

## Chapter 1 , The Early Instruments

**What we want is an instrument that will give us a continuous sound at any pitch. The composer and the electrician will have to labor together to get it.**  
(Edgard Varèse, 1922)

### History of Music Technology

- |                 |   |
|-----------------|---|
| 27th cent. B.C. | - Chinese scales  |
| 6th cent. B.C.  | - Pythagoras, relationship of pitch intervals to numerical frequency ratios (2:1 = 8ve) |
| 2nd cent. C.E.  | - Ptolemy, scale-like Ptolemaic sequence  |
| 16 cent. C.E.   | - de Salinas, mean tone temperament   |
| 17th cent. C.E. | - Schnitger, equal temperament  |

### Instruments

- Archicembalo (Vicentino, 17th cent. C.E.) 31 tones/8ve  
Clavecin électrique (La Borde, 18th cent. C.E.) keyboard control of static charged carillon clappers

### Futurist Movement

- L'Arte dei Rumori (Russolo, 1913), description of futurist mechanical orchestra  
Intonarumori, boxes with hand cranked "noises"  
Gran concerto futuristica , orchestra of 18 members, performance group of futurist "noises"

- Musical Telegraph (Gray, 1874)  
Singing Arc (Duddell, 1899)

### Thaddeus Cahill

- Art of and Apparatus for Generating and Distributing Music Electronically (1897)  
Telharmonium (1898)  
New York Cahill Telharmonic Company declared bankruptcy (1914)  
Electrical Means for Producing Musical Notes (De Forest, 1915), using an audion as oscillator, more cost effective

### Leon Theremin

- Aetherphone (1920) a.k.a. Theremin  
RCA acquired license to manufacture Theremin (1928), made only 200  
Airphonic Suite for RCA Theremin and Orchestra (Schillinger, 1929)  
Terpsitone (early 1930s), musical floor  
Bugging device for KGB (1947)

### Sphäraphon (Mager 1926), like theremin but with discrete pitches

Dynaphone (Betrand, 1928)

Trautonium (Trautwein, 1928)

- Concerto for Solo Trautonium and Orchestra (Hindemith, 1930)

Ondes Martenot (Martenot, 1928)

- Written for by Messiaen, Milhaud, Honegger, Ibert, Jolivet, Varèse, Jarre, and Boulez

Hammond Organ (Hammond, 1929)

Electronic Sackbut (Le Caine, 1948)

Mixturtrautonium (Sala, 1948), polyphonic subtractive synthesis instrument using amplified spun gut strings

Sound effects for Hitchcock's The Birds

- Five Improvisations on Magnetic Tape (1961)

RCA Mark II Electronic Music Synthesizer (Olson, 1957)

Princeton arrival (1959)

Written for by Wourinen, Ussachevsky, and Babbitt

Milton Babbitt

Composition for Synthesizer (1961), Vision and Prayer (1961), Philomel (1963),  
Ensembles for Synthesizer (1964), and Phonemena (sop. & piano ver. 1969, sop.  
& synth. ver. 1975)

Free Music Machine (Grainger and Cross, mid-1950s)

## Chapter 2 , The Great Opening Up of Music to All Sounds

Colors are not used because they are true to nature but because they are necessary to the particular picture (Wassily Kandinsky)

LINEARITY OF ART HISTORY (Newtonian Period, ca. 1600-1900)  
Newton: Absolute Time

### 20TH-CENTURY ASYNCHRONISITY

Einstein: Special Theory, multiple clocks

Apollinaire: Lundi Rue Christine (1913), poetry with juxtaposition of unrelated phrases and fragments

Busoni, "Music was born free; and to win freedom is its destiny."

Stravinsky, Le Sacre du Printemps (1913)

Ives, Putman's Camp (1914)

### Found Sound

Respighi, Pines of Rome (1924), recorded nightingales

Antheil, Ballet Mécanique (1926), airplane engine on stage

John Cage, first composer to use found sounds

Had affinity for Duchamp's "readymades"

Construction in Metal (1939)

"I felt the need of some structural means adequate to composing for percussion. This led me eventually to a basic reexamination of the physical nature of sound. Sounds, including noises, it seemed to me, had four characteristics (pitch, loudness, timbre and duration), while silence had only one (duration). I therefore devised a rhythmic structure based on the duration, not of notes, but of spaces of time..." [Cage quote pg. 25]

4'33", define parts before putting in sounds

Imaginary Landscapes, collection of works with different sounds inserted (1, phonographs; 3, tin cans and oscillators; 4, 12 radios; 5, 42 LPs)

"I believe that the use of noise to make music will continue and increase until we reach a music produced through the aid of electrical instruments which will make available for musical purposes any and all sounds that can be heard...whereas, in the past, the point of disagreement had been between dissonance and consonance, it will be, in the immediate future, between noise and so-called musical sounds." [Cage quote pg. 26]

Pierre Schaeffer (ORTF)

Etude aux Chemins de Fer (1948), Railroad Studies

Coined the term "musique concrète"

Concert de Bruit (Concert of Noise), radio broadcast

w/Pierre Henry, Symphonie pour un Homme Seul (1950), locked groove disc

Edison cylinder (1877)

Gramophone (1887)

Magnetic recording proposed (1888)

Telephone (1898), wire recorder

Blattnerphone (1925), steel ribbon recorder

Dailygraph (1925), cartridge wire recorder

Powdered magnetic material (1927)

Optical recording (1930s)

Magnetophone (1935), plastic tape

Improvement of frequency response to 15 kHz at 30 ips

Became a spoil of war and examples shipped to USA (1945)  
 3M black oxide coating (early 1947)  
 3M red oxide coating (late 1947)  
 Stereo tape machine (1949)  
 pupitre d'espace (1951), sound distribution system  
 Photogène (1951), variable speed tape recorder  
 Morphophone (1951), multiple head tape recorder

Groupe de Recherche de Musique Concète (1951)  
 Schaeffer (Founder), Hodier, Boulez, Messiaen, Stockhausen, Philippot, Henry,  
 Milhaud, Varèse, Barraqué

Pierre Henry  
Orphée (1951), Le Voile D'Orphée (1953), Studio Apsome (1959), Variation pour une Porte et un Soupir (1963)

Groupe de Recherche Musicales (1958)  
 Ferrari, Mâche, Philippot, Xenakis, Schaeffer

Iannis Xenakis  
Diamorphoses (1957), Concret P.H. (1958), Orient-Occident (1960), Bohor (1962)

A la recherche d'une musique concète (Schaeffer, 1952), first "how-to" book of  
 musique concrète  
Traité des Objects Musicaux (Schaeffer, 1966), essays on musique concrète

NWDR (Cologne, Germany, 1952)  
 Meyer-Eppler, Beyer, Eimert (1st Director), Goeyvaerts, Koenig, Stockhausen, and  
 Maderna

Bruno Maderna  
Musica du Due Dimensioni (1952), flute, percussion, and tape  
 "electronische musik," an extension of serialism

"I, in turn, assert that any musician who has not experienced—I don not say understood, but in all exactness, experienced—the necessity for serialism it useless." [Boulez quote pg. 37]

### Serialism

"It is certain that no means of musical control could have been established over electronic material had it not been for the revolutionary thought of Anton Webern... Alone among the twelve-tone composers, Anton Webern conceived the row non-subjectively... In his work, for the first time, we see the beginnings of three-dimensional row technique—of what, in shore, we know as serial technique... everything, to the last element of the single note, is subjected to serial permutation... This electronic music is not 'another' music, but is serial music...Talk of 'humanized' electronic sound may be left to unimaginative instrument makers." [Eimert quote pg. 37]

Karlheinz Stockhausen  
Studie I (1953), Studie II (1954), Gesang der Jünglinge (1956), Kontakte (1960),  
Telemusik (1966), Hymnen (1967)

"In my Gesang der Jünglinge, I attempted to form the direction and movement of sound in space, and to make them accessible as a new dimension for musical experience. The work was composed for five groups of loudspeakers, which should be placed around the listeners in the hall. From which side, by how many loudspeakers at once, whether with rotation to left or

right, whether motionless or moving—how the sounds and sound-groups should be projected into space: all this is decisive for the comprehension of this work. The first performance took place on May 30<sup>th</sup>, 1956, in the main broadcasting studio at Cologne Radio Station. Today there are already quite a number of electronic spatial compositions..." [Stockhausen quote pg. 40]

Jikken Kobo (1951), experimental workshop  
Yuasa, Takemitsu, Suzuki, Fukushima

NHK (Tokyo, Japan, 1954)  
Mayuzumi (ORTF), Shibata, Maroi (NWDR), Ichiyanagi, Yuasa

Joji Yuasa  
Projection Esemplastic (1964), Aoi no Ue (1961)

MOMA Concert (Oct. 28, 1952), first electronic music concert in the USA  
Vladimir Ussachevsky Sonic Contours; Otto Luening Low Speed, Invention, and Fantasy in Space

"We wrote a report for the Rockefeller Foundation on the state of experimental music in Europe and the United States, including recommendations about the best program to be followed here.  
Our studio in the Ussachevsky living room was moved to my apartment. We then reported to President Kirk of Columbia University that unless we could have space on campus, our whole program would be seriously jeopardized. Soon afterwards, we were provided with suitable quarters—the charming "Charles Adams" house, located on campus at the site of the former Bloomingdale Insane Asylum..." [Luening second quote pg. 45]

Columbia University Electronic Music Studio (1955)  
Columbia-Princeton Studio (1959), established with RCA Mark II Electronic Music Synthesizer  
Davidovsky, El Dabh, Ussachevsky, Babbitt, Arel, Luening, and Wourinen

RAI (Italy, 1955), Studio di Fonologia Musicale  
Berio (Founder), Maderna, Lietti, Pousseur, and Nono

At that time, techniques and procedures were quite time consuming. Everything was done by cutting and splicing tape...In order to create certain effects, some sounds had to be copied sixty, seventy, and eighty times, and then spliced together. Then these tapes had to be copies further at different speeds in order to achieve new sound qualities more or less related to Cathy Berberian's original delivery of the text. I was interested in constant and controlled transformation from discontinuous to continuous patterns, from periodic to nonperiodic events, from sound to noise, from perceived words, to perceived musical structures, and from syllabic to phonetic view of the text...I didn't surrender to the difficulties...It's surprising now to think that I spent several months of my life cutting tape while today I could achieve many of the same results in much less time by using a computer." [Berio quote pg. 50]

Bruno Maderna  
Continuo (1958), Invenzione su una Voce (1960), Serenata (1961), Le Rire (1962), Tempo Libero (1972)

Luigi Nono  
Omaggio a Vedova (1960), La Fabbrica Illuminata (1964), Ricordati Cosa Ti Hanno Fatto in Auschwitz (1966), Non Consumiamo Marx (1969)

Tristram Cary (independent studio), film/tv music

The Lady Killers (1955), The Little Island (1958), BBC tv series Doctor Who

Louis and Bebe Barron, film music  
Forbidden Planet (1956)

John Cage  
Williams Mix (1952)

Harmonielehre (Schoenberg, 1911), "Klangfarbenmelodie" - "sound color melody"

Kandinsky, "Colors are not used because they are true to nature but because they are necessary to the particular picture." (1912)

Varèse, "Our musical alphabet must be enriched...we also need new instruments very badly..."

