an interest more musical than technical were by David Lewin, Ercolino Ferretti, James Tenney (whose tenure at Bell Labs from 1961 to 1964 has been discussed in chapter 7), and James K. Randall. Tenney was perhaps the first composer to use the computer *idiomatically,* to let it make compositional choices and employ logics unknown in previous music. In Tenney's Bell Labs pieces, such as *Analog #1: Noise Study* (1961), *Dialogue* (1963), and *Ergodos I* (also 1963), he programmed the computer to deploy the sounds in a statistical manner within given guidelines. Since Tenney came armed with notions of timbre and structure from Varèse and Cage, his computer pieces are much more accepting of noise and surface complexity than those by the technicians, who had tried to mimic conventional musical results.

From these early days to the late 1970s, computer music was made by punching Hollerith computer cards in stacks of maybe 3,000 for a few seconds' worth of music, sending those cards out to a mainframe computer for processing, then having the resulting number-coded tape run through a digital-to-analogue converter to get actual sound. This generally meant punching your cards and waiting two weeks for them to come back—often only to find that some number error or miscalculation had torpedoed the desired results. Along with Godfrey Winham and Hubert Howe, Mathews worked on successive generations of Music I which became quicker, more subtle, and more user-friendly.

Princeton University was the first institution to create computer music outside Bell Labs. On the faculty there since 1958 had been James K. Randall, born 1929 in Cleveland, a product of Columbia, Harvard, and Princeton who had studied composition with Sessions and Babbitt. One of the most effective early computer works was his *Mudgett: mono-*

logues by a mass murderer (1965) for soprano and computer tape, in which the soprano delivers, in singing and *Sprechstimme* (speech-song) a collage of texts narrating the life of a nineteenth-century murderer. Randall's *Lyric Variations for Violin and Computer* (1965–1968) is in twenty variations; the violin plays the first five solo, the next five are for computer, and the last ten are for computer and violin together. The work has a slow, thoughtful, sad quality to it, as the computerized sounds rumble and swell in the background. Just as tape splicing was conducive to pointillism and collage, the computer encouraged gradual or linear sound transformations, and so from the very beginning computer synthesis led generally to a slower, smoother aesthetic than did tape or synthesizer music.

The same can be said for much of John M. Chowning's music. Though few people know of him as a composer, everyone involved with synthesizers is at least vaguely aware of him, for Chowning invented an innovation that had an enormous impact even in pop music: FM synthesis, or frequency-modulation synthesis. Born in Salem, New Jersey, in 1934, he studied for three years with Nadia Boulanger in Paris, got inspired by Mathews's 1963 article "The Computer as a Musical Instrument," and in 1964 found himself at Bell Labs. Experimenting with extreme vibrato, Chowning used one pitch signal to modify another and found that by so doing, he could achieve changes of not only pitch but timbre, far more quickly and with less calculation than by the methods of previous synthesis. Yamaha licensed the technique in 1974, and the Yamaha DX synthesizers became ubiquitous in the 1980s. Chowning's *Sabelithe* (1966–1971) is the first work to use FM synthesis, and *Turenas* (1972) the first to create the impression of a continuous 360-degree soundspace with just four loudspeakers.

Perhaps the most durable body of early computer music work is that of Charles Dodge, for he keeps his musical premises simple enough that the technology doesn't overwhelm the musical message. Born in 1942 in Ames, Iowa, Dodge has taught at Columbia, Princeton, Brooklyn College, and Dartmouth. Synthesizing computer-generated speech had been a major goal since Mathews's early experiments, and Dodge made a breakthrough. In 1972 he recorded his voice into a computer via microphone and had the computer analyze the pattern and replicate it. The eventual result, primitive-sounding now but widely celebrated then, was *Speech Songs,* a group of poetic fragments read by computer.

The achievement of speech synthesis opened the way to a number of speech compositions, including *In Celebration* (1975) and a computerized version of Samuel Beckett's radio play *Cascando* (1977) with robotic speech and raspily hesitant background noises that capture the existential mood of Beckett's atmosphere of futility. One of Dodge's tours-de-force is *Any Resemblance Is Purely Coincidental* (1978), in which he took recordings of the great opera singer Enrico Caruso from which all the scratchiness of the original records had been removed—along with the

piano accompaniments as well. Dodge resupplied a new accompaniment and bent Caruso's voice to his will, doubling it, transposing it, distorting it into his own melodies.

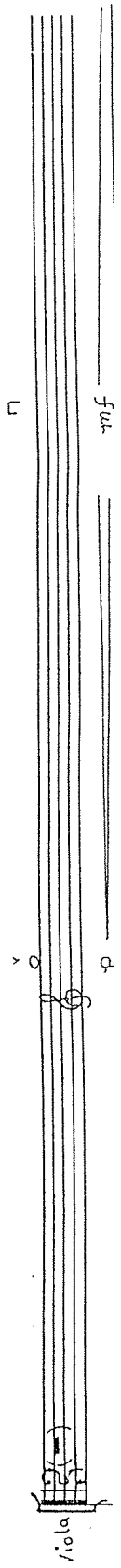
While Tenney, Subotnick, and others have allowed computers and synthesizers to make compositional decisions according to logical structures, few composers have used technology to write music for live performers to play. The composer best known for computerized composition was the Greek avant-gardist Iannis Xenakis, but he was anticipated by one of the most unusual computer achievements ever: the computer-composition of the *Illiac Suite* for string quartet by Lejaren Hiller and Leonard Isaacson. The pair composed the work via the Illinois Accumulator computer (thus the title *Illiac*) at the University of Illinois in 1957 in order to demonstrate the computer's ability to follow compositional logics such as the rules of counterpoint. In four movements, the *Illiac Suite* explores strict counterpoint, randomness, twelve-tone writing, and statistical probability. The piece has a charmingly unpretentious American flavor reminiscent of Cage's 1950 String Quartet.

