Web Resources:

Electronic Music Foundation

Electronic Music Interactive, created by Jeff Stolet: http://nmc.uoregon.edu/emi/

Rane Pro Audio Reference: http://rane.com/digi-dic.html

EARS: ElectroAcoustic Resource Site: http://www.ears.dmu.ac.uk/

Canadian Electroacoustic Community

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STYLES, AESTHETICS, TRENDS, GENRES

MUSIQUE CONCRÈTE

ACOUSMATIC

REDUCED LISTENING

SPECTROMORPHOLOGY

ELECTRONISCHE MUSIK

TAPE MUSIC

TAPE +

FIXED-MEDIA

DIFFUSION

LIVE ELECTRONICS/REAL-TIME ELECTRONICS

INTERACTIVE ELECTRONICS

ACOUSTIC ECOLOGY

SOUNDSCAPE

SOUNDWALK

PHONOGRAPHY
SEMINAL STUDIOS and FACILITIES

RTF (Radio-diffusion-Television Francaise)/GROUPE de MUSIQUE CONCRÈTE, Club d’Essai

GRM (GROUPE DE RESEARCH MUSICALE) / INA-GRM

WDR (Westdeutscher Rundfunk), Cologne

BELL LABS, Murray Hills, NJ

Philips Studio, Eindhoven/Institute of Sonology, Utrecht

Columbia-Princeton Electronic Music Center

University of Illinois Experimental Music Studios

San Francisco Tape Music Center

CCRMA (The Stanford Center for Computer Research in Music and Acoustics)

UPIC/CeMAMU/CCMIX (CENTRE DE CREATION MUSICALE IANNIS XENAKIS)

IRCAM (Institut de Recherche et Coordination Acoustique/Musique)
WAVE (TIME DOMAIN)

OSCILLATE

FREQUENCY

CYCLES

PERIOD

HERTZ (Hz/KHz)

AMPLITUDE

INTENSITY Acoustics. The external measured level of a sound, i.e., the sound pressure level. Note that intensity is an objective measurement; contrast with loudness which is a subjective measurement.

LOUDNESS The SPL of a standard sound which appears to be as loud as the unknown. Loudness level is measured in phons and equals the equivalent SPL in dB of the standard. [For example, a sound judged as loud as a 40 dB-SPL 1 kHz tone has a loudness level of 40 phons. Also, it takes 10 phons (an increase of 10 dB-SPL) to be judged twice as loud.] Note that loudness is a subjective measurement; contrast with intensity which is an objective measurement.

SOUND PRESSURE LEVEL (SPL) 1. A measure of intensity. The rms sound pressure expressed in dB re 20 microPa (the lowest threshold of hearing for 1 kHz). [As points of reference, 0 dB-SPL equals the threshold of hearing, while 140 dB-SPL equals irreparable hearing damage.]

INVERSE SQUARE LAW
DECIBEL (dB)

0 dBu [0.775 Vrms]
+4 dBu [1.23 Vrms]
0 dBV [1.0 Vrms]
-10 dBV [0.316 Vrms]
0 dB-FS

INSTANTANEOUS PEAK METER

OVERS

VU METER

RMS

SPECTRUM (FREQUENCY DOMAIN)

PARTIALS

FUNDAMENTAL

HARMONIC SPECTRA

INHARMONIC SPECTRA

OVERTONES/OVERTONE SERIES

HARMONICS
WAVEFORMS

   Sin
   Tri
   Ramp/Saw
   Square/Rectangular/Pulse
   Duty Cycle

BALANCED/UNBALANCED

DC OFFSET

PHASE

INTERFERENCE

NOISE

   White
   Pink

ENVELOPE

   Attack
   Decay
   Onset
   Transient

RESONANCE

FORMANT(s)

MODES
PHYSICS of SOUND

ECHo

REVERB

Source
Early Reflections
Main Body
Tail

DECAY TIME

WET/DRY MIX

PRE-DELAY

DENSITY (Early Reflections)

DIFFUSION (Main Body)

REVERB TYPE

Room
Hall
Cathedral
Ambient
Plate
Spring
Non-Linear

HF DAMPING

LF DAMPING

CONVOLUTION

Impulse Response (IR)
Source
ANALOG RECORDING and SOUND PRODUCTION

ANALOG SIGNAL

SPEAKERS

MAGNETIC TAPE

SPLICING

CHANNELS

PANNING/SPATIALIZATION

SPEED CHANGE

DIRECTION CHANGE

DELAY EFFECTS/LOOPS

MICROPHONE

Dynamic/Condenser

Phantom Power

Mic Pre-Amplifier

Pad

Diaphragm (Small-Diaphragm/Large-Diaphragm)

Pencil/Side Address

PICK UP PATTERN

Omni/Cardioid

FREQUENCY RESPONSE

MIC CABLE (twisted pair, shielded)

Balanced

XLR – (M/F)