Brussels World Fair (1958), Xenakis and Le Corbusier pavilion  
Edgard Varèse Poème Electronique  
Iannis Xenakis Concert P.H.

## Chapter 3 , Expansion of the Tape Music Idea

*Electrical instruments...will make available for musical purposes any and all sounds that can be heard (John Cage, 1961)*

Estudio de Fonologia Musical (University of Buenos Aires, 1958)

Francisco Kröpfl

Ejercicio de Impulsos (1960), Dialogos I, and Dialogos II

CLAEM (Centro Latinoamericano de Altos Estudios Musicales, Instituto De Tella, Buenos Aires, 1963)

Davidovsky (Founder), Kröpfl (Director, 1967), Lanza, Kusnir, Marazano, Martinez, Caryevschi

Became CICMAT (Centro de Investigaciones en Communication Massiva, Artes, y Technologia, 1971)

1959 University of Toronto received first multi-track tape recorder built by Hugh Le Caine

"When I came in, there were two Multi-Track tape Recorders, the proto-type, and an update. In the updated version, you could play sixteen channels of pre-recorded sound through a sixteen-input mixer which was controlled by sixteen touch-sensitive keys. It was a performance instrument. The National Research Council had been interested in commercializing it if it looked better and if it could be debugged, so Hugh had done a dress up of the original prototype. But by the time we had it refined, no one was interested in it. It would have been a very expensive instrument for its time—the original projections were between \$25,000 and \$30,000" [Ciamaga quote pg. 64]

Radiophonic Workshop (BBC, 1958)

"applied electronic music" (Hodgson, 1962)

Swedish Radio

Oyvind Fahlström, Fåglar i Sverige (1963)

Lars-Gunnar Bodin, Cybo I (1967)

Fylkingen

Sten Hanson, Che (1968), How Are You (1969), fnarp(e) (1970), Opis! (1971), and Ouhm (1973)

Becomes leader of "text-sound group"

Kontakte (Stockhausen, 1960), addition of live element

Times Five (Brown, 1963), multiply instruments

I of IV (Oliveros, 1966), performance onto tape

"I wanted to bypass editing, if I could, and work in a way that was similar to performance...As I was making I of IV, I was also listening to it. At one point in the piece there's a rather climactic scream-like melody that sweeps through most of the audible range. When that started coming out, I didn't expect it; it was incredible and very delightful. I was laughing and was amazed at that particular moment..." [Oliveros quote pg. 78]

Animus I (Druckman, 1966), competition with tape trombone

L's G.A. (Martirano, 1968), for "gas masked politico, helium bomb, a triple projection film and tape"

HPSCHD (cage, 1969), simultaneous yet unsynchronized, non-interactive performances; seven harpsichords at different tempos with Hiller's 51 tapes

I Am Sitting in a Room (Lucier, 1969), the room as sound modifier/(re)synthesizer  
Synchronisms #6 (Davidovsky, 1970), piano and tape makes piano “larger”  
Acousmonium (François Bayle, 1974), loud speaker orchestra  
MAP (Foss, 1971), game  
Yo-In (Jean-Claude Eloy, 1980), flexible collection of tapes to mix with live sounds

## Chapter 4 , Out of the Studios

*It is by rules and compasses that the Greeks discovered geometry—musicians might do well to be inspired by their example* (Pierre Schaeffer, 1960)

Cartridge Music (Cage, 1960), “to make electronic music live”

Karlheinz Stockhausen

Mikrophonie I (1964), Mixtur (1964), Mikrophonie II (1965), Prozession (1967),

Stimmung (1968), Aus den Sieben Tagen (1968), and Mantra (1970)

Electronic transformation of acoustic sound

“Sonics I”, concert by Sender, Oliveros, Riley, and Winsor

San Francisco Tape Music Center (incorporated 1962)

Bridging conflict between electronic and concrete by calling it “tape music”

SFTMC's equipment went to Mills College for fiscal management of the Rockefeller grant (\$200,000)

Once Group (Ashley and Mumma, 1961)

Wolfman (Ashley, 1964)

Hornpipe (Mumma, 1967)

The soloist seats himself comfortably near the differential amplifier, and the assistant begins the procedure of applying the electrodes to the soloist's head. This operation involves cleaning the scalp with alcohol, applying special conducting electrode paste and gauze pads to secure the electrodes, measuring the electrical resistance between the electrodes (which should be below 10,000 ohms), and adjusting the gain and DC balance of the differential amplifier. The procedure takes several minutes to complete, generally a time of remarkable effect upon the audience...the situation is both ambiguous and dynamic. This period of time, before the first tapped brain-waves are directed to their resonant instruments, is really quite mysterious. After the sounds have begun, one come to recognize the coincidence of the soloist opening his eyes with the stopping of the alpha-articulated sounds." [Mumma quote pg. 96]

Music for Solo a Performer (Lucier, 1965)

I had made the acquaintance of Edmond Dewan, a very imaginative physicist who was on the faculty at Brandeis but who was then working for the Air Force doing experiments with brain waves. They thought that certain pilots who were prone to epilepsy were blacking out when the speed fo the spinning propellers got to a crucial point...When the sunlight would shine through the spinning props, it would lock onto something visual in the brain of the pilot...

Dewan described to me this phenomenon that had to do with visualization, that by putting yourself in a non-visual state...you could release the potential of the alpha that is in your head. It's a very small amount, but it would become perceptible, at least to an amplifier... Alpha itself is below audibility; it's too low to hear as pitch, but that high energy, those bursts of alpha, would come bumping through the loudspeakers, making the grille cloth on the speakers bump, and I got the idea of using that enerby to compulte the loudspeakers to instruments. I used gongs, tympani, bass drums...

Most people thought the material was too simple...but I finally did what I thought was the most honest thing. I tried to be very accurate about what the piece really meant: one person, alone, sitting very, very quietly, releasing a flood of energy which permeates the concert space. And to me, that was a beautiful idea..." [Lucier quote pg. 97]

**Dance****Merce Cunningham**Symphonie pour un Homme Seul (Henry and Schaeffer, 1952), Rainforest  
(Tudor, 1958), Walkaround Time (Behrman, 1967)**Sonic Arts Group/Sonic Arts Union (1966)**  
Behrman, Mumma, Ashley and Lucier**Musica Electronica Viva, a.k.a. MEV (1966)**Rzewski, Curran, Teitelbaum, Bryant, Phetteplace, Plantamura, Vandor, Lacy, and  
Lavine  
Group improvisation, Spacecraft (1967), Zuppa (1968), and Sound Pool (1969)**Experiments in Art and Technology, a.k.a. EAT (1966)**

“9 Evenings: Theater and Engineering”

Variations VII (Cage)Brandoneon! (Brandoneon Factorial) (Tudor)**Other Festivals**

“First Festival of Live Electronic Music” (Mills College, 1967)

“Cross Talk Intermedia Festival” (Tokyo, 1969)

## Chapter 5 , Computer Music

It turns out that computer music is a very social activity—the inventors worked in teams, interacting with one another, and it continues that way (Larry Austin)

### FIRST COMPUTER GENERATED SOUNDS

Bell Telephone Laboratories (Murray Hill, NJ, 1957)

Max Mathews

Tests to judge telephone sound quality used “converter” to put sound into/out of a computer

John Pierce, as Director of Communication Sciences Division supported Mathew's research (coined the term “transistor” in 1948)

Music I (1957), first sound-generating computer program

In the Silver Scale (Guttman, linguist and acoustician at Bell Labs), first computer music piece; used altered diatonic scale

Only one voice, one waveform (triangle wave), no envelope control

Music II (1958), four voices, arbitrary waveform, and wavetables

Music III (1960), “when all things came together” (Mathews)

Modularity (unit generators) for Orchestras

Score

“Music from Mathematics” (1960), recording from Bell Labs

Aaron Copland, “The implications are dizzying and, if I were twenty, I would be really concerned at the variety of possibilities suggested.”

Pierce visited the University of Illinois (1961) where he visited Hiller,

Isaacson, Partch, and Tenney; he hired Tenney to officially do research in psychoacoustics, but really to do computer music.

James Tenney (Bell Labs, 1961-64)

Analog #1, Noise Study (1961)

PLF 2, a composing program

Four Stochastic Studies (1962) and Dialogue (1963)

Music IV (Miller and Mathews, 1962: improvements Howe and Winham, Music IV-B)

“The Digital Computer as a Musical Instrument.” Science (Mathews, 1963)

“There are no theoretical limitations to the performance of the computer as a source of musical sounds, in contrast to the performance of ordinary instruments. At present, the range of computer music is limited principally by cost and by our knowledge of psychoacoustics...Computer music appears to be very promising technically. However, the method will become significant only if it is used by serious composers. At present, our goal is to interest and educate such musicians in its use... ”[Mathews quote pg. 110]

Risset does research at Bell Labs (1964)

Music IV-BF (Howe, 1967), first software synthesis system (SWSS) to be machine independent (written in FORTRAN)

Music V (Mathews, Moore, Risset, and Miller, 1968), definitive version of Music n series of SWSS

F. Richard Moore, “We used to send the Music V program out in two full boxes of punched cards, about 3500 cards, and a letter saying, ‘Good Luck!’”