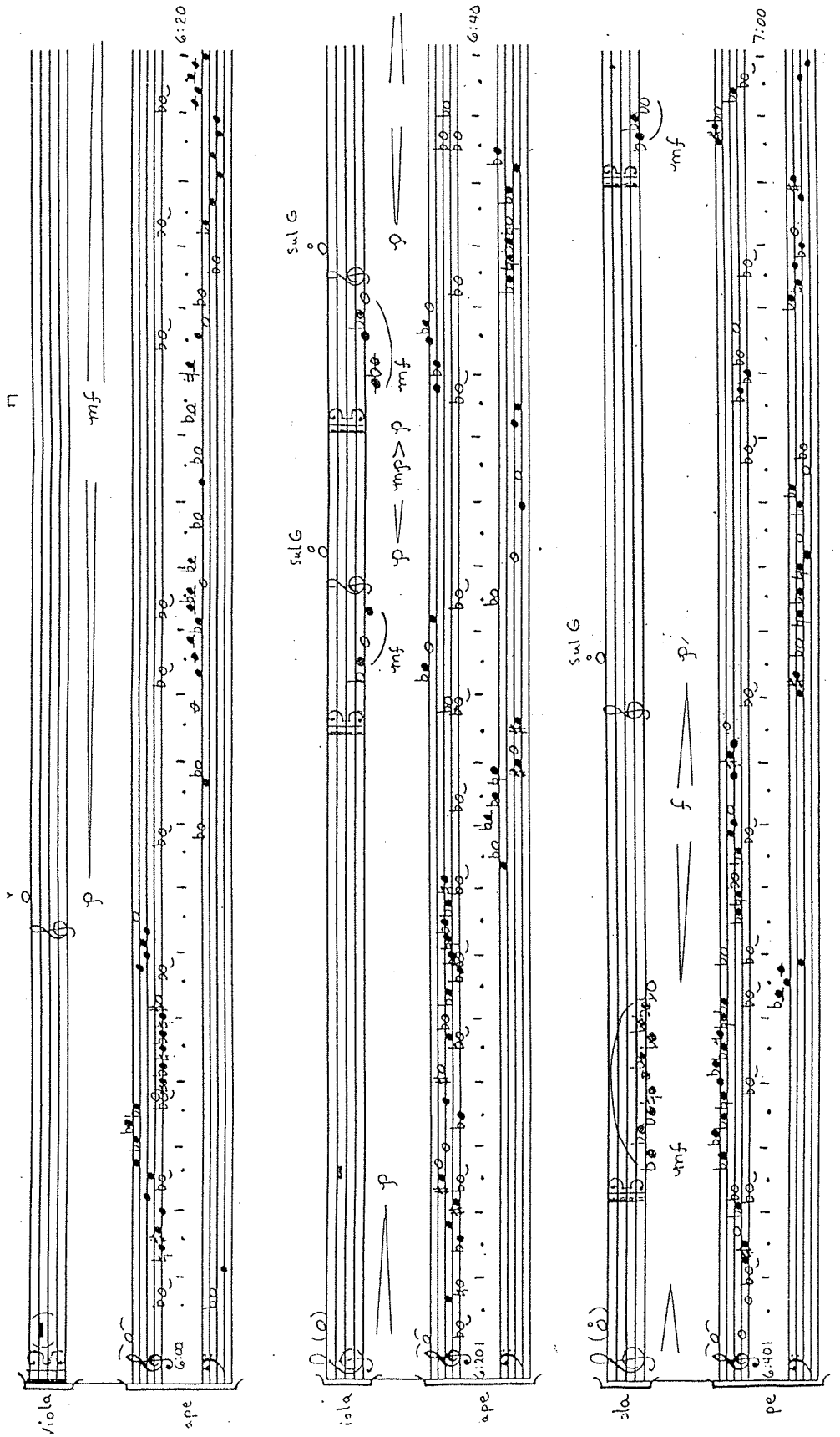
Born in New York in 1924, Hiller began his career as a chemist, working for DuPont for ten years. He later received a master's in music from the University of Illinois in 1958 and taught there until 1968, when he relocated to SUNY at Buffalo. Aside from his computer activities, he was a fairly conventional composer of seven string quartets, two symphonies, and six piano sonatas. His early music, as evident in his Sonata No. 4 (1950) and *Fantasy for Three Pianos* (1951), wavers between grand Romanticism and a wryly humorous neoclassicism. In his computer work, however, he remained for many years the leading pioneer of computer-composed music. After the *Illiac Suite,* Hiller's best-known work was probably his theater piece from 1968, *Avalanche,* for "pitchman, prima donna, player piano, percussionist, and pre-recorded playback," featuring a player-piano roll containing a random array of ninety themes from the symphonic literature that grow thicker and thicker in an avalanche of words and sounds.

Hiller's greatest public exposure came in 1969, when he collaborated with Cage on a spectacular sound environment called *HPSCHD*—the computer handle for harpsichord. Using a computerized *I Ching* to make the thousands of chance decisions required, the two assembled quotations of music by Mozart, Beethoven, Chopin, Schumann, Gottschalk, Busoni, and Schoenberg to be played on harpsichords by seven soloists, accompanied by tapes from fifty-six tape recorders. The event attracted 6,000 spectators to the University of Illinois' Assembly Hall, presaging and dwarfing ambient music-and-video environments of the 1990s.

Listening Example: Charles Dodge,* Viola Elegy *(1987)

Though not connected to his better-known speech synthesis, Dodge's *Viola Elegy,* written upon Morton Feldman's death as a memorial, is typ-





EXAMPLE 10.2 Charles Dodge, *Viola Elegy*.

ical of the lyricism and linear simplicity he brings to the computer medium. In the score the electronic tones are marked "Elusive, with no obvious onset," and the computerized tones move by in a gentle blur in which individual pitches are difficult to distinguish. The live viola part emerges almost mystically from the computer tones, and in fact always doubles something in the computer part at the unison or octave. Dodge wrote the computer part algorithmically, then wrote the viola part by choosing from the notes of the computer, so that the computer surrounds the viola like a halo. The viola choices emphasize certain pitches over and over as boundaries—much as Feldman sometimes did in his own music—including, in example 10.2, a high G and a low E-flat, the latter of which increasingly appears pizzicato as the piece continues. As the work progresses the viola becomes more active, until at last the tape ends and the viola has a long soliloquy grounded in that pizzicato E-flat. The work proves that the computer can be a source of sonic poetry.

The Personal Computer Revolution

In the early 1980s, the whole nature of the game changed, cleaving the history of electronic music neatly down the middle. From 1952 to 1980, electronic music was pretty much a studio activity. The computers involved were huge, mainframe machines obtainable only by large institutions such as universities. The necessary synthesizers and tape recorders took up a lot of space, and it was more efficient to have them at a central location where everyone could work. Except for a few wealthy rock-star hobbyists, electronic music was essentially a collective activity. The advent of personal computers, in conjunction with an explosion of digital technology, changed that forever.

First came the development of a revolutionary new type of instrument that would eventually transform the face of music: the sampler, which could record any sound through a microphone and play it back at any pitch level, usually by keyboard. The sampler also allowed composers to turn sounds backwards, loop them, and gradually transform one sound into another. Perhaps more exciting, one could record a cicada, a train whistle, a car crash, and play cicada melodies, train whistle melodies, car crash melodies. With the sampler, the old promise of electronic music—that any noise could become available for musical use—has become virtually a reality, if not a virtual reality.

For the first few years, samplers were prohibitively expensive. The first was the Fairlight CMI (Computer Music Instrument), introduced in 1980 at $25,000.[10] The Synclavier II followed, and then the Emulator I, at $10,000. By 1984, Ensoniq had developed a sampler called the Mirage for an affordable $1,295. By the mid-1980s, any working stiff could have

sound-producing and -manipulating power in his basement that put the great electronic studios of the 1970s to shame.

At the same time, the entire music field was revolutionized, for better or worse, by the organized move toward a universal standard for computer music controls. In 1981 technicians from three companies—Roland, Oberheim, and Sequential Circuits—met to begin designing a universal interface for electronic instruments, so that equipment from different manufacturers would be compatible within one system. By 1983 several Japanese companies had come up with MIDI: Musical Instrument Digital Interface. Through MIDI, all electronic keyboards (and eventually electronic wind instruments, guitars, and drum machines as well) could hook up to computers for interactive sequencing, sound manipulation, playback, and so on. MIDI was not everyone's cup of tea. It had a strong orientation toward keyboard performance, tied into the concept of the individual note, that old-time analogue synthesizer users felt imposed a conceptual grid on the compositional possibilities. Nevertheless, MIDI broke through so many communications barriers that it quickly took over both the commercial and the academic markets.

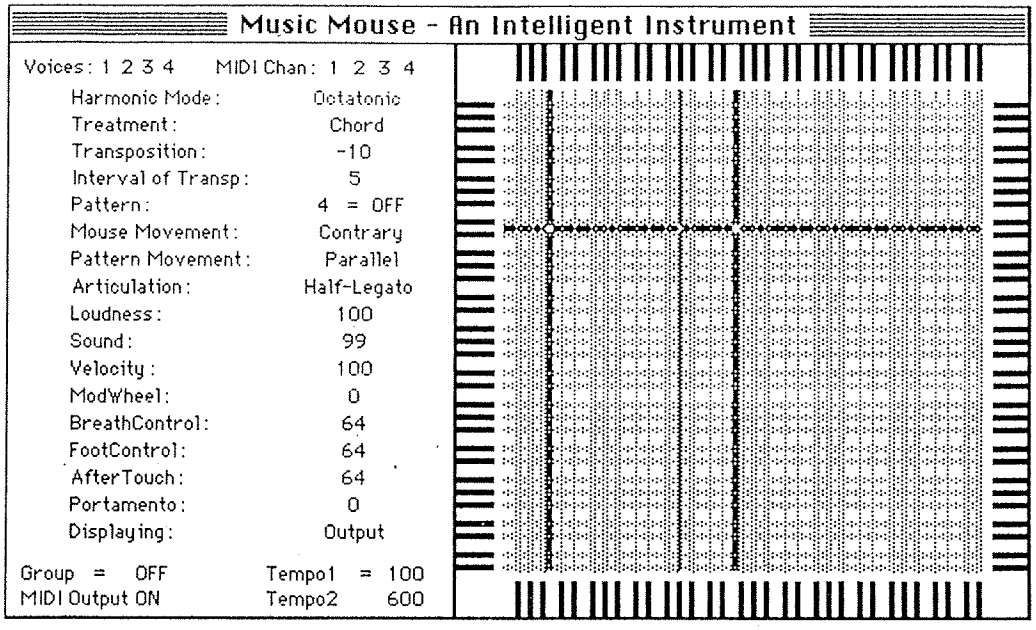
Armed with sequencing and sound-manipulation software, a small home computer, and a few thousand dollars worth of synthesizers and samplers all MIDI-cabled into a central keyboard, the isolated recluse could now produce electronic results every bit as sophisticated as any mogul of a world-famous computer music center. If the downtown conceptualist scene of the seventies had seen the rise of the solo composer-performer, the digital revolution made that route not only viable but attractive. Since the early eighties, the American composer has had the option of becoming self-sufficient and independent from all institutions and organizations, without having to make the heavy sacrifices that characterized the careers of Ives, Partch, and Nancarrow.