MIC LEVEL vs. LINE LEVEL (look up “Levels” on the Rane.com Web site)
SYNTHESIS

HISTORICALLY SIGNIFICANT INSTRUMENTS

TELHARMONIUM

TELHARMONIC HALL

THEREMIN

ONDES MARTENOT

RCA MARK II

MOOG

BUCHLA

OSCILLATOR

AMPLIFIER

ENVELOPE GENERATOR

ENVELOPE

Attack

Decay

Sustain

Release

Break Point

MIXER

SIGNAL CIRCUIT

CONTROL CIRCUIT

ADDITIVE SYNTHESIS

SUBTRACTIVE SYNTHESIS
SYNTHESIS

AM SYNTHESIS

MI

RING MODULATION

FM SYNTHESIS

CARRIER

MODULATOR

SIDEBANDS

DEVIAITON

MODULATION INDEX (MI)

DIGITAL FM SYNTHESIS

ALGORITHM

FFT

SPEECH SYNTHESIS

ANALYSIS/RESYNTHESIS

CONVOLUTION

Impulse Response (IR)

GRANULAR SYNTHESIS

ALGORITHMIC COMPOSITION
FILTERS and EQUALIZERS

- Attenuate
- Boost
- Cut Off (Threshold)
- Slope (Roll Off)
- Knee
- Shelf
- Pole (Single Pole, 2 Pole, 4 Pole)
- Order (1\textsuperscript{st}, 2\textsuperscript{nd}, 3\textsuperscript{rd}, etc.)
- High Pass Filter
- Low Pass Filter
- Band Pass Filter
- Band Reject Filter
- Notch Filter
- Peak Filter
- Center Frequency
- Q
- Bandwidth
- Resonance
- Parametric EQ
- Graphic EQ
COMPUTERS & MUSIC

BINARY

BIT

WORD/BYTE

CPU

MEMORY

GUI

OBJECT ORIENTED PROGRAMMING

DSP

DAW

SAMPLE

SAMPLE RATE

RESOLUTION (BIT DEPTH)

RED-BOOK AUDIO SPEC

DYNAMIC RANGE

NORMALIZE

DAC

ADC
NYQUIST FREQUENCY

ALIASING

QUANTIZING

DITHER

Dither Down

Quantization Noise

CONNECTION TYPES

Firewire

USB

S/PDIF

AES/EBU

Optical

ADAT

Ethernet
MIDI is serially transmitted binary data - it is represented as a series of voltage interruptions in an otherwise continuous current.

MICROCOMPUTERS and MIDI

The concurrent development of microcomputers and MIDI redefined the market of "computer musicians." Microcomputers simply require an interface to convert MIDI data to a compatible data format and vice versa. The MIDI interface is connected to the computer via a serial port. Some microcomputers have been developed with built-in MIDI interfaces (these have not been terribly successful computers). Some synthesizers are now produced with built-in serial/MIDI interfaces, thus eliminating the need for additional hardware beyond a microcomputer, serial cable and the synthesizer itself.

MIDI

MIDI NETWORK

MIDI INTERFACE

MIDI IN/OUT/THRU

MIDI NETWORK

MIDI CHANNELS

SYSTEM MESSAGES

   System Exclusive/System Real-time/System Common

CHANNEL MESSAGES

   Status Bytes

   Data Bytes

   Note On/Note Off

   Aftertouch (Monophonic/Polyphonic)

   Control Change

   Program Change

   Pitch Bend
MIDI MODES

Poly/Mono

Omni On (no channel discrimination)/Omni Off (only responds to designated channel)

LOCAL ON/OFF

KEYBOARD THRU

MULTITIMBRAL

GENERAL MIDI (GM, GS, GX)

MIDI CONTROLLERS

KEYBOARD

DRUM MACHINE/SEQUENCER

DRUM PAD/TRIGGER

GUITAR

EVI/EWI

DISKLAVIER

INFRARED/PROXIMITY

PHYSICAL/ANATOMICAL

MIDI SOFTWARE: A large and diverse market of MIDI software has developed and can be categorized as:

COMPOSITION AND PERFORMANCE

NOTATION

SEQUENCING

SYNTHESIZER EDITOR/LIBRARIAN

EDUCATIONAL/CAI
MUSM 433/533 & 434/534

READINGS BY TOPIC

Spatialization and Psychoacoustics
Lost in Space
A Place for Everything
In the Hall of the Reverb King
Can You Believe Your Ears

Acoustics, Physics of Sound
All About Additive
Loud, Louder, Loudest
You’ve Got the Power
Meter Matters
Sawing Logs
Pitch versus Frequency
Resonance and Radiation

Audio Recording and Editing
Razor’s Edge
In the Loop
Double Your Pleasure
Microphone Machinations
Mics in the Mix
Mic Specs Demystified

Dynamics, Condensers, and Ribbons
Optimum Gain Structure

Digital Audio
Digging into Digital Audio, by Scott Wilkinson
Dithering Heights, by Scott Wilkinson
Up From the Noise Floor

Filters
Spectrum Sculpting
EQ Explained
Equal Time

Synthesis
Modulation Synthesis Methods
FM Basic Training
A World in a Grain of Sound

Digital Signal Processing
A Stitch in Time
Voices from the Machine
Convolution Number Nine