Non-intuitive interface and lack of real-time interaction

John Chowning

SAIL (Stanford Artificial Intelligence Laboratory)

Music IV running (1964) for research on sounds traveling through space

Research leads to discovery of musical application for frequency modulation (1967)  
 "The Simulation of Moving Sound Sources," Journal of the Audio Engineering Society, vol. 20, no. 6 (1971)  
 First summer workshops in computer music (1969)  
 Continued research in FM (1971)  
 "The Synthesis of Complex Audio Spectra by Means of Frequency Modulation," Journal of the Audio Engineering Society, vol. 21, no. 7 (1974)  
 American companies not interested in FM  
 Yamaha licenses FM (1974)  
 CCRMA (Center for Computer Research in Music and Acoustics), form with co-director Leland Smith (1975)  
 John Pierce joins as research professor (1983)  
 Max Mathews joins as research professor (1987)  
 Patent for FM issued (1977)  
Samson Box (Sampson, 1977), delivered  
 Researchers included Loy, Jaffe, McNabb, and Schottstaedt  
 Functioned as real-time Music IV  
 Used until 1989  
Sabelithe (1971) and Turenas (1972), spacialization  
Stria (1977), Golden Section for relations within sound timbre (partials) and between sounds

Jean-Claude Risset  
 "Computer Study of Trumpet Tones," Bell Labs (1966)  
 "On the Analysis, the Synthesis and the perception of Sounds, Studied with the Aid of Computers," dissertation (1967)  
 Computer Music Group at the Institut d'Electronique Fondamental (Orsay, France)  
 First computer music implementation, Music V, in Europe (Risset, 1969)  
 "An Introductory Catalog of Computer Synthesizer Sounds," Bell Labs (1969)  
 Becomes Music Department Head at the Centre Universitaire de Marseille-Luminy (1971)  
Dialogues (1975), for four instruments and tape  
 Becomes the "Responsible" for the computer department at IRCAM (1975)  
 Accepted a post at the University of Aix-Marseille (1979)  
 Appointed to CNTS (Centre National de la Recherche Scientifique, 1985)  
Suite for Computer Little Boy (1968) and Inharmonique (1977), unique timbres  
Sud (1985), bridging the natural and synthesized timbres

IRCAM (Institut de Recherche et Coordination Acoustique Musique, Paris, France, 1970)  
 Music research institute formed as part of the Centre National d'Art Contemporain  
 Created and directed by Pierre Boulez  
 New facility completed as part of the new Centre Pompidou (1977)  
 Mathews appointed as scientific advisor (1974)  
 Espace de Projection, adaptable black-box performance space  
 Five departments: computer, performance, electronic music, pedagogy, "diagonal" (to keep all the others cooperating)  
CHANT (Rodet, 1978), physical model of singing  
FORMES (Rodet, et al, 1981), control of hierarchical musical processes  
Chreode (Barrière, 1983)

Barry Vercoe  
 Music 360 (1968-71)  
 Taught at Yale (1970-71)  
 MIT (1971)  
 Digital Equipment Corporation gives Vercoe a PDP-11 mini-computer  
 Music 11 (developed for the PDP-11, 1973), two modes of control: 1) musical keyboard entry for simple timbre verification of notes and rhythms in real-time, and 2) full fidelity Music 11 mode not in real-time

Synapse (1976), for viola and computer

CARL (Computer Audio Research Laboratory, University of California San Diego, 1979)  
 F. Richard Moore (Director)

The question that interested me was whether to work for an industrial research lab where we were unofficial but had money, or to go to a university where we were official but had not money. In industry, you're guaranteed to make progress but not necessarily in a direction of your choosing. In a university, you're guaranteed that you can choose your direction, but you're not necessarily going to make any progress" [Moore quote pg. 122]

## Last significant Music-n installation, cmusic (VAX)

## Charles Dodge

Analysis-synthesis approach to speech synthesis  
Speech Songs (1972), The Story of Our Lives (1974), In Celebration (1975), Cascando (1977), Any Resemblance Is Purely Coincidental (1978), and Roundalay (1985)

## “Generality” of SWSS

“There was no limit on the complexity of the sound that could be produced. If you wanted to produce 10,000 sine waves all at the same time, you could do that, no problem. In fact, it gave you time to get a cup of coffee while you waited for it to compute. Another thing is that it very much lent itself to experimentation. It is far easier to prototype a software unit than to prototype a hardware unit, and it doesn't require anything near the technical expertise.” [Moore quote pg. 127]

Institute for Music and Acoustics at the Zentrum für Kunst und Medientechnologie (Karlsruhe, Germany, 1988)  
 Johannes Goebel (Director)  
Übersetzen über den Fluss (1988), resonant filtering of fractal noise  
 SubBass-ProtoTone and Extended Tuba, new instruments for new sounds

## Dennis Smalley

Gradual (1974), Vortex (1982), Tides (1984), Wind Chimes (1987), and Valley Flow (1992)  
 Use of computer to “compose sound”

“My musical ideas come out of the sounds themselves. I explore their characteristics. I discover. With digital techniques, for example, I can isolate fragments that the ear can't otherwise hear. So I can pick out surprising elements, and I might say, "Let's play with it," and see if it gives me something. Or I might say, "Now that's a great sound. I have to use it." Or I might think that there are qualities in there which I can harness in building a piece of music. [Smalley quote pg. 130]

SoundBall (Lockwood, 1984), spacialization via flying speaker  
Three Short Stories and an Apotheosis (Lockwood, 1985)

BEAST (Birmingham Electro-Acoustic Sound Theatre), multi-loudspeaker playback system

## François Bayle

Les Couleurs de la Nuit (1982), Son Vitesse-Lumière (1983), and Aéroformes (1984)

CTR (Centro Tempo Real, Florence, 1979)  
 Berio and Di Guigno (Founders), Otto, Bernardini, Settle, and Puckette

TRAILS (Tempo Reale Audio Interactive Location System), sound spacialization system to route audio signals through a multi-speaker network (MiniTRAILS, smaller system)

Curtis Roads, Clang-tint (1995)

Paul Lansky

Six Fantasies on a Poem by Thomas Campion (1979), As It Grew Dark (1983), As If (1982), Idle Chatter (1984), just more idle chatter (1987),  
Not just more idle chatter (1988), Smalltalk (1988), The Sound of Two Hands (1990), Night Traffic (1990), Table's Clear (1992), Quakerbridge (1992), and Still Time (1994)

Human origin of electronic sounds

Dexter Morrill

Colgate University lab operational (1972)  
Studies (1975), Fantasy Quintet (1978), Six Dark Questions (1979), Tarr (1982), Getz Variations (1984)

Focus on works that included live performers

Trevor Wishart

Red Bird (1977), Tongues of Fire (1994)

Transformations of sounds

Formed music discussion and presentation group called "Interface" with Orton and Endrich

CDP (Composers' Desktop Project), system for computer synthesis on Atari ST

Wishart, Orton, Endrich, Malham, Atkins, et al

First port of SWSS to personal computer

Larry Austin, "It turns out that computer music is a very social activity—the inventors worked in teams, interacting with one another, and it continues that way."

John Pierce, "It' Billy Klüver's idea that 'isn't it wonderful that the arts will attract the assistance of a lot of engineers,' but the real thing is that it's amazing how many musically talented people become expert with computers."

## Chapter 6 , Synthesizers

A user interface...also includes the software (Donald Buchla)

Robert Moog (rhymes with vogue)

Articles on theremin construction: Radio and Television News (1954), and Electronics World (1961)

Meets Herb Deutsch (then at Hofstra University) at New York State School Music Association meeting while trying to sell his theremins (1963)

First hand-wired VCOs and a VCA by Moog (1964)

Visited University of Toronto Electronic Music Studio (1964)

"Electronic Music Modules," AES Journal, 1965; read at the 1964 meeting

Switched On Bach (Carlos, 1968), popular in 1969

"the gimmick for 1969"

Minimoog (1969), first single-unit integrated synthesizer, prototype of the Model A built

First public concert with a Minimoog was by Dick Hyman at the Eastman School in 1970

By 1970 the company was in trouble and purchased in 1971 (William Waytena of Musonics), then Norlin in 1973; sales increased under David Van Koevering as marketing manager.

Production stopped in 1980 with over 12, 000 sold

Polymoog, polyphonic synthesizer

Phonosynth (Ketoff, 1963-64), large studio-oriented synthesizer built for Gino Marinuzzi

Synket - Synthesizer Ketoff (Ketof, 1965), installed at the American Academy in Rome

John Eaton

Songs for RPB (1965), for soprano, piano and Synket

Concert Piece for Synket and Symphony Orchestra (1967), the new Synket optimized for live performance commissioned by the composer

Myshkin (1971), opera

Duet (1968), for both Moog and Synket

R7 - Roma 7 (mid-1960s), group of initially seven composer formed as a contemporary performance ensemble of Synkets, later joined by Ennio Morricone (from spaghetti western fame)

SFTMC - San Francisco Tape Music Center (1963)

"We put an SOS out to a fire insurance company that dealt with hi-fi stores, and they called us and said that a store had burned down, and they had all the inventory...We didn't have any money, but we rented a truck to get the equipment, and we gave them a bad check thinking that we'd find the money before the check bounced. So we sold enough equipment from the inventory, intercoms basically, also microphones, and we finally got enough money to cover the check we'd given them." [Subotnick quote pg. 146]

Donald Buchla

Optically Controlled Synthesizer, analysis of hand shape in an optical path;  
"This is the wrong way to do it"

Sequencer, analog automation of a set sequence of events (notes, amplitudes, filters, etc.); meant to reduce tape splicing and enhance performance

Pressure sensitive "keyboard"

All built on a \$500 grant from the Rockefeller Foundation grant in 1965

Series 100 (rights sold to CBS in 1969), fringe market appeal

Series 200 (1971), digital oscillators

Series 500 (1971), very large system (16 oscillators and gating matrix)

Series 300 (1972), a computer-based controller that interfaced with the Series 200  
 Series 400 (1978), a computer-based system including computer monitor and programming languages (Midas III, CHOPS, and Patch VI)  
 The Modular Electronic Music System  
 Morton Subotnick

"My method was to go to work at about 8 A.M. and to work until 2 A.M. the next morning, six days a week, and I purposefully did not know what results I was after. I believed that with this new instrument, we were in a new period for composition, that the composer had the potential for being a studio artist, being composer, performer and audience all at once, conceiving the idea, creating and performing the idea, and then stepping back and being critical of the results. I wanted to explore what kind of art I would create in that new circumstance." [Subotnick quote pg. 148]

Silver Apples of the Moon (1967), Wild Bull (1968), Touch (1969), a series of compositions for recordings from Nonesuch Records  
 NYU from 1966-1969  
 California Institute for the Arts since 1969  
Sidewinder (1970), Four Butterflies (1971), Until Spring (1975)  
Cloudless Sulphur (1978), written for the inauguration of the new JBL speaker factory  
Jacob's Room, Pt. 1 & 2 (1986)

Putney Studio (Putney, England), Peter Zinovieff  
 Purchase of DEC PDP-8 with 4K of memory (1967), purchased to develop a computer sequencer  
 David Cockerell built peripheral equipment  
Partita for Computer (1968), filled the hall at a January concert at Queen Elizabeth Hall  
 EMS Ltd., formed with Tristram Cary and Cockerell to "make something to sell"  
 VCS-1, built to sell for around 50£  
 VCS-3, "Putney", built for U.S. market with "pin matrix patching"  
 DK-2 keyboard  
 Synthi A, a.k.a. Portabella, portable synthesizer  
 Synthi-100 (1970), large sequencer-based synthesizer (256 sequencer, random voltage generator, pitch-to-voltage converter, Octave filter bank)  
 AKS (1971) portable synthesizer in a case with sequencer and touch-sensitive keyboard  
 Hans Werner Henze  
Glass Music (1970), Prison Song (1971), Tristan (1973)  
 Harrison Brittistle  
Four Interludes (1969), Medusa (1970), Signals (1970), Chronometer (1971), Orpheus (1976)  
 Both Henze and Brittistle detached from the technology but enamored to the precise results and possibilities  
 MUSYS-3 (Grogono, 1970), computer control language for analog synthesizer modules  
 VOCOM - Voice Communications (Eastty, 1973), digital filter bank for analysis and resynthesis  
 Tristam Cary  
The Pilgrims Progress (1972) and Divertimento (1973)

Electronic Arts Foundation  
 Established in 1971 to acquire, preserve, and display historical instruments (Tom Rhea and David Van Koevering)

Starting in the late 1960s popular groups/artists started playing synthesizers. Artists using synthesizers included Emmerson, Lake & Palmer, Stevie Wonder, Blood, Sweat & Tears, Mothers of Invention, Todd Rundgren, Yes, Pink Floyd, Jan Hammer, John McLaughlin, Billy Cobham, Herbie Hancock, Chick Corea, Roxy Music, and Brian Eno.