Laurie Spiegel

Laurie Spiegel started out as a folk musician, playing lute, mandolin, banjo, and guitar, and these origins have profoundly influenced her conception of computer music. She sees the computer itself as a kind of folk instrument, and as a grassroots phenomenon; as she says,

> I don't think it's a coincidence that there seems to be a high percentage of women, and other composers who the musical mainstream might discriminate against, working in electronic media. You gain a lot by being able to go all the way from idea to playing the piece for people without having to get support from established organizations.[11]

The most extreme expression of Spiegel's folk-music philosophy has been a software program called Music Mouse (example 10.3), which con-



EXAMPLE 10.3 Laurie Spiegel's Music Mouse.

tains complex networks of musical logic that can be altered to create musical languages that sound more like conventional tonality, or more like Bartók, or Ligeti, and so on. In Music Mouse, even small movements of the mouse can bring down cascades of notes in complex harmonic progressions of changing timbre. Many rock musicians have employed Music Mouse in their recordings, and the software is so conditioned by Speigel's own algorithmic sense of composition that the use raises troubling and perhaps unanswerable questions about copyright and intellectual property. Spiegel's own music sometimes uses Music Mouse and sometimes not; when it does, however, her synthesizer setup is so complex that the music is generally more conditioned by the setup than by the slight mouse movements used to trigger events.

Spiegel was born in Chicago in 1945 and studied classical guitar at Oxford. Upon her return to the U.S. she enrolled at Juilliard as an early-music player on Baroque and Renaissance lutes. She also studied composition with Jacob Druckman and computer composition with Emmanuel Ghent. At the same time, she began working at Bell Labs (1973–1979), where Max Mathews gave her access to a computer system called GROOVE (Generating Realtime Operations On Voltage-controlled Equipment), on which she composed her first computer works: *Appalachian Grove* (1974), *Patchwork* (1974–1976), *Old Wave* (1975), *Pentachrome* (1974), and *The Expanding Universe* (1975). GROOVE allowed her to create and manipulate patterns of change over a period of time, parameter by parameter instead of note by note. In deliberate reaction against what she called "an overdose of heavy, sad, introspective contem-

porary music," specifically the twelve-tone variety, she made computer music in a sprightly minimalist style reminiscent of rural banjo-picking.

In the early eighties Spiegel lived as an independent composer, writing film scores and works for piano or classical guitar. By 1985, however, she had developed Music Mouse, an "intelligent musical instrument" capable of extending simple mouse movements into a complex system of decisions. In Music Mouse, the performer selects in advance whether to use chordal harmony, melodic ornamentation, contrapuntal lines, and so on, and then guides a cursor through an on-screen grid (example 10.3). "In coding Music Mouse," Spiegel explains,

> I tried to minimize violations of musicality while allowing maximal variety of output. I used constraints, logical tests, filtration, transformation, a loosely enforced bias toward continuity in all dimensions, and very careful specification of non-user-settable constants for harmonic progression and modulation. . . . For me, the most interesting material tends to happen when Music Mouse is played with only minimal mouse movement but with lots of use of the qwerty keyboard to change the compositional, orchestrational, and other interpretive variables. . . . [A]ll sound is in direct response to player action. Nothing is random. The player is in control.[12]

The phrase "a loosely enforced bias toward continuity in all dimensions" is a key to the aesthetics of Spiegel's music, for her works have a remarkable tendency to transform complex textures with extreme gradualness, with a large-scale rhythm reminiscent of natural processes: the resonant boom of ice cracking on a lake, the slow crescendo of a rainstorm. In works like *Sound Zones* and *Riding the Storm* (both 1990), she performs, using Music Mouse, on a Macintosh computer MIDI-controlling a synthesizer and two signal processors, recording each piece directly. The resulting textures are orchestral in scope, with shimmering bells, energetic drums and rattles, waves of sound that crest with glacial inevitability.

Paul Lansky

If there is anyone whose computer music is even more accessible than Spiegel's, it is Paul Lansky. Though he began in twelve-tone work, he declared his apostasy in the late sixties and became devoted to the idea of using computer music to reflect one's daily life. In *Table's Clear* (1990), for example, he used the noises of his children banging away on tableware, and in *Quakerbridge* (also 1990) the sounds of people shopping. Yet the resulting pieces are highly structured, the sounds abstracted and listened to for their richness of texture rather than for superficial associative value. The stripped-down pitch language of his music was partly inspired by minimalism, partly the result of working with speech syn-

thesis; his return to tonality, he says, came as a result of "simplifying the pitch landscape to allow you to pay attention to something else."[13]

Born 1944 in New York, Lansky studied at Queens College and Princeton with Perle and Babbitt, becoming involved in Perle's theory of twelve-tone tonality. At first he began using the computer to program all of the complicated, serialized rhythms and pitch relationships that live performers couldn't handle. In 1975, though, through Godfrey Winham and Charles Dodge, he became interested in speech synthesis, and realized that "real world sounds were a lot more interesting than anything I could invent on the machine."[14] His first important speech synthesis work was *Six Fantasies on a Poem by Thomas Campion* (1978–1979), which used the voice as a trigger for resonance frequencies. Remarking on resonant pitches one can find while singing in the shower, Lansky sets up, In works like *Smalltalk* (1988) and *Word Color* (1992), what he calls "dozens and dozens of tiny little shower stalls" within the computer software, whose frequencies are triggered as the voice sweeps past them. The result is a halo of sound that can either draw attention to selected qualities of the vocal sound or flow through various harmonies as the piece progresses.

A breakthrough came for Lansky one day as he heard a group of inner city youths hassling a cop in rap. Attempting to elicit similar qualities from rhythmic speech, he recorded Hannah MacKay's voice, and—taking a cue from the phase music of Steve Reich—layered it in loops of different lengths. The result, *Idle Chatter* (1985), suggests a kind of complexly textured minimalism, a babble of almost-comprehensible voices that gives the ear, as he likes to say, "room to dance in." Two later companion pieces, *just_more_idle_chatter* (1987) and *Notjustmoreidlechatter* (1988), moved in the direction of greater harmonic and contrapuntal complexity. Infectious despite their surface complexity, these pieces have won Lansky, as the "computer postminimalist," a following beyond the specialist audiences of electronic-music mavens.

The Sampler: Stone, Amirkhanian, Gwiazda, Rolnick, Creshevsky

The sampler's greatest contribution to music is a philosophic one and is only beginning to be felt: it makes the new unit of musical thought not the individual note but the sound complex. The sampler works against the musical atomism of which serialism was the most extreme expression, an atomism that tape splicing and early analogue synthesizers encouraged. Composers who use sampling begin not at the level of the individual note, as composers have done since the development of notation, but at the level of the found sound object, a complex to be decon-

structed. The composer can either reveal the inner nature of the sound complex, transform it globally, let it be itself, or combine it with yet other sound complexes. The sampler frees composers from the habits inculcated by Western notation.