History, Literature and Aesthetics
The Electronic Century, Part I, II, III, IV by Joel Chadabe
Acousmatics : http://cec.concordia.ca/contact/contact82Dhom.html
Pre-cursors to the Formation of the Columbia-Princeton Electronic Music Center
David Tudor’s Rainforest: An Evolving Exploration of Resonance
Music by the Numbers
BOOKS RECOMMENDED FOR FURTHER STUDY


On Sonic Art, by Trevor Wishart (ML3805 .W57 1996x)


Computer Music, 2d ed., by Charles Dodge and Thomas A. Jerse

Acoustic Communication, 2d ed., by Barry Truax

TIME LINE

1759  Clavecin Electrique invented by Jean-Baptiste de Laborde. Low voltage electricity applied to a harpsichord-like keyboard rang bells so long as a key was depressed.

1807  J.B. Joseph Fourier publishes paper introducing the Fourier Series.

1863  Hermann Helmholtz published The Sensations of Tone, an important early treatise on the principles of acoustics.

1876  Alexander Graham Bell transmits voice using electrical current.

1876  Thomas Alva Edison invents the phonograph.

1880s  Heinrich Hertz’s research proves the existence of electromagnetic waves.

1898  Vlademar Poulsen developed the Telegraphone, the first magnetic recording device, which used wire as its recording medium. The machine failed because of lack of amplification.

1906  Thaddeus Cahill builds the first Telharmonium (later dismantled and installed into Telharmonic Hall), a massive instrument that generated sounds electronically and resulted in the first commercial effort to distribute music over telephone lines.

1913  Luigi Russolo published the Futurist manifesto The Art of Noises, which proposed the composition of works based entirely on the use of sound sources from the environment. This work was an aesthetic influence of Pierre Schaeffer.

1919  Léon Theramin (Lev Sergeyevich Termen) developed the Theramin, which produced sounds using two oscillators that responded to the proximity of hands to antennae.

1928  Maurice Martenot developed the Ondes Martenot, an electronic instrument written for by many prominent twentieth century composers (Hindemith and Messiaen to name two).

1928  Harry Nyquist publishes paper implying the principles of the Nyquist Theorem, later proved by Claude Shannon in 1949.

1948  Pierre Schaeffer begins experiments with Musique Concrete. He classifies 56,000 sound possibilities, of which the Objet Sonore is the basic sound event. He also identified two possible approaches to composition in this style: a rational, studio oriented approach and a creative, sound oriented approach.

1948  Louis and Bebe Barron experiment with Tape Music (musique concrete) in their home studio in NYC. Their aesthetic was based on the equipment (the studio approach). They attracted many music personalities that would go on to prominence in and out of electronic music (John Cage and David Tudor to name two).

1948  Pierre Schaeffer’s Concert de Bruits is broadcast over French Radio, the first public presentation of musique concrete. The concert featured Schaeffer’s five musique concrete études.

1951  Schaeffer's assistant Jacques Poullin designed the auditorium/studio of Groupe de Musique Concrète, Club d’Essai.
1951  Cologne electronic music studio established at Westdeutscher Rundfunk (WDR), committed to the creation of music that adhered to the philosophies of Meyer-Eppler.

1952  Vladimir Ussachevsky and Otto Luening present a Concert of Tape Music at the Museum of Modern Art, NYC. They and their work would overshadow the work of the Barron’s in and out of America.

1955  Harry Olson and Herbert Belar developed the RCA Mark I Synthesizer. An expanded and modified version, the Mark II, was installed at the Columbia-Princeton Electronic Music Center in 1958 on the Columbia University campus.

1955  RAI studios (Studio di Fonologia Musicale) established in Milan, Luciano Berio its director. The studio philosophy emphasized texture, sonority and speech manipulation. It was one of the best equipped studios of its day, featuring the Springer Machine.


1957  Max Mathews creates the first computer performance of music with MUSIC I software.

1958  Columbia-Princeton Electronic Music Center established with a grant from the Rockefeller Foundation.

1958  Lejaren Hiller founds the Experimental Music Studio at the University of Illinois at Urbana-Champaign.

1958  World’s Fair, Brussels, featuring the Philips Pavilion (designed by Le Corbusier and Iannis Xenakis), a multimedia experience including Edgard Varèse’s Poème Electronique and Iannis Xenakis’ Concrete PH.

1961  Harold Bode, inventor of the Melochord, published an article on transistor based, modular synthesizer devices (oscillators, filters, etc.). This article provided the basis for the development of new synthesizers in the 1960’s that were small, modular and affordable.

1965  Robert Moog developed and marketed the first moderately priced and commercially available voltage-controlled synthesizer, the Moog, designed for both studio and live performance.

1966  Donald Buchla developed the Buchla synthesizer for the San Francisco Tape Music Center, designed primarily for studio composition (most Buchla synthesizers lack a keyboard controller). The commercial availability of both the Moog and Buchla synthesizers made for a boom in the number of studios at a fraction of the former cost.