#### ARP Instruments

Started in 1969 by Alan Pearlman

Model 2500, modular synthesizer

Model 2600, portable synthesizer: "blue meanie" or "blue marvin"

Also the Pro-Soloist, Odyssey, Axxe, and Omni

#### Tom Oberheim

Worked for Norlin making ring modulators and such under the Maestro brand

Became an ARP dealer after seeing a 2600 at a NAMM show in 1971

DS-2, 144-note digital sequencer; sold for \$25 (1972)

Synthesizer Expander Module - SEM, incorporating a digital sequencer that could be played at the same time as the keyboard

Four Voice, a modified keyboard design licensed from E-mu Systems combined with the SEM (1975)

OB-1, programmable monophonic synthesizer

#### Sequential Circuits (Dave Smith)

Prophet-5, fully programmable and polyphonic synthesizer with microprocessor auto-tuning (1978)

#### University of Toronto

Piper, digitally controlled analog synthesizer (Ciamaga and Gabura, 1965)

Increased from one to four voices

Ended in 1973 when IBM removed the computer

#### Bell Labs

GROOVE (Generated Realtime Operations on Voltage-controlled Equipment), digitally controlled analog synthesizer (Max Mathews-conductor program and Richard Moore-composition algorithms, 1967)

Built around a brand new Honeywell DDP224 acquired for dedicated sound research

Laurie Spiegel (1973-78)

Appalachian Grove (1974), Patchwork (174), Waves (1975), The Expanding Universe (1975), Drums (1975), Clockworks (1975), A Voyage (1976)

Emmanuel Ghent (1967-78)

Battery Park (1969), Molly Bloom's Lament (1969), Danger-High Voltage (1969), Helices (1969), Innerness (1970), Fusion (1970), Supernova (1970), Phosphones (1971)

The Honeywell computer was removed from service in December 1978

Sound Workshop (interim tape studio as EMS was being designed and built; EMS is Elektronmusikstudion and not the same as EMS Ltd.), opened in 1965 by Knut Wiggen

Bodin: Toccata (1969) and Traces I (1970); Hanson: Che (1968) and How Are You (1969)

#### Fylkingen, Swedish new music organization

EMS (Karl Birger Blomdahl started and Knut Wiggen finished, 1970)

Took six years to complete due to unwillingness to compromise in quality, organizational issues, and politics

Originally financed by Swedish Broadcasting Corporation

Ownership of studio's equipment transferred to foundation in 1970

DEC PDP-15 obtained computer (1970)

"The software was poor. It was complicated and painstaking to program the thing. You had to sit and write on a teletype machine and the code was coming on punched tape which you had to feed into the computer. You could be sure you'd get hundreds of error messages. There wasn't any goo editing program, so you had to try and write another punched tape." [Bodin quote pg. 167]

#### Tamas Ungvary

Seul (1972), basic Barrier (1973), Traum des Einsamen (1975), Les Mouvements Mousseux (1979), Ite, Missa Est (1982), and L'Aube des Flammes (1984)

Per-Olof Strömberg appointed interim director (1975)

Jon Appleton invited to be director (1976)

Lars-Gunnar Bodin became temporary director (1977) and director (1978)

Evaluation report recommended closing EMS but a large protest meeting saved and even assisted in the restart of EMS with new money (1978)

#### Studio for Electronic Music (a.k.a. Institute of Sonology, 1967) at the University of Utrecht

Developed Variable Function Generator to act like sequencer (Tempelaars, 1961)

Gottfried Michael Koenig director (1964)

Funktion Grün (1967), Funktion Gelb (1968), Funktion Orange (1968), Funktion Rot (1968), Funktion Blau (1969), Funktion Indigo (1969), Funktion Violett (1969), and Funktion Grau (1969)

DEC PDP-15 obtained (1971)

VOSIM - VOice SIMulation (Werner Kaegi, 1973)

POD - POisson Distribution (Barry Truax)

#### University of Toronto

SSSP - Structured Sound Synthesis Project (Buxton, 1978), interactive digital computer music system on a PDP-11/45/LSI-11/digital synthesizer

#### Dartmouth College

Jon Appleton joins faculty and establishes studio (1967)

Georganna's Farewell (1975) and In Medias Res (1978)

Bregman Studio receives large Moog modular system, etc. (1969)

Appleton, Sydney Alonso, and Cameron Jones begin collaboration to design a digital synthesizer (1972)

Dartmouth Digital Synthesizer - ear training by day/composition by night (due to CAI grant from the Sloan Foundation)

Other compositions of note: Bilder (Images), Lars-Gunnar Bodin; Emergence, Russell Pinkston; Tapestry I, William Brunson

#### New England Digital - NED

Formed by Alonso and Jones (1975)

Controlled with a NOVA minicomputer

Contract with Norlin (of Moog heritage, 1976)

Dropped by Norlin (1977)

Developed 16-bit computer called ABLE (1977)

Appleton returns from Sweden and resumes working on this project (1977)

Kapingamarangi (1979), Sashasonjon (1981), and Brush Canyon (1986)

Synclavier is born (1977)

Joel Chadabe purchase first Synclavier but without the keyboard/control panel; writes his own programs in XPL

Michel Redolfi (Groupe de Musique Expérimentale de Marseille - GMEM)

Purchases first system with keyboard/control panel (1977)

Pacific Tubular Waves (1979)

#### Bell Labs

Alles Synthesizer designed and built (1977)

Laurie Spiegel

Concerto for Self-Accompanying Digital Synthesizer (1977), composed for fiftieth-anniversary celebration of talking pictures

## GRM

SYTER - SYstème TEMps Reel/Realtime System, a hybrid digital synthesizer/PDP-11/60 system (1982)

SYTER ported to Macintosh system creating the first version of GRM Tools (commercially available, 1993)

## Gruppo Electronacustica di Napoli

Founded by Giuseppe Di Guigno (1973)

4A synthesizer built (1976)

## IRCAM

Di Guigno goes to Paris (1976), brings 4A  
Antony (David Wessel, 1977)

4B finished (Di Guigno and Alles, 1977)

4C completed (1979)

Light (Machover, 1979) and Soft Morning, City! (Machover, 1980)

4X in semifinal state (1981), first digital signal processor

Répons (Boulez, 1981), early performance of work

Also used by Berio, Henry, Bayle, Barrière, Rowe, Battier, and Lippe

MAX first written to control the 4X by a PDP-11 (1987)

MAX ported to Macintosh connected to 4X via MIDI with Patcher graphics interface (1988)

Pluton (Philippe Manoury, 1988) and Partition du Ciel et de l'Enfer (Manoury, 1989)

## Chapter 7 , The MIDI World

Electronic music is all over the place, it's ubiquitous—  
what do you hear that isn't electronic music? (Robert Ashley)

Fairlight CMI (Computer Music Instrument), first of the samplers (Ryrie and Vogel, 1980)

Synclavier II (New England Digital)

First based on FM synthesis technology

Sampling unit added due to market interest (sample-to-RAM and sample-to-disc)

General Development System - GDS (Crumar/Digital Keyboards)

Based on the Alles Synthesizer acquired from Bell Labs

Synergy (1983), cost effective version of the GDS

E-mu 25 (E-mu Systems, 1971)

E-mu Systems formed by Dave Rossum and Scott Wedge (1972)

Originally built modular synthesizers

Licensed technology for digital scanning keyboards and integrated circuits

Audity (1979), analog synthesizer (\$70K)

Emulator I (1981), sampler (\$10K)

Drumulator (1983), "affordable" drum machine

Emulator II (1984), adding features such as a hard drive and higher quality

Proteus (1989), 256 ready to use sounds with simple user interface; big hit!

LM-1 (Linn and Moffit Electronics, 1980)

Funded by deposits for orders to be filled in three months

Linn Drum (1982), beat Oberheim DM-X to market; sold 5,000

Linn 9000 (1984), drum machine/economic disaster

Linn Drum MIDI Studio (1986), never released and eventually produced by Akai as the MPC-60

OB-X (Oberheim, 1979)

Programmable, microprocessor-controlled synthesizer, expanded to eight voices

OB-XA (1980), improved model of the OB-X

DS-X (1981), digital sequencer

DM-X (1981), drum machine

Xpander (1983), midi analog synthesizer

Matrix-12 (1985), two Xpander with pressure-sensitive keyboard

Matrix-6 (1985), design began

Ownership of company transferred to Oberheim/EEC owned by his lawyer;  
continued to work for company for 2 years

Name sold to Gibson Guitars (Oberheim files suit for malpractice against his former lawyer)

Syrinx (Synton)

"duophonic thing" with state variable filters, ADSRs, a ring modulator, noise,  
random voltage source, everything; never produced

Synton Hybrid Modular Systems interfaced with PDP 11/03

Syntovox 221 (1980s), vocoder

Synton also became a distributor for E-mu, Fairlight, and Linn

Syco (Peter Gabriel, early 1980s)

Distributor of synthesizers by private appointment

Sycologic (1984), analog-to-MIDI converter

PSP (Percussion Synthesizer Programmer, 1984)

M-16 (1984), MIDI patch bay

The Tablet (1984), digital recording and editing system

**Syncrom (Rochat, 1983)**

Evolved from Musical Instrument Manufacturers to distribute synthesizers  
 Opened Spyre to allow musicians to learn the instruments at their own leisure

**Roland (Ikutaro Kakehashi, 1972)**

SH-1000 (1973), monophonic synthesizer; followed by the SH-2000  
 System-700 (1976), complete analog synthesizer system  
 GR-500 (1977), first guitar synthesizer system  
 MC-8 (1977), stand alone sequencer  
 TR-808 (1980), programmable rhythm machine  
 Jupiter 8 (1980), eight-voice polyphonic synthesizer  
 Initiated discussions with American companies about MIDI (1981)  
 JUNO-106 (1984)  
 D-50 (1987)

**Dave Smith (Sequential Circuits, 1981)**

Presents paper at AES convention proposing the USI (Universal Synthesizer Interface)  
 Prophet 600 (1982), first MIDI keyboard  
 Prophet-T8 (1983), MIDI keyboard with 76 wooden keys, velocity sensitivity, and polyphonic pressure; sold keyboards to New England Digital

First instruments built on MIDI standard (Roland and Sequential Circuits, 1983)

MIDI a compromise between price, performance, and politics

Serial communication chosen due to cost effectiveness

**Yamaha DX-7 (1983)**

First MIDI hit below \$2K  
 Anticipated sales: 5000 units; Sold: around 200,000

**Marion Systems (Tom Oberheim, 1987)**

Consulting for Roland and Akai until 1991  
 MSR-2 (1991), MIDI synthesizer with internal synthesis module plugins

**Ensoniq**

Mirage (1984), 8-bit sampler, \$1295!