With that philosophic shift come more practical, even legal, considerations, for to sample is also to steal. Rap musicians, who were quicker than composers to take advantage of the sampler, have often run into copyright difficulties, and several lawsuits have resulted from a rap artist stealing, say, a drum sound from a James Brown disc. What does it mean, in terms of intellectual property and artistic morality, that one person can produce a sound and another incorporate it into his or her own work?

One Canadian composer, John Oswald, confronted the issue directly: in 1989 he released a disc called *Plunderphonics* made entirely from samples stolen from other recordings and twisted, slowed down, looped, and so on. He used soundbites from the Beatles, Michael Jackson, Beethoven's Seventh, *Le Sacre du Printemps,* Dolly Parton, Metallica, often in humorous juxtapositions. He covered himself, too: he sent copies of the disc out for free, and never received a penny, stating in the liner notes that no copies could be bought or sold. Nevertheless, the Canadian Recording Industry Association threatened a lawsuit (largely because, to illustrate the gender-changing quality of his speed transformations, Oswald had printed a cover with Michael Jackson's face pasted above a naked woman's body), and ordered him to destroy the remaining copies. Oswald has since released other, more legal Plunderphonics discs, but the experience made him a martyr and inspiring symbol to dozens of American sampler composers.

Perhaps the best known American sampler composer, Carl Stone seems like the quintessential composer-performer of personal-computer technology. He performs his work by sitting at a table, typing keys on his laptop computer. As he taps the occasional key, orchestras burst forth, sound environments emerge, loops lengthen or shorten, and prerecorded music articulates harmonies and rhythms that the original musicians had never dreamed of playing. Born 1953 in Los Angeles, Stone studied composition at CalArts with Subotnick and Tenney. He served as Music Director at KPFK, one of the country's leading radio advocates for new music, from 1978 to 1981.

In *Shing Kee* (see the listening example below), he looped a segment of a Schubert lied, changing the length and speed of the sample as it looped. In *Hop Ken* he played with and sped up samples from *Pictures at an Exhibition,* finally using its chords to beat out a propulsive rock rhythm that would have surprised Mussorgsky. In *Mom's* (1990, named for a barbecue joint) he shattered samples of Asian music into fragments of a few milliseconds each, then used permutational techniques to switch them around into different groupings, with a jerky but infectious rhythmic

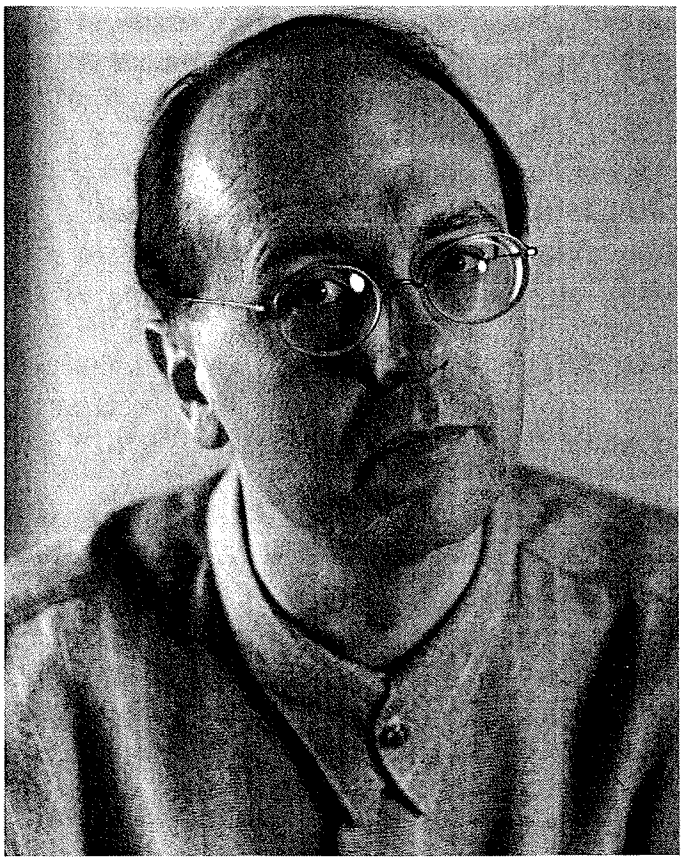
momentum. More recently Stone has turned to longer works such as *Kamiya Bar* (1992), a sensuous, seven-movement tapestry of the environmental sounds of Tokyo. Famously, all of Stone's works are named after restaurants, usually those that serve Asian cuisine. (It was I who took him to the rural Pennsylvania diner named in his 1996 piece *The Wagon Wheel.*)

Another lover of environmental sounds, Charles Amirkhanian creates a kind of extended, pictorial *musique concrète* with some of the longest samples in the business. Born in 1945 in Fresno, California, he was influenced on one hand by Steve Reich's *Come Out* and on the other by Gertrude Stein and the sound-text poet Clark Coolidge; the combination made him something of a half-poet–half-composer, using tape loops, delay, and multitracking to base text-sound works on the more playful aspects of words. Performing over taped accompaniment, he would turn phrases like "rainbow chug bandit" (*Seatbelt Seatbelt,* 1973) or "dichotomy bongo" (*Dot Bunch,* 1980) into an engaging rhythmic interplay. Such pieces relied on Amirkhanian's radio-announcer's ability to articulate phrases like "rubber baby buggy bumper" in fast, precise rhythms, for from 1969 to 1992, he was Music Director at San Francisco's KPFA public radio station. The first radio personality to champion minimalist music and Nancarrow, he exercised profound influence on the exposure of American composers.

In 1984, however, he discovered the Synclavier II synthesizer, which he valued for its ability to record and play back samples of three minutes or more. Using it, Amirkhanian has produced a series of natural-sound tone poems, often made as tributes to composer friends or historical figures: *Metropolis San Francisco* (1985–1986), *Walking Tune* (1986–1987, an homage to Percy Grainger), *His Anxious Hours* (based on a Brahms Intermezzo), *Pas de voix* (1987, a Samuel Beckett tribute), and *Politics as Usual* (1989). "One of the things that's interested me about environmental sounds," Amirkhanian explains,

> is that, if you hear footsteps, you visualize something. If you hear a violin, you just hear a violin. The sounds have a different kind of affect and are pictorial in nature. That has an interesting effect on the listener, because at the same time you're listening in the Cagean manner (all sound is music) but you're also getting a mental picture.[15]

Amirkhanian's *Walking Tune (A Room-Music for Percy Grainger),* for example, overlays reverbed lines for solo violin with the humming of hummingbirds, the squeaking of rusty gates, and footsteps crunching on a gravel path. *Pas de voix* took its title from the fact that Beckett refused to allow anyone to record his voice. Amirkhanian went to Beckett's Paris apartment building and recorded the ambient noise of construction workers, football fans, and a metro station. He layered these sounds with the voices of French children, fart sounds ("orally synthesized," he assures us), and the flushing of a toilet magnified by being played on



Henry Gwiazda. *Photo by Jaime Penuel.*

sampler as a forearm tone cluster—all in keeping with Beckett's insistence on including the less savory details of daily life in his plays.

Meanwhile, Henry Gwiazda has combined the sampler with a technology of which he is the chief pioneer: virtual audio. Born in 1952 in New Britain, Connecticut, Gwiazda played in garage bands as a teenager and has taught at Moorhead State University since 1981. In 1986, he discovered the Ensoniq Mirage sampler and made it his primary instrument. In collage works like *whErEyoulivE* (1989) and *wM* (1992—running words together and eccentric capitalization are Gwiazda idiosyncrasies), he performs by playing guitar and sampler keyboard at once. Gwiazda makes extensive use of sound effects libraries and, rather than manipulate the sounds, places them next to each other to create tone pictures drawn from daily life. In *MANEATINGCHIPSLISTENINGTOAVIOLIN* (1990), a lithe violin phrase recurs over and over in conjunction with the crunch of potato chips, as cows moo and dogs bark.