1970  Pulitzer Prize awarded for an electroacoustic work for first time, Charles Wuorinen’s Time’s Encomium (1968-69).

1972  Intel released the first general purpose microprocessor

1976  Synclavier produced, a performance oriented, first all digital synthesizer. It featured a VDU for editing and control programming, which was to influence the development of software in the future. The original design and development was at Dartmouth College, a collaboration of Jon Appleton, Sydney Alonso, and student programmer Cameron Jones.
1977  IRCAM (Institut de Recherche et Coordination Acoustique/Musique) established

1978  Iannis Xenakis founded the research center CeMAMU, which would become Les Ateliers UPIC (1985), and later CCMIX (CENTRE DE CREATION MUSICALE IANNIS XENAKIS).

1978  First off-the-shelf commercial microcomputers (built around microprocessors) are released: Commodore PET, Radio Shack TRS-80, Apple II. Until 1980, desktop microcomputers were targeted primarily at the education market.


1981  IBM released the PC, attracting business and other commercial sector areas.

1981  E-mu Emulator I first lower-cost commercial sampler, offering 30 Hz, 8 bit resolution.

1982  A protocol is suggested that transmits note on/note off data. Later that year, Robert Moog announced MIDI (Musical Instrument Digital Interface).

1983  Specifications on MIDI are published - it is a standardized method (protocol) of communicating CONTROL DATA (NOT SOUND).

1983  Yamaha DX-7 released, featuring the patented FM algorithms of John Chowning. It was fully MIDI compatible, and featured Velocity Sensitivity, Aftertouch, Microtuning, Computer Editing, Multitimbral Performance (1985), and very high audio specs.

1984  Society for Electro-Acoustic Music in the U.S. (SEAMUS) founded

1986  Carla Scaletti writes the first version of Kyma, a visual programming language for sound design used by musicians, researchers, and sound designers. Kyman uses dedicated DSPs to process audio independent of the computer running the software.

1986  Barry Truax developed the first ever implementation of real-time granular synthesis.

1980s  Miller Puckette writes Max, a graphical development environment for music and synthesis, which he developed while working at IRCAM.

1980s  First HARD DISK RECORDING FACILITIES (tape-less) offered.

1980s  DSP units released: sample analog input, apply delay effects in digital domain and convert to analog signal in (near) real-time.

1980s  Synthesizers released with built in sequencers: WORKSTATION

1990s  Sample Playback units become popular. Digital Audio Workstations (DAWs) based on personal computers introduced into commercial and home studios.

1990s  Software synthesizers and samplers, as stand-alone software or as DAW plug-ins, rival and/or replace hardware as the principle sound creation and manipulation tools as laptops become more powerful.
STUDIO EARLY HISTORIES

INA-GRM (Institut National Audiovisuel, Groupe de Recherches Musicales)

GRM - a Paris studio formed by Pierre Schaeffer in 1951 to foster and encourage the development of electronic music, later assisted by François Bayle, who became its director in 1966. GRM incorporated with INA (another branch of the Office de Radio Television Francaise) in 1974.

50 years of Musique Concrète (excerpt, entire article here: http://www.furious.com/perfect/ohm/inagrm.html)

by François Bayle

Pierre Schaeffer’s first experiments with musique concrète date from April 1948. He was joined shortly afterwards by Pierre Henry and from then on that new form of music, which distinguishes sound from its initial acoustic cause, experienced a rapid development. 50 years later, the acousmatic experience is still going strong.

The invention of musique concrète, or, in a broader sense, sound as musical material, must not be confused with several other types of music, which, in musicology or organology, belong to neighbouring fields. The use of electricity to produce a sound wave dates back to 1906 with T. Cahill’s Telharmonium, followed by L. Theremin’s Aetherophone in 1921, and the Onde Martenot (invented by Maurice Martenot) in 1928. The futurist movement also had its composers, including L. Russolo, who published a radical futurist music manifesto entitled L’arte dei rumori in 1913, while the American composer John Cage gave the first stage performance of a work using variable-speed turntables and frequency recordings (Imaginary Landscape, 1938). As for that great pioneer Edgar Varèse, who composed Ionisation, a score for 13 percussionists, in 1931, and, before that, in 1926, Intégrales, in which he envisaged a spatialisation of sound, such gestures remained within the framework of conventional music, even though he attempted to break away from it.

The invention of musique concrète by Pierre Schaeffer in 1948 had nothing to do with those mentioned above, other than the fact that it happened in a context of modernity, using a resource that had never been used before: that of sound presented on a medium and accessible from that medium without having to return to the initial acoustic causes. Several degrees of freedom then suddenly became apparent: freedom from things, from time, and even freedom from moments of sound.

Suspended sounds

Thus, Pierre Schaeffer set out to explore the creative possibilities of the bossed groove recorder. Instead of allowing the record groove to follow its usual spiral course, he closed it in on itself to form a loop and then set about observing the surprising effect obtained when a moment of sound is suspended, isolating an atemporal musical figure that has been freed from its anecdotal origin; or else opening the recording shortly after an attack by the piano, he observed a complete change in timbre, which reminded him at the time of the oboe. Continuing his exploration, he read the recording backwards and noted the astonishing result, the violent change in perception resulting from the change in sound profile, for which he used the term ‘anamorphose’ (anamorphosis).