**Opcode Systems (Oppenheim)**

Music software  
 Start when Oppenheim built a computer system (IMSAI) for the control of a Moog modular system at the Boston School of Electronic Music  
 Use PLAY software (Chadabe and Meyers) to interface with custom board and Moog  
 Establishes that Macintosh will communicate via the serial port at the MIDI clock rate (1984)  
 Opcode Systems officially started at Macworld Expo (1985)  
 Meets Zicarelli at MacFest at Stanford  
 Shows sequencer (Oppenheim) and DX editor (Zicarelli) at NAMM show (1985)

**Dr. T's Music Software (Emile Tobenfeld, 1984)****Steinberg Research (Steinberg, 1983)**

Pro-16 (1983), sequencing software  
 Pro-24 (1986), sequencing software for Atari 520ST  
 Cubase (1989), sequencing software for Atari and Macintosh; IBM version released (1992)

**Digidesign (Gotcher and Brooks, 1983)**

Started designing sounds for Linn, Oberheim, Simmons, and E-mu

Sound Designer (1985), digital sound editing software for Macintosh  
Sound Tools (1988), digital sound interface for Macintosh  
Audiomedia, Pro Tools, Session 8, etc.

#### IRCAM

David Wessel instigates donation of MIDI studio from Yamaha  
Wessel put in charge of new personal systems department (1986)  
MacMix (Freed); MIDI LISP (Wessel and Boynton); PreFORME (Boynton)  
Patchwork (1988), integrated composition system with graphic interface

MidiShare (Orlarey, 1987), software enabling multiple music applications to work simultaneously; eclipsed by Apple's inferior MIDI Manager

#### Intelligent Music

M  
Jam Factory

MAX, graphic object oriented music programming environment

Developed at IRCAM

Zicarelli signs agreement to work on MAX to be distributed by Intelligent Music (1989)

Opcode Systems takes over agreement to publish MAX (1990)

U2 uses MAX to trigger sequences and send time-code to video

## Chapter 8 , Inputs and Controls

It's long term research (Robert Moog)

CEMAMU - Centre d'Etudes de Mathématiques et Automatiques Musicales (Xenakis, 1972)

UPIC - Unité Polyagogique Informatique de CEMAMU, computer-based system for the graphic control of musical parameters

La Légende d'Eer (1977), Mycenae-Alpha (1978)

Les Ateliers UPIC - UPIC Workshops (Massy, 1985), CEMAMU production and pedagogy satellite

Eye on Genesis I (Yuasa, 1991)

Phonogramme (Lesbros, 1993), system utilizing imported pictures to produce image and sound

Toca (Battier, 1993), utilized phonogramme in the realization

Electronic musical instruments can take on any and all shapes and sizes and can use any performance interface to control any musical parameter in real-time or non-real-time

Traditional instruments are so due to historic practice

Morton Subotnick

Two Butterflies (1974) and Before the Butterfly (1975), utilizes muted violins to control electronic devices

After the Butterfly (1979), utilizes a "ghost" instrument, a recording of an instrument not present, to control electronic devices

Ascent into Air (1981), utilizes two audible cellos to control the IRCAM 4C (Di Giugno) synthesizer

Hungers (1986) and Jacob's Room (1993), utilizes Interactor (Coniglio) software, a further development of Vercoe's score following paradigm, to track performers' actions to control devices

Events in the Elsewhere (La Barbara, 1990), utilizes Interactor to track her voice to control video

Tod Machover

Valis (1986-87), utilizes only two instrumentalist and the 4X processed voices (Di Giugno) to foreshadow the concept of the hyperinstrument

Hyperinstrument, the extension of a performer's actions to expand the musical result

Begin Again Again (1991), utilizes the hypercello to effect the work on an increasingly larger structural and timbral scale as the work progresses

Multiple-Touch-Sensitive Keyboard (Moog, 1972), under a commission from John Eaton, localized control in the fingertips; started in 1977 at Big Briar and finally delivered to Eaton in 1991!

Genesis (Eaton, 1992), composed for the MTS Keyboard but found MIDI modules were unable to handle the degree of sensitivity afforded by the keyboard

Big Briar (Moog, 1977), company specializing in alternative controllers (touchplates, theremins, ribbon controllers, ultrasonic sensors, etc.)

Electron Farm (Kramer, 1972), design and construction of synthesizers (orig. from CBS Buchla 100 parts inventory)

PASS - Public Access Synthesizer Studio (1977)

Harvestworks, supported PASS and Electronic Art Ensemble

Clarity (1981), licensed technologies to Lexicon, et al

**Zeta MIDI violin**

Synthophone (Hurni, 1981), prototype of a controller utilizing sensors and microprocessors to transform a traditional saxophone; first commercial model available in 1986 (Softwind Instruments)

IR-violin (Beyls, 1990), altered violin with infrared transmitter and receiver as sensors

trombone-propelled-electronics (Collins, 1986)

Real Electronic Music (1986), Tobabo Fonio (1986), and 100 of the World's Most Beautiful Melodies (1989)

Guitar controller (De Marinis, 1978), evolved into a guitar-like controller rather than starting as a modified guitar

MIDI Horn (Nelson and Talbert, 1983), controller for the brass player

Fractal Mountains (Nelson, 1988)

Celletto (Chafe, 1987), bodiless cello utilizing a pitch-to-MIDI converter

Thunder (Buchla, 1990), a hand-shaped surface with touch sensitive surface

Lightning (Buchla, 1991), utilizes wand or ring shaped transmitters to transmit information to the receiver  
En Plein Vol (1991) and Trajectories (1992)

Hands (den Biggelaar, 1984; later enhanced by Rijnsburger), alternative controller for hand control; finger movement and relative position of each hand

Michel Waisvisz

Beat Concert (1984), Touch Monkeys (1987), Archaic Symphony (1989), The Scream Lines (1990), Songs from the Hands (1991), and Faustos Schrei (1994)

Power Glove (Mattel Toys, mid-1980s), unsuccessful product for the toy company but interested many musicians as a controller

Lady's Glove (Sonami, 1992), glove with flex sensors, micro-switches, and ultrasound emitter used to compose/perform What Happened II

Radio Baton (Boie/Mathews, 1987), two batons with low-frequency radio-signal transmitters over a set of receivers; grew out of performance controllers originally built for the GROOVE system

Richard Boulanger

Shadows (1987), I Know of No Geometry (1990), Concerto for Virtual Orchestra (1991), Solemn Song for Evening (1992), Virtual Encounters (1992), Three Symphonic States (1993, with Power Glove), The Dark Wind (1994), and OutCries (1995)

David Jaffe

Wildlife (1992), Terra Non Firma (1992), and The Seven Wonder of the Ancient World (1995)

Music Kit (Jaffe and Smith, 1986), software tools allowing for the power of software synthesis and the real-time interactivity of MIDI

Gordon Mumma

Ambives (1971), Telepos (1972) and TV Rerun (1992), used accelerometers as controllers

MidiDancer (Coniglio, 1989), dance movement sensors transmitted to a computer via wireless link

Macedonian Air Drumming (Rolnick, 1990) and The Persistence of the Clave (1992) used air drums (Palm Tree Instruments) as controllers

Theremin (Theremin, 1920), alternative controller

The Pigmy Gamelan (DeMarinis, 1973), instead of building a synthesizer built a piece

Holosound (Raes, 1972), used ultrasound technology to sense a performers movements in three-dimensional space

Very Nervous System (Rokeby, 1989), analyzed video images of a performer's movement and translated them into musical controls

Bruno Spoerri

In and Out (1991), Shake, Shuttle, and Blow (1991), Spiegelei (1992), and Did You Do? (1993)

3DIS - 3 Dimensional Interactive Space (Veitch, early 1980s), video-based control system utilizing one to twelve cameras

Hear the Dance, See the Music! (Burt and Bandt, 1989), Jazzmaze (Burt, 1991), and Sine Waves, Harbour Waves (Brassil, 1993)

Contact (Otto, 1988), desktop control surface containing ninety-one knobs, switches, and faders

Crackle Box (Waisvisz, 1976), a touch sensitive hand size wooden box containing electronics and a speaker that "crackled" when touched.

## Chapter 9 , Making Sound

I don't think that most people are aware of how commercial software colors their musical process and causes standardization (Barry Truax)

Joel Ryan, "The rules of thumb of engineering are basically antithetical to the development of musical instruments."

Stan Tempelaars (Institute for Sonology), musical sounds are modulated: global modulation, pitch and general loudness; micro-modulation, change from instant to instant (internal, generated by the properties of the instrument and external, from performer's input)

ACROE - Association pour la Création et la Recherche sur les Outils d'Expression (Cadoz, Luciani, and Florens, 1978)

Cordis-Anima for the modeling of physical systems; "to research the equilibrium between what, in a sound event, precedes from the gesture and what proceeds from the instrument"

The voice has been viewed by many as the model for an ideal synthesizer: IRCAM's CHANT (Rodet) and CCRMA's Spasm (Cook) are examples that could be based on this concept

Anticredos (Wishart, 1980), uses the voice to produce primarily non-verbal sounds

**Joan La Barbara**

New Wilderness Preservation Band, helped her extend her timbral awareness and vocabulary

Hear What I Feel, performance piece

Began to explore the "beautiful in strangeness"

Vocal Extensions (1975), electronics to extend the voice

Autumn Signal (1978), uses Buchla equipment to process and spatialize her voice

73 Poems (1993), uses electronics to differentiate the author's double texts, one light and one dark

Santur Opera (Ivan Tcherepnin, 1976), uses filters and modulators by Serge

Tcherepnin to expand the range of sounds traditionally performed on the santur (Iranian lute)

**Simon Emmerson**

Established studio at City University of London in 1976

Ophelia's Dream II (1979), Time Past IV (1984), and Sentences (1990)

Second performer, additional performer to manipulate electronic from the audience's perspective

**Alcides Lanza**

Ekphonesis II (1968), uses a Putney synthesizer to modify the human voice in real-time

Trilogy, combines Ekphonesis V (1979), Penetrations VII (1972), Ekphonesis VI (1988) as a full-evening solo opera accompanied only by the tape and digital signal processing

Electronic extensions, using digital signal processing to grade the comprehensibility between clear semantic meaning and abstract sound

EIS - Expanded Instrument System (Oliveros, mid-1960s), to extend, enhance and transform her improvisations on accordion by controlling digital signal processors via foot pedals and switches.