Gwiazda's virtual audio works allow him to choreograph sounds and control their perceived location in space above and outside the placement of the actual loudspeakers. His first—*buzzingreynold'sdreamland* (1994)—must be listened to with loudspeakers at chest level, fourteen

feet apart, with the listener seated about ten feet away from them. If you position yourself correctly, you hear a seagull circle lazily through the air, a person work in a virtual kitchen before walking around to your right, and at one point a basketball bouncing toward you. Another virtual audio work, *thefLuteintheworLdthefLuteistheworLd* (1995), must be heard on headphones for proper effect. A door opens behind you, a person walks up and begins to cut your hair, and then sneezes over your right shoulder with frightful auditory realism.

One of the most active East Coast electronic musicians is Neil Rolnick (born 1947 in Dallas, Texas), who specializes as a live computer performer using sampled material. His samples reflect his travels and passions: an extended stay in Yugoslavia just before that country broke apart resulted in his use of recorded Balkan music in *Balkanization* (1988) and *Requiem Songs—for the victims of nationalism* (1993), the latter a lament in which the computer is joined by violin and two sopranos in simple, folk-like melodies. Rolnick often employs video or film. His *Sanctus* (1990), for example, takes samples of masses from Machaut to Verdi to beautifully accompany a film of moving X-rayed skeletons. A smooth showman, he employs striking performance techniques, as in *Macedonian Air Drumming* (1990), where he triggers samples already stored in the computer by gesturing with velocity-sensitive, computer-wired wands. Rolnick directs the iEAR Studio at Rensselaer Polytechnic. His works vary tremendously in style and materials but are always whimsical and human.

Noah Creshevsky (born 1945 in Rochester, New York) is a reclusive composer of trenchant electronic collages. He worked with Virgil Thomson at SUNY at Buffalo and Nadia Boulanger in Paris, later studying at Juilliard with Berio, and now teaches at Brooklyn College. Like a latter-day Ussachevsky, Creshevsky revels in using digital sampler and computer to extend the possibilities of conventional acoustic instruments, in effect to create a music of impossible ensembles in which organs play devilishly fast rhythms and voices stray outside the range of the human throat. His *Variations* (1987) sounds like a thick ensemble of strings, voices, harps, and electronic instruments, often alternating notes in quick succession, and his *Talea* (1991) uses a fourteenth-century isorhythmic principle as a hidden structure for notes produced by a variety of voices, winds, keyboards, and so on. Creshevsky's music is witty and sometimes political; his *Strategic Defense Initiative* (1986), a collage of interruptions within a militaristic beat, was a response to one of President Reagan's more whimsical foreign policies.

Listening Example: Carl Stone,* Shing Kee *(1986)

Stone's *Shing Kee* is a classic of sampler technology, a supple minimalist work that makes the potential of the medium immediately apparent. Stone's complete source material is a recording of a Schubert lied—"Der Lindenbaum" from *Die Winterreise*—sung by a Japanese pop star, Akiko

Yano. As the piece opens, we hear a piano chord reverberating in suspended animation. As Stone lengthens the repeating loop, Yano's voice enters, first as merely a breathing sound, only later perceived as a sung tone. The German phrase grows longer and longer, finally breaking (at 8:30) into a later phrase from the song. As this latter phrase repeats, Stone gradually slows down the sample until it blurs into a wavery melody. The result overall is sensuous and restful, as hypnotic as any minimalist music. And Yano's pop inflection, Japanese accent, and German text create a sharp ambiguity as to the nature of the source; in Stone's hands, the sampler shows how drastically a few milliseconds can alter our recognition of familiar sounds.

Interactive Computer Systems: Chadabe, Teitelbaum, Lewis, Rosenboom, The Hub

In the hands of interactive-software composers, the computer has become a jazz partner to jam with. New software enables a computer to receive and quantify sounds from an instrument (or, alternately, supplied by the computer operator) and then transform them to send out, usually via MIDI, to synthesizers and other sound generators for replication. "Transform" in this case may mean something as simple as transpose or slow down, or something as complex as the mapping of quantities onto other parameters so that a pitch contour becomes a metaphor for timbral change or vice versa. The computer's echoes can be obvious, but more often it is used to create an entire language from the input it receives, and the sonic results often remain mysterious to the listener. Interactive computer music hasn't solved its aesthetic challenges yet, but no one has had to delve more deeply into the archetypes of musical language than those composers who program computers to do their musical thinking.

The first composer to entice interactive performance from electronic systems was Joel Chadabe. Born 1938 in New York, he studied with Elliott Carter at Yale and has taught at SUNY at Albany since 1965. Just out of graduate school, Chadabe was asked by SUNY to set up an electronic studio, something he knew nothing about at the time. Gathering together "the world's largest concentration of Moog sequencers under a single roof,"[16] he programmed random processes in complex enough arrays so that the sonic results would be surprising. The first result was *Drift* (1970), in which melodies swooped through musical space beyond his control. In *Ideas of Movement at Bolton Landing* (1971), Chadabe shared control with the sequencers. In 1987 Chadabe completed a software program called M, which has since been used by many live-computer performers. An example of M's potential is Chadabe's charming *After Some Songs* (1987–1995), a group of pieces based obliquely on jazz standards. In these works, percussionist Jan Williams improvises along with what he

hears from the computer, while Chadabe modifies the computer output to fit with what Williams is playing.

Richard Teitelbaum's music has also centered around automata, in his case the gradual bringing to life of a musical machine. Born in New York in 1939, Teitelbaum graduated from Yale studied in Italy with Luigi Nono and Goffredo Petrassi. Returning to New York in 1966, he bought a Moog, and when he returned to Rome to join Rzewski and Alvin Curran in the group that would become Music Elettronica Viva, he took with him the first Moog synthesizer that Europe had seen. Teitelbaum's first work to receive much attention was a set of Nancarrow-inspired pieces called "Digital Piano Music," in which he interfaced three pianos with a computer via the Marantz Pianocorder system, a large black box placed over the piano keys to play them with rubber-tipped rods. In *In the Accumulate Mode* (1982), for example, the computer would store all information Teitelbaum would play on one piano and then recirculate it to the other pianos. With an expansion in computer memory came more complex works like his *Concerto Grosso* (1985), which he wrote for himself, trombonist George Lewis, and reed player Anthony Braxton as soloists and for four synthesizers and two digitally-controlled pianos as accompanying orchestra. In this work, anything that happens in the orchestra is only a response to the soloists; the computer stores up information, and makes changes in delay, transposition, and so on, as triggered by the soloists' input. As Teitelbaum explains,

> To me improvising has a lot to do with the unconscious. My system reflects these actions back to me like a mirror. If it's complex enough that I don't quite know what I'm doing, it simulates the unconscious in a way. You don't know exactly what consequences your actions are going to have. It's like a shrink, a self-reflexive loop with your unconscious mind.[17]

With Teitelbaum's passion for musical automatons, it was natural that he gravitated toward the Jewish Golem myth of Rabbi Lowe, who in 1580 supposedly created a Frankenstein-type man intended to save the Jewish people, but which had to be destroyed because it ran amok. Similarly, Teitelbaum's *Golem* series, computerized improvisation-and-response systems are pushed gradually to a point of complexity at which the relationship between input and results is no longer audible and the system overloads. The series climaxes with Teitelbaum's opera *Golem* (1989), based on kabbalistic chant and number gematria formulas (Hebrew numerology) with video projectors, slide projectors, and two vocalists; at the chaotic climax, the computer goes out of control. Like Stone, Teitelbaum has frequently visited Japan, and in 1988 he was the only non-Asian composer commissioned to write a piece for twenty Buddhist monks: *Iro Wa Nioedo* (Colors Will Fade), in twelfth-century Japanese notation.