Immediately Schaeffer saw the immense experimental possibilities that lay ahead. This led to all the musical research of the second half of the 20th century, which, from essays to works, from manifestos to institutions, took the author from Études de bruits (1948) to his Traité des Objets Musicaux (1966), and from the Club d’Essai (1943) to the Groupe de Recherches Musicales (GRM, 1958), then the Service de la Recherche (1960) and, finally, the creation in 1975 of the Institut National de l’Audiovisuel (INA), including the GRM in its recent Département d’Innovation.

Very soon, Schaeffer felt the need for collective research, associating the creative field of researchers and technicians with that of the musicians themselves. It was then, from his meeting with Pierre Henry onwards, that the musical adventure really took off, in particular with their famous Symphonie pour un homme seul (1950). Right from the very first public concerts in 1950, it was a sensation.

Co-authors of musique concrète, Schaeffer and Henry came together in 1949, and during the early years they welcomed (not without great controversy in some cases!) young musicians such as P. Boulez, K. Stockhausen, O. Messiaen, E. Varèse, M. Philippot, M. Jarre, H. Sauguet, I. Malec, A. Boucourechliev, I. Xenakis… to mention but a dozen of those who have now become the classics of the 20th century.
Q: Not much is known about Herbert Eimert. Could you talk about his life?

Herbert Eimert was a musicologist who studied at the Music Conservatory of Cologne and at Cologne University. While he was a student in the '20's, he published a book about 'atonal music' (the recent 12-tone music of that time). This was too dangerous for his professors and he was kicked out of the conservatory. He worked as a journalist at the Cologne newspaper and shortly after the Second World War, when the West German Radio was reorganized, he joined the station as a music editor and programmer. Together with his colleague Robert Beyer, who was a sound engineer there, he succeeded in founding the famous electronic studio there in the autumn of 1951. He can be considered the founder of the Cologne branch of electro-acoustic music.

During the first years, before the studio was officially founded, he and Beyer composed some smaller pieces with very, very primitive technical tools at that time, amongst which was 'Klangstudie II.' From 1953, Eimert saw that he would not be strong enough as a composer to push the studio in the future. He invited Stockhausen to come and work in the studio. A year later, he also invited Gottfried Michel Koenig to work there. These two composers had been the main force behind the development of Cologne electronic music, which was one of the very special branches of electro-acoustic music at the time.

Later on, during the second half of the fifties, quite a lot of other composers came to work there. Actually, I had been the last person to be invited by Eimert to work in that studio in 1959, when I was still a school boy. Eimert had quite a lot of confidence in people and quite a lot of courage, opening his doors to them. That was a quite exciting time. There was much more discussion on an aesthetic level than nowadays. I had been collaborating with Koenig and worked in the studio with Bruno Maderna. Working together with Stockhausen has influenced me very much.

Q: What do you think was Eimert's grand scheme for starting the WDR studio?

Eimert's grand idea was that the music which would be produced by synthetic means and would be the historical continuation of the musical achievements of the late Anton Webern. He wanted to transpose the structural ideas of Webern into a new medium which he was thought more apt than the instrumental medium. There was a disagreement between Eimert and Beyer. Eimert was a structuralist and Beyer was a utopian dreamer. Beyer dreamt of spacialization of music, floating sounds, indefinite spaces - he had a vision of electronic music that was completely different from Eimert's. From 1953 on, certainly when Stockhausen and Koenig came to the studio, both visions were kicked a little bit out of the game because the young composers developed a much more refined concept of serialization of synthetic sound production. Though that was something Eimert accepted, he distained that. From a compository view, that was one step too far for himself.

Q: How did Beyer and Eimert manage to collaborate early on?

There are different which they composer together. There was a piece called "Sound in Indefinite Space," which shows more the impact of Beyer. "Klangstudie" shows more the impact of Herbert Eimert. It is a little bit more rigid, orientated on models of instrumental composition, not on compositions. It has a more rigid structure than certain of their other early pieces. I never talked to him about that but I think in this piece, his influence has been stronger than Beyer's.
Q: What kind of equipment were they using at the time?

In the beginning they had the melochord designed in the 1940’s. This could produce sounds nearly as clear and clean as sine waves. This was an instrument with a keyboard so they had to take every sound from the keyboard, put it on a tape and then start the synchronization and the montage work. That was mainly what, and just about all that, they had. Even when I came to the studio seven or eight years later, they only had two primitive sine wave generators, not even a noise generator, and some very primitive filters. All these instruments were loaned to them from the technical department at Cologne radio. So these instruments were not build for the purpose of composing music but they were made for measuring and things like that.

The interesting thing is that these people made very fascinating compositions with very primitive tools. Every step they took, every button they turned, they had to think twice or three times about what they were doing. With these tools, every mistake would take you HOURS to correct. With the early Eimert pieces which last only two or three minutes, some of them took months or half a year to realize in a studio. Nowadays, you punch a button without thinking about anything and the algorhythm puts itself to work and it’s always the same thing coming out.