Further developed with Panaiotis (late 1980s) and David Gamper (1990s)

Deep Listening Band (Oliveros, Gamper and Dempster), play the EIS collectively

Perfect Lives (Ashley, 1977-1983), video opera which required “Buddy,” the world’s greatest piano player to play on a piano which is transformed over 3.5 hours; accomplished with an acoustic piano transformed into an electric piano with microphones

Edge, U2’s lead guitarist, accomplished his signature sound through the unique combination of old and new technology

String Quartet No. 1: In Memoriam... (Motague, 1993), uses amplification and electronic sound to develop sounds that go beyond the traditional, super instruments

Kaija Saariaho

Vers le Blank (1982) and Jardin Secret I (1984), uses IRCAM’s CHANT to generate sounds

Stilleben (1988), composed by transforming “environmental and singing and orchestral sounds.”

Focuses on extending instrumental sounds

Nymphaea (1987), uses string quartet and their independently and differently processed to form them into the work’s harmonic structure

Amers (1992), for cello, synthesizer, sampler, and various amplified acoustic instruments uses each string of the solo cello processed individually

Io (1987), uses an analysis of a double bass sound as the starting point

Shozyg (Davies, 1968), instrument containing small amplified objects

Concert Aeolian Harp (1972), used amplified jigsaw blades which were struck, bowed, plucked and blown; by 1986 it included springs, a plastic wheel, and a section of “rainbow” computer cable.

Wave Drum (Mori/Korg, 1995), an acoustic drum transformed by internal digital signal processing system

frequency modulation, an audio rate carrier oscillator’s frequency is transformed by an audio rate modulating oscillator creating spectrum enhancing sidebands whose number and intensity are related to the ratio between the modulator amplitude and its frequency; the c:m ratio determine the placement of the sidebands

Julius Orion Smith, CCRMA, to design an electronic instrument as a model of a familiar instrument to extend the possibilities of the instrument beyond physical limitations (physical modeling, waveguide synthesis, or virtual acoustics)

Silicon Valley Breakdown (Jaffe, 1982), uses the Extended Karplus-Strong Algorithm he developed with Julius Smith

Perry Cook

Whirlwind, a physical meta-model combines trombone, flute and clarinet models

HIRN, meta-wind instrument controller which sensed bite, breath pressure, keys, linear slide, and rotation controls

CNMAT - Center for New Music and Audio Technology (UC Berkeley)

David Wessel

Along with Jean-Claude Risset, disagrees with the physical model approach  
Sees additive synthesis as the solution to electronic sound as it speaks directly to the ear

With Rodet, Freed, and Goldstein develops a “fly-by-wire” system to control additive synthesis using a neural network as an adaptive system

SSP - Sound Synthesis Program (Koenig, 1970), describing the wave form in terms of amplitude and time values in order to get away from the classical instrument paradigm

Sawdust (Brun, 1972), a series of explorations that allow the user to control the smallest part of waveforms (grain, quanta or wavelet)  
Dust (1976) , More Dust (1977), More Dust with Percussion (1977), Dustiny (1978), A Mere Ripple (1979), U-Turn-To (1980), and I told YOU so! (1981)

Musiques Formelles (Xenakis, 1963), early proposal for granular synthesis

Barry Truax

Develops granular techniques into a sound generating algorithm  
Joins faculty of Simon Fraser University  
Sonic Landscape No. 3 (1977), Androgyny (1978), and Arras (1980)  
Leads to the idea through granulation that sound and structure were no longer separate  
University acquires DMX-1000 digital signal processing system  
Ports POD software into PODX for real-time control of the DMX-1000  
Wave Edge (1983), Solar Eclipse (1985), and Riverrun (1986) composed with this system  
The Wings of Nike (1987) and Pacific (1990) granulate recorded sounds

Dave Smith, The general user doesn't want distinctive sounds

Edgard Varèse, "I need an entirely new medium of expression: a sound-producing machine (not a sound reproducing one)" (1939)

Jean-Claude Risset, "The easier a system is to use, the more limited are its possibilities"

Paul Lansky, "The most interesting music is generally going to be by people who have taken the design of their instruments into their own hands"

Larry Austin, "The only constraints that affect my work are those that I define—I have several very powerful software synthesis packages, including Csound and Cmix..."

Csound (Vercoe, 1985), a translation of Music-n programs (a la Mathews) is now possible to run in real-time on a microcomputer

Cmix (Lansky, 1986), a toolkit which makes instrument design easy

MacMix (Freed, 1985), Macintosh graphical interface connected to a VAX 11/780 for sound editing  
Freed commissioned IMS to build a specialized hardware device to replace the VAX and called Dyaxis  
IMS is purchased by Studer and renamed Studer Editech  
Clang-tint (Roads, 1995), used the Dyaxis system

CSC - Centro di Sonologia Computazionale (University of Padua)

Dashow, De Poli, Vidolin, and Rampazzi  
Dashow and Tisanto implement Music IV-BF (1974)  
Acquire 4I synthesizer from IRCAM (1984)  
LIBM - Laboratorio permanente per l'Informatica Musicale della Biennale di Venezia, organized as an event organizer by Vidolin out of CSC  
Dashow designs a personal DSP system, Music 30, from the 320-C30 Texas Instrument DSP chip  
Reconstructions (1992) and Morfologie (1993)

ISPW - IRCAM Signal Processing Workstation (1988), specialized  
DSP environment housed in a NeXT host as a successor to the 4X  
NoaNoa (Saariaho, 1991), Près (Saariaho, 1992), En Echo (Manoury, 1994),  
...explosante-fixe (Boulez, 1994), and Music for Clarinet and ISPW (Lippe, 1992)  
Cort Lippe, "It was everything I was looking for..."  
ISPW was finished as NeXT stops making computers

IRIS - Istituto di Ricerca per l'Industria dello Spettacolo (Paolo Buontempi, 1987),  
began to try and simplify the 4X as the MARS (Musical Audio Research Station)  
Sylviane Sapir becomes manager of MARS software development  
Stockhausen, Kessler, Sciarrino, Richard, and Berio use MARS

CERL - Computer-based Education Research Laboratory (University of Illinois)  
Carla Scaletti and Kurt Hebel meet in 1981  
Platypus (Hebel and Haken, 1984), a RAM-based micro-programmable digital signal  
processor  
Kyma (Scaletti, 1985), Mac Plus-based software synthesis system  
Funding for music hardware dries up

Bruno Spoerri, "MIDI? At the moment, it's the only way to live."

## Chapter 10 , Automata

It wasn't that obvious that you could be interested in music and science and technology and not be a candidate for a psychiatrist's couch (Barry Truax)

Water wheel powered bellows for a pipe organ (1644)  
Panharmonicon , (Maelzel, early 19th-cent.) orchestra of 42 robot musicians;  
Beethoven composed Wellington's Victory for this instrument  
Musical Dice Game (Mozart), use of randomness in musical composition

John Cage

"It is thus possible to make a musical composition the continuity of which is free of individual taste and memory (psychology) and also of the literature and 'traditions' of the art" (1952)

Birdcage (1972), composed at SUNY Albany, Joel Chadabe assisting.

Cage would not and did not use randomness in a completely unconstrained free-for-all where anything was possible anytime in any composition. Cage differentiated and defined his compositions by the questions he asked.

Reunion (1968), a five-hour series of chess games played by Cage against Marcel and Teeny Duchamp on an electronically wired chessboard (Cross) that "gated" through loud speakers the music produced by Cross, Tudor, Behrman, or Mumma

Accidents (Austin, 1967), piano work for Tudor in which the performer only plays the piano on accident

Tamas Ungvary, working at EMS in Stockholm, composes focusing on the instability of the EMS hybrid system

Earth's Magnetic Field (Dodge, 1970), work whose pitches and rhythms were taken from "Bulletin No. 18" of the International Association for Geomagnetism and Aeronomy

Lajaren Hiller and Leonard Isaacson

Began working on a series of experiments in automatic composition in 1955

Illiad Suite for String Quartet (1957)

composition by rule; generate-and-test principle

Norbert Wiener, "Messages are themselves a form of pattern and organization...the more probable the message, the less information it gives. Clichés, for example, are less illuminating than great poems."

HPSCHD (1969), collaboration between Hiller and Cage on a commission from harpsichordist Antoinette Vishner.

Cage develops computer subroutine to generate random numbers called ICHING

Cage wrote three programs, the first of which is DICEGAME to produce seven version of a harpsichord score; second program, HPSCHD, incorporated subroutines previously written (for Computer Cantata and Algorithms I) to compose 51 audio tapes, each of 20 minutes in duration that utilize equal-tempered scales of five to fifty-six divisions to the octave

First performance at the University of Illinois

Herbert Brun

Anepigraphe (1958), WDR in Cologne

Klänge unterwegs (1962), at Siemens Studio in Munich

Invited to become a NSF research associate at the University of Illinois by Hiller in 1963

Futility 1964, for tape

Works with software package, MUSICOMP, on the IBM 7094  
Sonoriferous Loops (1964) and Non Sequitur VI (1966), both composed with  
 MUSICOMP  
 Begins working on the Illiac II using FORTRAN in 1967-68  
Infraudibles (1968), music, and Mutatis Mutandis (1968), graphics

#### Iannis Xenakis

Coins the term stochastic music in 1956 to describe music based on the laws of probabilities and the laws of large numbers  
Achorripsis (1957), for orchestra, uses Poisson distribution to determine timbre, pitch, loudness, and duration  
 Makes contacts within IBM-France to give him a place and tools to continue his work  
ST/48-1,240162 (1962), Amorsima-Morsima (1962) and Atréees (1962), performed at IBM-France on 24 May 1962 (all for acoustic ensembles)

#### Gottfried Michael Koenig

Studies computer programming while at WDR in 1960  
 Begins to write out of serialist ideas the program PR1 (Project 1); moves to Utrecht in 1964 and finishes PR1 in 1967  
Beitrag (1986), for orchestra, written using PR1  
 Begins work on PR2 in 1968, which becomes "a complicated program" so he mostly uses PR1  
 Extends PR1 to interface with the VOSIM oscillators in 1978 resulting in PR1X and then modifies said in 1979 in PR1XM  
Output (1979), uses PR1XM

#### Otto Laske

Invited to work in Utrecht by Koenig in 1970  
 Works with PR1 and the analog studio  
 Interest in generative musical grammars as an extension of Pierre Schaeffer's "objet sonores" and his defined need for a treatise on how these objects are linked  
 Develops the theory of musical "competence", "performance", and (task) "environment" through the 1980s and later includes "biography"  
 "With hindsight, I realize that my main interest was always in creativity..."