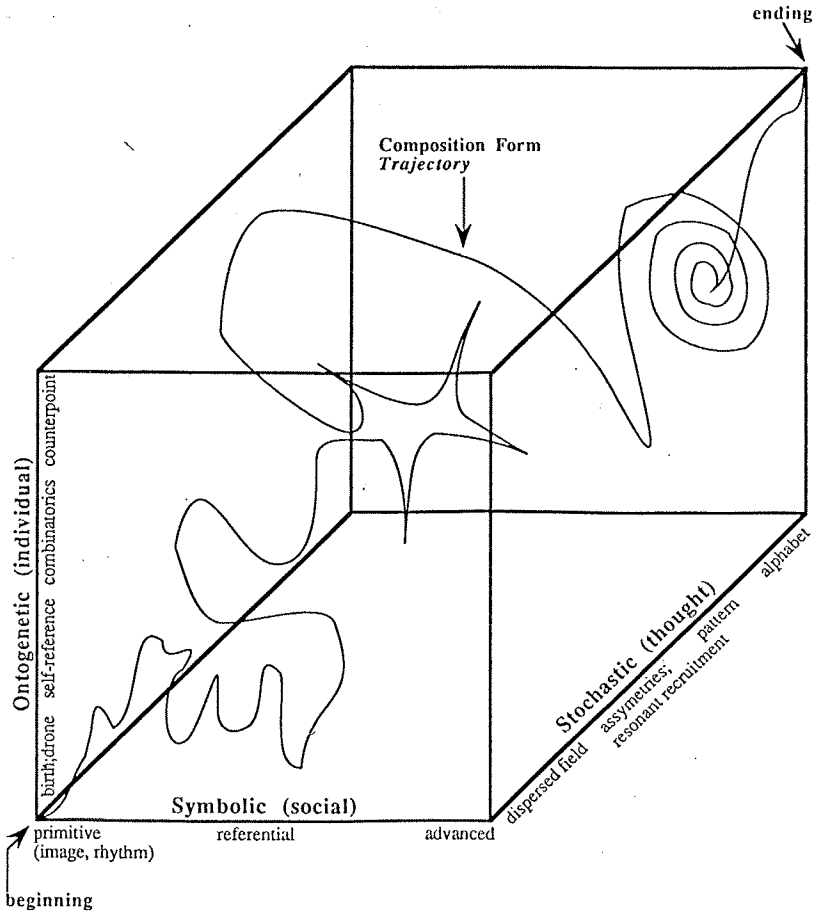
Teitelbaum's associate George Lewis is an unusual figure, his life a synthesis of two worlds: computer-interactive software and the free improvisation associated with the Association for the Advancement of Creative Musicians (AACM, for whom see chapter 11). Born in Chicago in 1952, Lewis studied with Muhal Richard Abrams before getting a degree at Yale, and he often plays trombone with Roscoe Mitchell and other AACM figures. He might have had the life of an improvising trombonist had he not visited Mills College in 1976, where David Behrman introduced him to the KIM-1 computer; his first piece for computer was *The KIM and I* (1979), for microcomputer, synthesizer, and improvising musician. Subsequently Lewis began to incorporate electronics into his AACM-style group improv situations, as in *Chicago Slow Dance* (1977). In his more frequent solo works for soloist and "interactive computer music composer-listener," as he calls the system, such as *Rainbow Family* (1984) and *Voyager* (1987), Lewis uses his digital partner as a fellow improviser.

Perhaps no composer has used more complex logical processes than David Rosenboom, a brilliant and multi-talented musician who also performs virtuosically on both piano and violin. If Chadabe's electronic systems remain cool and consistent and Teitelbaum's go out of control and self-destruct, Rosenboom's grow organically according to some seeded plan. His primary interest is in models of evolution, often starting with the paradigm of the primeval drone from which everything emerges—evident in one of his largest and most compelling works, *Systems of Judgment* (1987), which opens with a resonant, pulsating drone like distant thunder. Born in Iowa in 1947, Rosenboom studed at the University of Illinois with Martirano and others. Living in New York in the sixties, he worked with La Monte Young, Terry Riley, and Morton Subotnick. Rosenboom's *How Much Better If Plymouth Rock Had Landed on the Pilgrims* (1968), a lively perpetuum mobile of diatonic patterns, is reminiscent of Riley and the psychedelic sixties.

In 1968 Rosenboom became interested, like Lucier, in biofeedback, leading to several brain-wave works, the most important titled *On Being Invisible* (1977). Rosenboom would perform with small instruments and computer; the computer would begin producing music algorithmically, change some parameter, then check through sensors to see whether Rosenboom had registered the change, in a mental feedback loop. Rosenboom moved in 1979 to Mills College, and in 1990 to Cal Arts. By 1981 he had developed—with Larry Polansky (for whom see chapter 13) and later Phil Burke—an object-oriented programming language called HMSL, or Hierarchical Music Specification Language, which he first used in an evening-length work for percussion and computer called *Zones of Influence* (1986). Much of Rosenboom's music has been collaborative; he wrote the computer environment *Layagnanam* (1990) for the South Indian *mrdangam* player Trichy Sankaran to improvise in, and *Two Lines* (1989) for Anthony Braxton. If Rosenboom's concepts are among

the most abstract in the business, his sonic results are often sensuous and arrestingly meaningful.

Interactive computers have generally encouraged group creativity. The most important interactive collective so far has been the Hub, a group of six San Francisco-area computer composers: Mark Trayle, Tim Perkis, Phil Stone, Scot Gresham-Lancaster, John Bischoff, and Chris Brown. When the group first formed around 1985 (they were born in the mid-fifties), they would perform all hooked into a central computer. The advent of MIDI freed them to decentralize, though they use MIDI, they say, "as it was never intended to be used: as a medium of communication between players."[18] Each of their works is "composed" by one of the members, who specifies what kind of data will be exchanged and what the rules will be. (They have been known to perform together located at different spaces, connected via telephone wires.) Despite the abstractness of the venture, the Hub's music has a warm, tactile quality of irreverent sonic gestures.

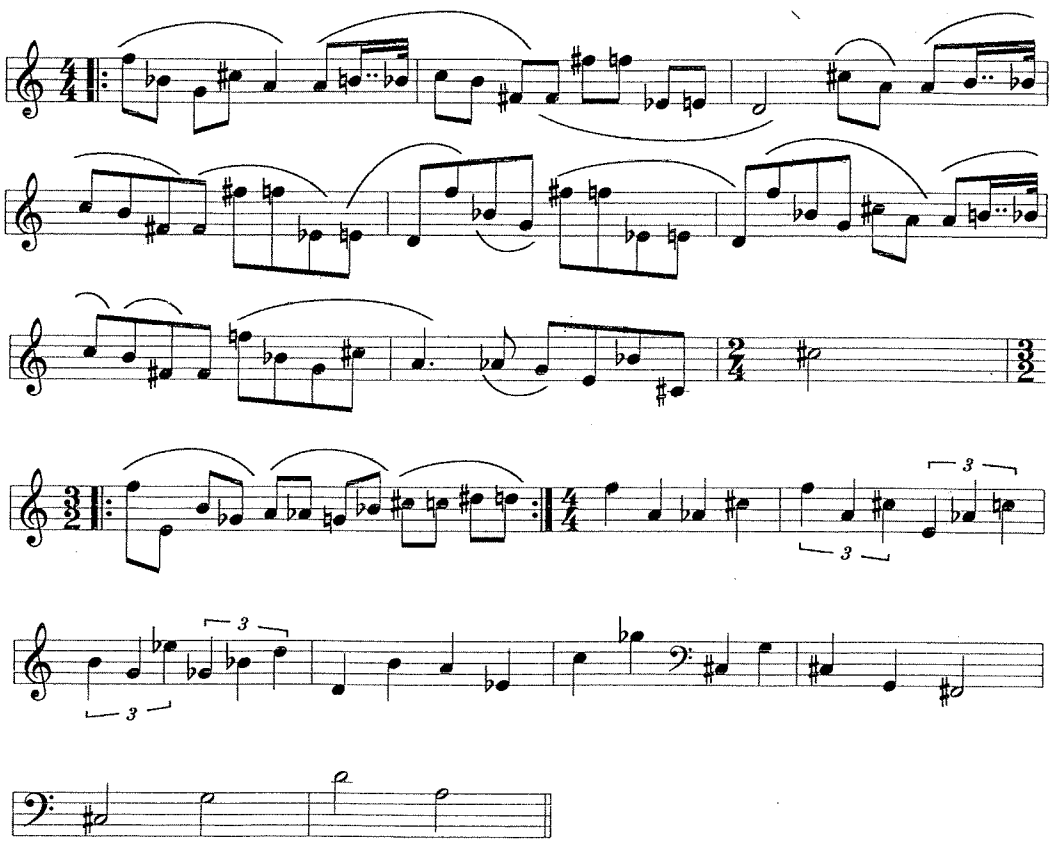


EXAMPLE 10.4 Concept space for Top-level Organization of David Rosenboom's *Systems of Judgment.*

Listening Example: David Rosenboom,* Systems of Judgment *(1987)

Systems of Judgment is one of the most remarkable and listenable works made so far with interactive computer software. The concept of the piece is that Rosenboom moves through a three-dimensional framework charted by three models of evolution, any one of which may exert more influence than the others at a given moment. The first model is that of a drone whose microscopic fluctuations, greatly magnified, eventually give rise to other tones. The second, complementarily, is that of random white noise, within which aberrations inevitably begin to suggest a specific direction. The third is an anthropological model of how we make distinctions between "primitive" and "more advanced" symbolic systems. Within these three possibilities, Rosenboom (playing piano and violin as well as guiding the electronics) follows the path graphed in example 10.4.