Q: Around the same time, Ussachevsky and Luening were beginning their own studio in New York. They also came to visit WDR at that time. What was the impact of that?

That was just curiosity. Both parties had heard from each other. Eimert didn’t understand very much about what they were doing with computers. They were suddenly very curious to look at that. Luening and Ussachevsky came to Cologne to look at what happened in Europe- they also visited Schaeffer in Paris at the time. They were touring around to see what these Europeans were doing. One thing which could be considered a consequence, Cologne composers became interested in pre-programming certain aspects of music and sense of parameters. It was especially Koenig who developed his own set of computer programs, which then led to computer composed music. The effect was not direct because they were not found of the Columbia-Princeton music- they thought it was a little childish and primitive. But the principle seemed very much in their interest.

Q: What about the French connection (INA-GRM)? Did Schaeffer's work had any bearing on WDR?

No. You could say that in the Fifties, you had two types of Cold War. One between the Soviet Union and the United States and one between the Cologne studio and the French studio. (laughs) They disgusted each other. The aesthetic starting points of Schaeffer were COMPLETELY different from Eimert’s views. Stockhausen has worked for a short time in the Paris studios. He did some things there which disgusted Schaeffer so he kicked him out. When Stockhausen entered the Cologne studio shortly after that, he behaved like somebody who didn’t want to talk about Paris. That was a very human affair.

It was only in the end of the fifties, that these two opposite genres, the electronic, purely synthetic music of Cologne and the music concrete in Paris, came a little bit closer. It was some of in Stockhausen’s and Ferrari’s work that you see that. It took quite a lot of time before THIS Cold War was over! I have been educated in both countries in Paris and Cologne. When I was in Paris, it was absolutely unheard of to talk about Cologne and when I came to WDR, it was unheard of to talk about Paris. So, I was a double-spy! (laughs) I’ve learned quite a lot from both.
The Columbia music department applied for money for a tape recorder in 1950, and received the grant in 1951. It was considered a big investment, since up to that time the total yearly budget for audio equipment for the entire department was about $1000. When the tape recorder—a Ampex 400—and microphone arrived, I immediately began to do a lot of recording. I recorded the concerts at Macmillan Theater, where many of the music department performances were stage. Then I began experimenting with recording piano tones. The tape recorder had a speed change switch, so I could double or halve the speed of the original tone. Shortly after that, I learned about tape feedback from (engineer) Peter Mauzey.

The Ampex 400, Peter’s own two boxes, plus a borrowed pair of earphones and a second recorder, were what I started with. There was no formal program, no research grant. I did experiments and then put a few simple pieces of music together, on my own time. I played my first composition at a Composer’s Forum concert at Macmillan Theater on May 9, 1952.

At the time, I was the director of Bennington Composers Conference, which is held every summer at Bennington College. When I heard what Vladimir had done, I asked him to pack up his equipment and bring it up to the conference. I said to Vladimir, “Let’s do some experimenting. I’ve got my flute, and I can improvise with my voice.” So up he came and we started to work together, experimenting with clarinet, violin, flute and piano tones. We were interested in bending and reshaping the resonance of those instruments. We worked with sound-on-sound and reverberation, mostly because we didn’t have anything else to work with. Finally we decided, “Let’s get some shape into these sounds and make little pieces.” So we made some tiny compositions. We played the pieces at a cocktail party at the conference. After our performance, several composers congratulated us, telling us that we had hit a new frontier, a new horizon.

My wife and I spent some time in France in 1950, but I didn’t meet any of the musique concrete people then. In 1953 I attended the First Congress of Experimental Music, in France. There I met Pierre Schaeffer, Pierre Henry, and some other composers. I had a chance to visit their facilities, which were much more extensive than those which I was using. I particularly remember their Phonogen, which is basically a tape player with provision for keyboard-controlling the tape speed. The French radio broadcast compositions by John Cage, Christian Wolff, and myself, which I had brought with me. I then visited Karlheinz Stockhausen and Herbert Eimert at their studio in Cologne. They were just in the initial stages of setting up, but they had the Bode Melochord, which was a very useful tone source. I believe that I was the first American composer to visit the Cologne studio.

By 1955, we had a small studio on the Columbia campus. A second grant enabled us to enlarge the studio and to travel to Europe to be in touch with developments there. In 1957, the studio was finally installed in permanent headquarters in Macmillan Hall. We were not yet teaching then, nor was the studio set up enough for composers besides Otto and myself to use.

We wanted to provide a center where composers could work and experiment without having to contend with the forces of commercialism. Most of the European studios were associated with radio stations, but we felt that wouldn’t work here because the forces pushing out work toward commercial exploitation would be too intense. We felt that the correct place was a university, where you have poets, literary and theater people, and acousticians on whom you could try out all this stuff with an audience and get reactions. At the same time you could feed it to students and make the studio available for people to work in, to experiment on a high level.
STUDIO EARLY HISTORIES

THE COLUMBIA/PRINCETON ELECTRONIC MUSIC CENTER

Ussachevsky: The original vision was of a distributed facility. There would be separate studios at Columbia, Princeton, University of Illinois, University of Toronto, and a fifth university. We would all cooperate and exchange information and ideas. But then the Rockefeller people, whom we had already approached, said to us, "Look, you two and Babbitt are good friends. You are able to collaborate easily. We think the studios should be set up at a central location. Why don't you three submit a proposal on that basis?" So we proposed a larger Center with facilities that were comprehensive enough to invite composers.