#### Barry Truax

After complete graduate school in 1971 he goes to Utrecht for further study  
 Laske's work becomes influential as a study of musical behavior, as against musical artifacts  
 Begins to develop the POD (Poisson Distribution) programs  
 Chowning visits Utrecht in 1973 and plays Turenas  
 Chowning visit leads Truax to introduce dynamically changing sounds to the POD system  
She, a Solo (1973), for mezzo-soprano and tape composed in the analog studio  
Gilgamesh (1974), for large ensemble and twelve tapes; one of the tapes is prepared with the POD system

#### Algorithmic composition, a.k.a. computer-automated composition

Le Caine designs the Serial Structure Sound Generator as a "analog algorithm" system

#### Larry Austin

"Through the late 1960s, I was fascinated by the process. The process itself was more important than the compositional content."  
 Purchases a Buchla synthesizer in 1969 to compose works incorporating analog synthesizer processes

Quartet Three (1971), and Primal Hybrid (1972), performed on tape and edited  
Walter 91971), Prelude and Postlude to Plastic Surgery (1971), and First Fantasy  
on Ives' Universe Symphony—The Earth (1975), performance pieces  
“My model was improvisation. I had gotten the machine to improvise”

## Chapter 11 , Interaction

Everything is possible, but some things may not be easy (Larry Polansky)

### Joel Chadabe

CEMS - Coordinated Electronic Music Studio  
Ordered from Moog in 1967  
Installed at the SUNY Albany in 1969  
World's largest collection of Moog sequencers under one roof  
Contained an array of sound-generating and processing modules, an automated matrix mixer, and a digital clock  
Drift (1970), automated composition for real-time performance  
Ideas of Movement at Bolton Landing (1971), using joysticks to control CEMS  
Echoes (1972), utilized the CEMS to transform in performance the sounds of the percussion, violin, cello, and trombone (from a tape delay)  
Daisy (Roy, 1972), a compact pseudo-random signal generator  
Studio acquires a small PDP-11 computer  
PLAY (Meyers and Chadabe, 1977), written as a basic software sequencer to control the analog synthesizer  
Settings for Spirituals (1977)  
design-then-do, use for all works of this time

Purchases Synclavier system from NED in 1977  
Roger Meyers designed a software structure for the flexible and interactive scheduling of musical events  
Solo (1978), uses Meyers' structure in which to write a program performed with two proximity-sensitive antennas (a la theremin)  
Playthings (1978), piece where the audience was invited to interact with the antennas  
Scenes from Stevens (1979) and Several Views of an Elusive Lady (1985)  
Bar Music (1985), using some keys on a keyboard as control keys  
Rhythms (1980) and Follow Me Softly (1984), with percussionist Jan Williams coins the term interactive composing

### Salvatore Martirano

"My father as a builder of public building, so building was part of my growing up—building instruments was a normal idea for me"  
Underworld (1965), uses a spatialization system designed by the composer  
Works toward the development of a piano that would have a dedicated magnetic pickup in 1964-65  
Cocktail Music (1962), uses a system of underlying patterns and permutation as an evolution of serialism  
Reads Digital Electronics for Scientists (Malmstadt and Enke) in 1966  
Malmstadt Enke Blues (1967), an instrument based on algorithms and pattern manipulation  
Marvil Construction (Martirano and Divibiss, 1968), real-time performance instrument  
SalMar Construction (Martirano and Divibiss, 1969), added touch sensitive switches  
Engineers Franso, Borovec, and Barr (and later composers Sekon and Mohn) join the project  
Finished in 1972

### GAIV - Groupe Arts et Informatique de Vincennes

Founded in 1969 by Greussay (composer) and Huitric (painter) at the University of Paris VIII in Vincennes  
Exemple (1970) and Expérience pour Como (1970), using several VCS-3s purchased in collaboration with students

Given an Intel 8008 (an early small computer)

Connected to analog synthesizers, four or five VCS-3s, through DACs controlled with the 8008 programmed through the Intelgreu (Intel + Greu[ssay]) assembly language

Sept heures d'activités continues autour de mini-ordinateurs... (1978), a group

performance by Greussay, Englert, Arveiler, Battier, Dalmasso, and Roncin Girolles et Autres Campignons (Englert, 1978), based on ideas developed in four programs (Melanzane, Fragola, Basil 2, and Girolle)

Englert purchases a Synclavier in 1978

Roncin built a sixteen channel control device incorporating two joysticks and twelve sliders

Juralpyroc (1981), software controls sound contours, durations, timbre, and pitches through probability that is interactively weighted during performance by Englert

Quantuor 'S' (1979), Les Dits d'Amenhotep XIX (1980), Suite Ocre (184), and Model 'S' (1984)

### Mills College

League of Automatic Music Composers and later The Hub, developed interactive composition via computers

The League was started by graduate students Horton, Bischoff, and Gold

Horton first performs with the KIM-1 computer, purchased for \$250, in 1971

The League concertized extensively in the Bay Area during 1979 through 1983

Perkis and Bishoff builds a connecting box and called it "the hub" in 1984

The Hub was formed by Perkis, Bishoff, Gresham-Lancaster, Stone, Brown, and Trayle

Each member composes works for the group

Is It Borrowing or Stealing (Stone, 1987) and The Minister of Pitch (Perkis, 1988)

Gresham-Lancaster designed a MIDI interface to coordinate the group's communication; this allows each composer to use their own computer and sound generating equipment

### David Behrman

Voice with Melody-Driven Electronics (1975), for an array of pitch sensor that controlled special circuits and Joan La Barbara, commissioned by the Merce Cunningham Dance Company

Cello with Melody-Driven Electronics and Trumpet with Melody-Driven Electronics, part of a series of "very simple, minimal music"

The Cunningham Dance Company supported its composers by producing concerts in conjunction with a tour

On the Other Ocean (1977), interactive composition written for KIM-1 computer, six pitch sensors, homemade synthesizer, flute and bassoon

### George Lewis

Trombonist and composer visits Mills College in 1976 and is exposed to improvising computers (KIM-1s)

Trio by Candlelight (1977) and Chicago Slow Dance (1977), for electronic ensembles; Atlantic (1978), for amplified trombones with resonant filters; The Imaginary Suite (1978), for tape and instruments; The KIM and I (1979), for microcomputer, synthesizer, and improvising musician; Chamber Music for Humans and Non-Humans (1980), for computers and improvising musician; Minds in Flux (1980), for tape; A Friend (1980), for dance and tape; Homage to Charles Parker (1980), for electronics with instruments; Unison (9178, revised 1982), for soloist and score-following interactive computer program; Rainbow Family (1984), for interactive composition for computer with pitch sensor, synthesizer, and acoustic melody instrument; and Voyager (1987), for soloist and "interactive computer music composer-listener"

**David Rosenboom**

Begins work at SUNY Stony Brook with biofeedback researcher Les Fehmi in 1968  
 Starts to work at York University in Toronto in 1970

Ecology of the Skin (1970), create music based on the psychological state of the user wearing EEG sensors

Formed the Laboratory of Experimental Aesthetics at York

Portable Gold and Philosophers' Stones (1972), sound controlled by brain waves, galvanic skin response, and body temperature; Chilean Drought (1972), using biofeedback; On Being Invisible (1977, revised as On Being Invisible II in 1995), were feedback was based on ERPs

Joined the faculty at Mills College in 1979

Begins to work with the Buchla Touché synthesizer

Develops FOIL - Far Out Instrument Language

Becomes the director of the Center for Contemporary Music at Mills College

HMSL - Hierarchical Music Specification Language, begun with discussions between Rosenboom, Polansky, and Tenny was up and running by 1981

Polansky, "Everything is possible, but some things may not be easy"

Phil Burke, one of the developers from the beginning, becomes full-time project software engineer due to a grant from The Inter-University Consortium on Educational Computing; transforms HMSL into object-oriented language for Macintosh and Amiga

Zones of Influence (Rosenboom, 1986), for percussionist and Touché written in early HMSL and FOIL

**Larry Polansky**

B'rey'sheet (1984), based on the singing of the 11th and 12th cantillation melodies from the Torah; 17 Simple Melodies (1987), a HMSL program with only fundamental structures defines inviting the performer to specify the details; Cocks crow, dogs bark, this all men know, but even the wisest, cannot tell, why socks crow, dogs bark, when they do (1988); Horn (1990); 3 Studies (1990); There is more headroom, but one's feet are force into slipper of steel (1991); The World's Longest Melody (1993); The Birth of Peace (1989 with Chris Mann, Alistair Riddell, Simon Veitch, et al); and Dear John (1986, with Pauline Oliveros)

**Peter Beyles**

Tea for Two (1975), for two electronics performers; Heartbeat (1976), using a performers ECG signals; Crosstalk (1980, for live electronics; and The Hollow Man (1980), Painted Words (1981), Heading into the Storm (1985), all performances with computer

Focuses on interactive and intelligent systems at Brussels University artificial intelligence laboratory in the mid-1980s

Uses HMSL for creating Oscar (Oscillator artist), a knowledge-based performance companion, in 1985

**Felix Hess**

Electronic Sound Creatures (1983), 40 machines packaged in little aluminum boxes that react to the audience and each other; finished in 1983 at STEIM in Amsterdam

Moving Sound Creatures (1987), 24 small machines with two wheels, a bumper, and two microphones extended above the machine on a shaft

**Roger Dannenberg**

Starts to work on score-following programs in 1983

In pre-Macintosh days, "The sound was very crude but it was adequate and the whole thing fit into a little case that fit under an airline seat"

Shows system at the 1984 ICMC

Jimmy Durante Boulevard (Bloch, 1985), works with Dannenberg on piece for three performers (Bloch on keyboard, Dannenberg on trumpet, and Chabot on

flute) where the computer system acted as the composer's agent to focus the live performers towards a more structured performance

#### Richard Teitelbaum

Returns to New York from working with MEV in Rome in 1966 to build a synthesizer and study biofeedback techniques

Synthesizer built from modules he built and those from Moog; performs on keyboardless system by twirling knobs and changing patch cords

After working with Steve Lacy on an improvisational setting of Lao Tzu's The Way, he returns to MEV in Rome in 1967

Organ Music (1968), using brain waves and heartbeats

In Tune, brain waves controlling a synthesizer with processed heartbeats and breath sound

Alpha Bean Lima Brain (1971), brain waves transmitted via phone lines from Cal Arts made a pot of beans jump at the Avant Garde Festival in New York

Tai Chi Alpha Tala (1974), brain waves of a Tai Chi performer controlled a raga-playing sequencer accompanied by a live Indian drummer