The piece begins with a prologue in which a low, pulsating drone blends into samples of thunder and a sampled mountain stream. The next section (out of seven), introduces the "Theme of Wonderment" (example 10.5), which recurs throughout the work in various forms. Part



EXAMPLE 10.5 David Rosenboom, *Systems of Judgment,* "Theme of Wonderment."

three is the "Central Section," the work's core and longest movement, which opens with "Rhythms of Self-Reference," i.e., rhythms which become more complex by replicating themselves at various levels. Sections 4 and 6 are interruptions; in the fifth section, "The Macro-organism begins to reveal itself to the separate entities; the paths of counterpoint continuously approach and veer away from one central attractor." The final movement is a microcosm recapitulating all that has gone before, ending with the chugging of sampled trains as metaphors for white noise. Interestingly, *Systems of Judgment* follows a curve from primeval unity to differentiated civilization similar to that of La Monte Young's *The Well-Tuned Piano,* and Rosenboom's "Theme of Wonderment" is reminiscent, at least conceptually, of Young's "Theme of the Dawn of Eternal Time." There the resemblence ends, but few computer-driven works remain as fascinating on repeated hearings as *Systems of Judgment.*

Sound Installations and Other Electronic Strategies

In freeing composers from the live performer, electronic machines have opened up a new social situation to the composer: the sound installation. Since they need never go the bathroom or pop out for a sandwich, computers and synthesizers—if programmed to run themselves—can sit in a gallery, building lobby, or outdoor space playing their digital hearts out for sixteen, even twenty-four hours a day. As a result, many electronic composers work in situations more reminiscent of sculptors and other visual artists than of the traditional musician, setting up works for audiences to come in and observe for any length of time.

One of the best installation artists, and a true American original, is Maryanne Amacher (born 1946 in Kane, Pennsylvania); unique and also mysterious, because the physical requirements of her works make her performances and installations rare, though more common in Europe than in America. As a child she was obsessed with acoustics: "I didn't play the piano too well," she remembers, "because I was listening to the overtones."[19] She attended the Philadelphia Conservatory of Music and the University of Pennsylvania, where she started working with computers and met her most important teacher, Karlheinz Stockhausen. An early series of installations called *City Links* (1967–) wired environmental sounds—from steel mills, airports, rivers, utility companies, open fields—to distant locations.

Perhaps Amacher's best-known works are her *Music for Sound Joined Rooms* (1980–1995) and *Mini-Sound Series* (1985–), in which she

customizes sound environments to fit the architectural features of a building, including transmitting sounds so deep and loud that they resonate through the building's structure: as she puts it, "The rooms themselves become loudspeakers."[20] Because she requires so much time to prepare the building, Amacher can hardly be prolific, yet she has implemented installations in Vienna, Basel, Lugano, Rome, Berlin, Minneapolis, San Francisco, and Tokushima, Japan. Heard in their intended acoustic environments, her thick drones and huge, booming sounds—just as likely to come from a trash can as a violin or synthesizer—beggar description. As Ron Kuivila has said of her, "She's the only person I've ever seen get away with a half-hour fadeout."[21]

Kuivila is a composer whose output consists of sound installations and performances with no clear-cut distinction. Born in 1955 in Boston, he studied at Wesleyan and Mills with Lucier, Ashley, and Behrman and joined the Wesleyan faculty in 1983. His work has stemmed from several ideas used in combination. One is an interest in motion sensing, for which he originally used ultrasound and later video motion sensors. He has played with sounds that integrate themselves into their environments; in *Musical Chameleon* he used ultrasound to track movement as people searched for noises that would disappear if you got too close. From 1987 to 1990 he explored an interest in algorithmic composition, typified by *Loose Canons* (1987), a computer-composed Nancarrovian tempo structure. Noting that a spark is the visual analogue of a sound, Kuivila has made *Spark Harmonicas* and *Spark Harps* (with wires and pipes through which 12,000 volts of electricity shoot periodically) as sound sources to create a soft *ts-ts-ts-ts* of sparks. In *Civil Defenses* (1994), Kuivila performed at a keyboard as his movements, registered by video camera, triggered sounds via motion-sensitive points on a screen. If Kuivila's work sounds abstract, it is conceptually, but his pieces are often bracingly visceral.

Nic Collins (born in New York in 1954) attended Wesleyan at the same time as Kuivila and also studied with Lucier. A residency by David Behrman stirred his interest in homemade electronics, and for several years he worked in David Tudor's group, Composers Inside Electronics. Collins' primary instrument is a computerized trombone through which he can play sampled sounds that loop at the touch of a button, and send them to various speakers around the room. A landmark in his output was *Devil's Music* (1985), made by scanning, sampling, and looping the radio airwaves, making a thick collage of bits of pop songs. In *It Was a Dark and Stormy Night* (1990), an actor tells a story-within-a-story-within-a-story, each new phase beginning with the piece's title, as the words increasingly trigger voice-activated percussion and drones from the mixed ensemble. Collins also made a rather humorous CD quintet called *Broken Light* (1991) for hot-wired CD player and string quartet,

with movements named for the composers violated: Corelli, Locatelli, and Torelli.

Given Collins's aptitude for musical ventriloquism, it was fitting that his primary attempt at theater so far is a musical séance. *Truth in Clouds* (first performed in progress in 1992) represents a séance held to contact two nineteenth-century figures, the pre-Raphaelite painter and spiritualist Anna Mary Howitt, and Elizabeth Siddal, wife of the poet Dante Gabriel Rossetti. The singers contact spirits via what must certainly be the first "Ouija-board-to-MIDI converter," which sends voices to loudspeakers placed all around the hall.

No computer composer of the younger generation has received more exposure than Tod Machover. Born in New York in 1953, Machover studied at Juilliard with Carter and Sessions, and from 1978 to 1985 he was Director of Musical Research at Pierre Boulez's prestigious IRCAM Institute in Paris. Since then he has taught at the MIT Media Lab. In 1994 he composed an opera, *Media/Medium,* for the magic duo Penn and Teller, and in 1996 his *Brain Opera* ran as an interactive installation at Lincoln Center in New York, afterward touring Europe. Inspired by the writings of the artificial intelligence expert Marvin Minsky and couched inside the ricercar from Bach's *Musical Offering, Brain Opera* allowed audience members to play rhythms and record remarks that would be incorporated into later performances of the opera; internet audience members could even contribute, although with so many individuals involved the chance of hearing one's own changes coming into play was like relocating a sesame seed dropped into the ocean.

Machover's more significant role has been as the developer of hyperinstruments, instruments augmented by computer-wired gloves that will transmit a tremendous range of information that can be used to elicit a halo of sounds from MIDI synthesizers. In his *Begin Again Again...* (1993) for hypercello, an FM radio transmitter in the bow, electronic sensors along the fingerboard, and a pressure-sensitive glove send information to three computers that let the cellist's melodies trigger other sounds, sending the accompaniment sweeping around the hall. Perhaps Machover's major work so far, though, is his electronic science-fiction opera *Valis* (1987), based on a novel by the popular writer Philip K. Dick. Scored for six singers, a massive video array, and only two musicians, the work was a landmark in the transformation of opera via computer into a medium that could achieve tremendous complexity with only a few performers; a landmark also in the assimilation of rock idioms into computer music.