Getting The First Synthesizer

Babbitt: At first the RCA synthesizer was not part of the proposal. However, I had been interested in that machine for quite some time. When RCA unveiled their first synthesizer, the Mark I, Dr. Harry Olson came over to Princeton and asked if he could try some of this stuff on the music students. Frankly, the students were put off. That's when I began talking with Olson in more detail. The second [Mark II] synthesizer, which is the one at the Center, is entirely different in technical detail from the first. The Mark I was used to make one record, then turned over for voice research. The Mark II, some say, was built for use in commercial recording. RCA made some very slick arrangements on that machine—sort of Mantovani pop. But the recordings were never released. At first RCA was interesting in building a second Mark II for the Center—if we could raise the half-million dollars or so that it would cost. It was not possible for us to raise that kind of money. Even the five-year Rockefeller Foundation grant that was given to set up the entire Center would, in its entirety, have paid only one-third of the synthesizer's projected cost. Then RCA said, "We'll rent the machine to you, but we want to maintain it." So that's how the Mark II came to be part of the Center. We rented RCA's Mark II for a nominal monthly amount for the first 20 months or so of the Center's existence. Then RCA agreed to turn the machine over to us outright for some token amount, one dollar or so.

STUDIO EARLY HISTORIES

IRCAM (Institut de Recherche et Coordination Acoustique/Musique)

IRCAM is a center for research into the science of music and sound and avant-garde electro-acoustic art music. It is situated next to, and is organizationally linked with, the Centre Pompidou in Paris.

In 1970 president Georges Pompidou asked Pierre Boulez to found an institution for research in music. In 1973 the section of the building underneath Place Igor Stravinsky was finished, and the center opened in 1977. From the outset, Boulez was in charge of the center. The initial administrators included Luciano Berio, Vinko Globokar, Jean-Claude Risset, and Max Mathews. Several concepts for electronic music and audio processing have emerged at IRCAM. John Chowning pioneered work on FM synthesis at IRCAM, and the real-time audio processing graphical programming environment Max/MSP. Many of the techniques associated with spectralism, such as analyses based on fast Fourier transforms, were made practical by technological contributions at IRCAM.
AURAL ANALYSIS PROCEDURE

Step 1 – Read the liner notes and research the piece on the Web!

Step 2 – FIRST LISTENING

• Identify what gestural or motivic material stands out, defines the work. Note track times of these events.
• Identify significant changes in texture or activity (including silence). Note track times.
• Note what the dominant organization of Frequency/Pitch/Noise seems to be.
• Note overall and significant sense of spatialization and depth.

Step 3 – SECOND LISTENING
Sketch a graphic representation of the work as it occurs over time. Use a manner comfortable for you (lines, dots, blocks, etc.). Label with track times and data from the 1st listening.

Step 4 – THIRD LISTENING
Guided by your graphic representation, evaluate the relation of structural phenomena to your first listening observations. Consider the following structural phenomena:

• Spatial Qualities
  o Dimensional Space (use of the stereo field, diffusion, reverb/echo)
  o Pitch Space/Frequency Space
• Timbral Qualities (Spectromorphology)
• Rhythmic Qualities (Time Space)
• Dynamics
• Polyphony - Monophony
• Sound Materials
  o Textures
  o Gestures
• Where do the sonic materials fall on the Syntax continuum of Abstract <-> Abstracted
• Where do the sonic materials fall on the Discourse continuum of Aural <-> Mimetic

Step 5 – ANALYSIS
Articulate your ideas about:

• the work’s structure,
• the relationship of its structure to the sonic materials,
• its relationship to other musics, past and present,
• what you read about the work compared to what you heard,
• its relative success and/or failure, specifically noting what contributes to these.

Step 6 – WHAT TO SUBMIT
Submit your graphic representation of the work (Step 3) and 2 page analysis in prose (Step 5).

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LISTENING ASSIGNMENTS

Listening assignments may be accessed as streaming audio via eReserves. The student is responsible for all material addressed in and out of class. Some works not on this list will only be heard in class.