Aspects (Duo) (1974) and Time Zones (1976), improvisations with Anthony Braxton

Blends (1977) for shakuhachi, percussion, and synthesizer

Colorless Green Ideas Sleep Furiously (1976), title is a sentence by Noam

Chomsky to demonstrate that grammar did not necessarily generate meaning Finds the difference between electronic instruments and acoustic instruments is the subtlety of the response

Loaned a s Pianocorder Vorsetzer to extend the piano (actually two such player piano systems with a controller piano attached)

Developed PCL - Patch Control Language, as an object-oriented language used to design interactive music environments

Solo for Three Pianos (1982) and Concerto Grosso (1985), use PCL

#### Salvatore Martirano

SAL - Sound And Logic, begun in 1986, as a performance program written in Le LISP

YahaSALmaMAC Orchestra (1986), a "real-time answering service" consisting of a Macintosh II, synthesizers, and a drum machine

Purchases a Kyma system in 1992

SAL is translated into SAL80 by Walker for use with the Kyma system

SAL80 is used as the basis for ImprovisationBuilder containing "listeners", "players", and "realizers"

#### Robert Rowe

Cypher, a listening program started in 1987

Flood Gate (1989), Sun and Ice (1990), Banff Sketches (1991), Maritime (1992), and Shells (1993)

Additional specific "listeners" developed for Not About Water (1994) and A Flock of Words (1995)

#### Intelligent Music

Started with no capital and great vision in 1993

M, 1986 Macintosh port by David Zicarelli of the work Chadabe had been doing on the Synclavier

Jam Factory, Zicarelli's improvisation software

OvalTune, another program by Zicarelli that extends his interactive concepts

#### Carl Stone

Sukothai (1979), composed at KPFK using a turntable and two stereo tape recorders (names after a restaurants in the Los Angeles are)

Kuk Il Kwan (1980), using a stereo Publison digital-delay harmonizer with recordings (commercial, soundscapes, urban, etc.)

Dong Il Jang (1982), for microphone, phonograph, recordings, and Publison

Hop Ken (1987), Wall Me Do (1987), Amatersau (1988), Jan Toh (1988), Nekai (1988), and Gadberry's (1989), utilizing M as his instrument (along with a TX-816 and Prophet 2000 bought with the insurance check from the theft of his studio)

#### Giuseppe Englert

Working with GAIIV in 1986

Mus Est Syllaba (1987), Basilico (1988), Dodeca (1989), and Plusieurs Multiples (1990), using M

Metro 3 (Lesbros) software was designed to allow for up to eight independent voices with each voice having control over timbre, tempo, rhythm, loudness, melody patterns, and random processes

Sopra la Girolmeta (1991), composed using Metro 3

#### Francisco Kröpfl

AREM - Algoritmos para la Reinterpretacion de Estructuras Musicales (Calzon, 1990), program for the probabilistic transformation of performance input to output; programmed in MAX

Incursions in the Arem (1993), using AREM to respond to the performer with it own personality

#### Bruno Spoerri

Became one of the founders of the SSCM - Swiss Society of Computer Music in 1982

SSCM holds first concert in 1983 with guests Max Mathews and Jean-Claude Risset

SCCM - Swiss Center for Computer Music, founded in 1984 by Spoerri, Greco Boesch, and Bennett

Controlled Risk (1986), using a MIDI feedback situation from two pitch-to-MIDI converters

Drum Song (1986), using Jam Factory

Rue du Cerche-MIDI (1987), using M

A Digit for Dr. Diamond (1989), using a prerelease version of MAX

## Chapter 12 , Were Are We Going?

And as we learn how to make it, we'll learn how to play it—  
and the other way around (Joel Chadabe)

### Bruce Pennycook

"The players that we see on a day to day basis out there making music are the players of traditional instruments—I'd like to have my pieces played live in the kind of venues that attract music lovers as those venues have for hundreds of years"

Praescio-I (1986), for saxophone player triggering sound events via a MIDI footpedal

Praescio-II Amnesia (1988), for soprano, flute, violin, cello, and keyboard synthesizer, the keyboard player triggering sequences of notes and effects

Praescio-III The Desert Speaks (1988), for harpsichord and electronics, the different registers of the harpsichord trigger accompaniment events in a pre-composed list

Praescio-V Frontline (1990), for trumpet, saxophone, and computer-MIDI-system uses MIDI-LIVE software that is controlled by switches installed on both instruments

Praescio-IV (1990, after Praescio-V), uses special keys on a clarinet to trigger electronic events

### Michel Redolfi

Underwater pieces where audiences floated and dived while listening to these concerts

Sonic Waters (1981), performed with a Synclavier over hydrophones (first in the ocean and later in public pools)

Sonic Waters II (1983-89), performed with a Synclavier II; L'écume de la Nuit (1984), for the Roman baths in Strasbourg, and Crysallis (1992), an opera composed for the Olympic pool in Grenoble

Electroacoustic music lends itself to a wide variety of venues including extravagant environments, interactive installations, CD-ROM, and the WWW

### Extravagant Environments

Phillips Pavilion (Brussels World's Fair, 1958), designed by Iannis Xenakis

Pepsi Pavilion (Japan Expo '70), including artificial fog, gigantic spherical mirror, robots, special lighting system

### Spectacles

Christian Clozier (mid-1980s), at locations such as Piazza San Marco in Venice, the Château de Cambord in the Loire Valley, the Château de Versailles, and the Bourges Cathedral

Iannis Xenakis' polytopes, Polytope de Montréal (1967), polytop at Persepolis in Iran (1971), Polytope de Cluny (1972), Polytope of Mycenae (1978), Diatope (1978) with La Légende d'Eer (1977)

Woody and Steina Vasulka, combining video and music began their explorations as early as 1970

### Interactive Installations

Well (Tony Martin, 1969), used vibrating mercury and transducers to sense people's hand movements

Sunspots (Liz Phillips, 1981), used theremin-type to detect movement in a gallery space

Talkshow (Lansky, 1988), used speech to activate rhythmic and speech templates, with the sounds made by synthesizers

Ich auch Berlin(er) (Paul DeMarinis, 1993), used a dichromate hologram of a 78 rpm record of the “Beer Barrel Polka” played on a transparent turntable by a green laser

Ron Kuivila

Il Giardino di Babele (1990), used a trompe l’oeil blue moon on the top floor of the tower in the piazza Poggi; a garden in which the alarms and chimes of 500 watches started sounding at nightfall and continues in staggered fashion throughout the next hour; and a playing field in which people’s movements affected sounds

Der Schnueffelstaat (1991), video images changed from crosshairs to Swiss flags when motion was detected in the room

Singing Shadows (1994), video sensing system scanned shadows whose shape controlled the musical processes

In Thin Air (Behrman, 1995), used footpedals, buttons, and light-beam sensors around a gallery space with which the public could interact

Barton and Priscilla McLean: The McLean Mix

Two threads developed through their work: nature and interactivity

Beneath the Horizon I (Priscilla McLean, 1978), used a tape of whale sounds; and In Wilderness Is the Preservation of the World (1985), included projections and environmental and animal sounds

Rainforest Images (1993), used recorded sounds of the Peruvian Amazon, Australia, and other “far flung places”, along with didgeridoos, voices, and instruments; all were processed in collaboration with Panaiotis using the EIS - Expanded Instrument System at the Oliveros Foundation

Rainforest, an installation where a taped drone of recorded and synthesized sounds and continuous projections of rainforest images provide an atmosphere in which members of the public are invited to perform on electronic and acoustic instruments

#### CD-ROMs

Max Mathews conceived of a system that would allow the user to purchase a score on transportable media and conduct an individual interpretation of the music; this resulted in the Radio Baton and Conductor Program

Intelligent Music’s business plan included the development of an interactive instrument for the home entertainment market

All My Hummingbirds Have Alibis (Subotnick, 1993), the first musical composition created specifically as a multimedia CD-ROM, allows the user to select the order of sections and visuals

Xplora 1 (Peter Gabriel) allows the user to move virtual faders in order to create their own mix

No World Order (Todd Rundgren), allows the user to control the tempo, mood, mix, and musical events

#### Interactive Software

Laurie Spiegel

Intelligent musical instrument (with Mathews, 1973), let people play music on a compositional level

“...it becomes possible for more people to make more satisfying music, more enjoyably and easily, regardless of physical coordination or theoretical study, of keyboard skills or fluency with notation. This doesn’t imply a dilution of musical quality. On the contrary, it frees us to go further and raises the base-level at which music making begins.”

Was a co-developer of the Apple II-based alphaSyntauri music system

Nomads (1981) and A Harmonic Algorithm (1981)

Extended the McLeyvier system into IMP - Interactive Music Processor in 1981

Three Modal Pieces: A Cosmos, A Legend, A Myth (1983), Harmonic Rhythms (1983), and Immersion (1903)

Finishes Music Mouse in 1985 as an intelligent musical instrument for the Macintosh, Amiga and Atari computers  
Cavis Muris (1986) and most of the CD Unseen Worlds (1987-90)  
Sound Effects Improvisation (Warren Burt, 1993), used Music Mouse with the addition of a Buchla Lightning

World Wide Web

Public Organ: An Interactive, Networked Sound Installation (Scaletti, 1995), introduced simultaneously on the WWW and at the ICMC in Banff; invites participants to experience linking, lurking, looping, and collective thinking through interaction

## Appendix 1 , Terms and Abbreviations

<b>ADC</b>	Analog to Digital Converter
<b>ADSR</b>	Attack, Decay, Sustain, and Release (see EG)
<b>AES</b>	Audio Engineering Society
<b>ASA</b>	Acoustic Society of America
<b>CEC</b>	Canadian Electroacoustic Community
<b>DAC</b>	Digital to Analog Converter
<b>DSP</b>	Digital Signal Processor
<b>EBU</b>	European Broadcasters Union
<b>ECG</b>	Electrocardiogram
<b>EEG</b>	Electroencephalogram
<b>EG</b>	Envelope Generator
<b>ERP</b>	Event-Related Potentials
<b>ICMA</b>	International Computer Music Association
<b>ICMC</b>	International Computer Music Conference
<b>MMA</b>	MIDI Manufacturers Association
<b>NAB</b>	National Association of Broadcasters
<b>NAMM</b>	National Association of Music Merchants
<b>NSF</b>	National Science Foundation
<b>SAN</b>	Sonic Arts Network (United Kingdom)
<b>SEAMUS</b>	Society for Electro-Acoustic Music in the United States
<b>SMPTE</b>	Society of Motion Picture and Television Engineers
<b>S/PDIF</b>	Sony/Phillips Digital Interface Format
<b>TDIF</b>	Tascam Digital Interface Format
<b>VCA</b>	Voltage Controlled Amplifier
<b>VCF</b>	Voltage Controlled Filter
<b>VCO</b>	Voltage Controlled Oscillator