Jon Appleton has had a career associated with a single instrument: the Synclavier, which he helped develop in the late seventies. Born in 1939 in Los Angeles, he worked in 1965 at the Columbia-Princeton Studio, joining the faculty at Dartmouth two years later and founding the Bregman Electronic Studio. Appleton's early music was in the nature

of tape collage, often commenting on culture, as in the irreverent *Chef d'Oeuvre* (1967), based on a TV spaghetti commercial, *Apolliana* (1969), using recorded voices of astronauts, and *C.C.C.P.* (also 1969), which layered the voice of Tolstoy with Russian music gradually sped up and slowed down. Although he was one of the inventors of the Synclavier, he has primarily used it as a sound-generating performance instrument instead of a sampler, in tonal works full of almost minimalist patterns, such as *Degitaru Ongaku* (1983) and *Brush Canyon* (1986), the latter a delightful evocation of Old-West musical archetypes.

Tom Hamilton is New York's leading improviser on analog synthesizers, instruments like the Serge Modular, the ARP 2500, and the Oberheim Matrix 12, whose replacement by digital MIDI machines has given them the character of museum pieces. Born in 1946 in Wisconsin, he is known for works that act either as sound installations or as backgrounds for improvisation. His first installation, *Morelos Sin Termino* (1979), attempted to evoke memories of Mexico in an audio form that gallery visitors could observe the way they look at paintings. In *Ejector Room* (1991), he videotaped four soloists, who then played live along with their juxtaposed tapes. Several of his pieces have been inspired by mass-transit systems, including *Third Rail Jumper* (1989), in which soloists drifted in and out of the space on schedule, and *Off-Hour Wait State* (1995), an installation for Oberheim sounds on a pair of randomly accessed compact discs, the structure of whose drones, whirrs, and noises were determined by taking timings from the station stops of the E-train in Manhattan.

Trimpin

One of the most phenomenal computer composers has never used an electronic sound in his music. Trimpin, the German-American composer, engineer, and inventor, has created an incredible world of computer-operated instruments that produce acoustic sounds via MIDI. Trimpin's stringed instruments use levers to bow cellos and pegs to finger the fingerboard. His MIDI-triggered clarinets use pumps to force air through reeds. His MIDI xylophones tap away upon digital commands. But conventional instruments are only part of Trimpin's story: upon MIDI directives, water drips from buckets in complex polyrhythms, duck calls spin a ripple of squawks around the room, xylophone notes zip up and down staircases with lightning speed. Trimpin has brought a new acoustic soundworld to life, and while for economic reasons they have not yet had widespread effect, they are bound to revolutionize music in the foreseeable future.

Trimpin (the name is his last name, and he no longer uses his first) was born in 1951 in the town of Istein, Germany, near the French and

Swiss borders. His father was a brass player, and as a child Trimpin had access to old instruments he could cut up and exchange the parts of. At twelve he would go to the junkyard and stack up old short-wave radios, risking his life by hooking them up to electricity and antennas.[22] Declared incapable of learning by his early teachers because his mind ran in such strange channels, he studied metal work and electronics. In his music therapy class, he invented a light-sensitive keyboard that handicapped patients could play by moving a light pencil with their mouths. A brass player, he had to give it up when he developed a skin sensitivity to the mouthpiece. His musical interests turned to other channels.

In 1980, Trimpin came to America because it was too difficult to find surplus material and used or obsolete high-tech equipment in Europe; America has far superior junkyards. He settled in Seattle in a studio bulging with ribbon cable, computer parts, and old instruments. One of his installations of the early eighties was a microtonal xylophone six stories high running through the center of a spiral staircase in an Amsterdam theater, with computer-driven melodies ripping up and down it. Another piece was an installation of water fountains dripping into glass receptacles, the drips digitally timed in complex rhythmic fugues. Commissioned for a dance piece, Trimpin designed dancers' shoes with small bellows that played duck calls. He has sent bass drums, beaten by mechanical mallets, traveling across the room suspended from tracks on the ceiling.

Another project is a gamelan with iron bells suspended in air by electronic magnets; when they rise to a certain point, the circuit is broken by a photo sensor, keeping the bell in an oscillating stasis in which, since they don't touch anything, they will ring with a phenomenally long decay. Trimpin's *Extended Woodwinds* was a quartet of extra-long bass clarinets with extra keys spiraled around the instrument for a scale of tiny microtones. Since humans only have ten fingers, the keys are played by computer, and all the humans do is blow. In 1987 Trimpin met Nancarrow, a mechanically-minded kindred spirit, at the Holland Festival. Having built a machine to convert player-piano rolls into MIDI information, Trimpin convinced the initially skeptical Nancarrow to allow him to save his complete works as computer files. Subsequently, Trimpin has arranged performances of Nancarrow's music for instruments other than player piano. Nancarrow's final work, Contraption No. 1, was written for Trimpin's IPP 71512, an "Instant Prepared Piano" played by mechanical bows and hammers.

As much as the sheer novelty of these Dr. Seussian inventions would suffice for historical interest, Trimpin's own music does not merely demonstrate them, but elicits engaging music from them. He creates spatial melodies that run around the room, tempo canons, and quick echoes that make pitches appear to dash through space. He doesn't

object to amplification on principle, but he does object to loudspeaker design, the one element of sound reproduction that hasn't changed in almost hundred years:

> this big magnet with a magnetic coil and a physical membrane—it's laughable. Digitally, every detail gets recorded, but the output lacks the resonance of the instrument. The future of loudspeakers is a different design that resembles more the acoustic resonance of instruments.[23]

Because Trimpin's music requires the transportation of so much equipment and so large a space to be heard in its spatial entirety, performances of his work have been rare, especially in penny-pinching America. There is little doubt, however, that someday composers will hear their music played by acoustic instruments, via computer, without a single human performer involved, without a single mistake, without any need to worry about whether enough ticket buyers will show up to pay for the concert, in perfect acoustic fidelity, with the sounds coming from a 360-degree radius. When that day comes, we may well look back to the genius-inventor Trimpin as the first musician of the new age.

Notes

1. Alice Shields, liner notes to *Pioneers of Electronic Music,* CRI CD 611, 1991.
2. Otto Luening, *The Odyssey of an American Composer* (New York: Charles Scribner's Sons, 1980), p. 512.
3. Ibid., pp. 512–513.
4. Ibid., p. 514.
5. Quoted in Joel Chadabe, *Electric Sound: The Past and Promise of Electronic Music* (Upper Saddle River, N.J.: Prentice Hall, 1997), pp. 16–17.
6. Ibid., p. 47.
7. Liner notes, *Columbia-Princeton Electronic Music Center Tenth Anniversary Celebration,* CRI SD 268.
8. Liner notes, *Silver Apples of the Moon,* Nonesuch 71174, 1967.
9. Quoted in Joel Chadabe, *Electric Sound: The Past and Promise of Electronic Music*, p. 109.
10. This and other prices and dates are from Joel Chadabe, op. cit.
11. Liner notes to *The Expanding Universe,* Philo 9003, 1980.
12. Quoted in Joel Chadabe, *Electric Sound: The Past and Promise of Electronic Music*, pp. 335–336.
13. Interview with the author, January 29, 1997.
14. Interview with the author, January 29, 1997.
15. Interview with the author, January 30, 1997.
16. Chadabe, op. cit., p. 286.
17. Interview with the author, February 7, 1997.
18. Tim Perkis, liner notes to *The Hub: Wreckin' Ball,* Artifact ART 1008, 1994.

19. Conversation with the author, January 30, 1997.
20. Personal communication to the author.
21. Conversation with the author, February 3, 1997.
22. This and following information from Kyle Gann, "Trimpin's Machine Age" in *The Village Voice,* April 20, 1993, pp. 84 and 87.
23. Ibid.