Olivier Messiaen, *Oraison* (1937)
Pierre Schaeffer, *Etude aux Chemins de Fer* from Cinq Etudes de Bruits (1948)
Otto Luening, *Low Speed* (1952)
Herbert Eimert, *Klangstudie II* (1952)
Karlheinz Stockhausen, *Elektronische Studie I* (1953)
Karlheinz Stockhausen, *Kontakte, Structure IX and Structure X* (1960)
Milton Babbitt, *Philomel* (1964)
Max Mathews, *Bicycle Built for Two* (1962)
Vladimir Ussachevsky, *Computer Piece No. 1* (1968)
John Chowning, *Stria* (1972)
James Tenney, *Dialogue* (1963)
Gottfried Michael Koenig, *Funktion Rot* (1968)
Karlheinz Stockhausen, *Elektronische Studie II* (1954)
Joji Yuasa, *Projection Esemplastic for White Noise* (1964)
La Monte Young, Excerpt 31/69 c. 12:17:33-12:25:33 PM NYC
Mario Davidovsky, *Synchronisms No. 5* (1969)
Karlheinz Stockhausen, *Mikrophonie I* (1964)
Olly Wilson, *Sometimes* (1976)
Chris Chafe and Dexter Morrill, *Duo Improvisation* (1991)
These are liner notes (occasionally edited), largely taken from the recordings that constitute the listening assignments.

Clara ROCKMORE (1911-1998, United States/Russia)

Valse Sentimentale (Tchaikowsky), 1977

Clara Rockmore first met Leon Theremin in 1928 in New York City. She was a teenaged violin virtuoso from Russia, Theremin also had come from Russia. Lenin himself had dispatched the young musician-physicist-inventor to the decadent, capitalist West to demonstrate the electrical marvels emanating from the newly formed Soviet Union. In quick succession, Rockmore became Theremin's student, his protegee, and then the world's foremost exponent of the space-controlled musical instrument that bears his name. Rockmore performed as soloist in over a hundred concerts with major symphony orchestras, and she and her pianist sister Nadia Reisenberg performed countless recitals over a five-decade period. "Valse Sentimentale" was in the repertoire that the two sisters played regularly.

-Robert Moog, producer and creator of the Moog synthesizer

Olivier MESSIAEN (1908-1992, France)

Oraison

Oraison was not the first all-electric work for the concert stage. It did, however, represent the first time a composer of this stature had devoted a whole piece to electrically produced sounds. The ondes martinet [a keyboard using a ribbon and ring to change pitch] had enjoyed a flavor-of-the-month popularity among European (especially French) composers in the late 1920s and early 1930s, but those composers all used the instrument as a new addition to the orchestral palette, exactly as its inventor, Maurice Martenot, intended it to be used. It was Messiaen, the mystic and organist, who heard something unique in the instrument and decided to write a piece for a whole ensemble of ondes martenot, without trying to meld it to preexisting acoustic instruments. The gliding, swooping sounds of the instruments create a mysterious, perhaps suspended, atmosphere that reflected Messiaen's mystical leanings perfectly.

-John Schaeffer, host of New Sounds on WNYC-FM, New York

Louange a L'Eternite de Jesus from Quatuor pour la fin du temps (1940-41)
French composer Pierre Schaeffer is known primarily as the "father of musique concrete", but he was also an excellent writer, pioneer and veteran of radio, and founder and director of many special projects within the French national radio. Finally, he was a thinker and researcher whose ideas had applications in audiovisual communication and, most directly, in music. His theoretical work is as important as his limited production of music. In 1934, Schaeffer started working at Radiodiffusion Française (the French national radio), where, in 1944, he created a studio dedicated to radiophonic training and experimentation. It was in this studio in 1948 that his curiosity led him to "invent" musique concrète through a succession of trials-and-errors.

In 1951, within the structure of the French national radio, he formed a musical research group that he named Groupe de Recherche de Musique Concrete. In 1958, he formed the Groupe de Recherches Musicales (GRM), which continues today. GRM was at first mobilized to conduct group research into its founder's idea: The goals were to define a "solfege" (i.e. define the "elements") of the sound universe based on the perception of sound and to question what were clearly false notions about music, listening, timbre, sound, etc. Schaeffer's monumental Traité des Objets Musicaux, written in 1966, encompasses the breadth of this research. Schaeffer later left the administration of GRM to François Bayle.

Schaeffer's musical production, which was exclusively electroacoustic, consists of a small number of works that were composed during several brief periods of activity. The first series of short compositions were the Etudes de Bruits of 1948. A second series includes works composed with Pierre Henry; Bidule en "ut" (1950) and two more ambitious compositions: La Symphonie pour un homme seul (1949-50) and the concrete opera Orphée (1951-1953), for which Schaeffer wrote the libretto. The provocative association of classical song and tape music in Orphée was considered a scandal at its performance at Donaueschingen in 1953, as if it had been a crime of high treason against the avant garde. In 1975, his release from official responsibilities gave him free time to compose the Trièdre fertile, a series of compositions in which he used electronically generated sounds for the first time.

The fifteen years that Schaeffer passed without composing were nonetheless largely occupied with music, primarily with writing the Traité des objets musicaux. The "T.O.M." is a monumental work, not easily accepted because it upsets too many well-established ideas. It is an interdisciplinary work in which music is seen as an art-crossroads where we encounter linguistics, psychoacoustics, phenomenology, etc. To quickly enumerate some of the revolutionary guideposts that this work poses for new music: the distinction of four ways to "hear" (hear, perceive, listen, understand) and the analysis of this "circuit of musical communication" into four sectors: complementary definitions for "sound object" and "focused listening," two key notions introduced by Schaeffer; a dialectic in perception relating to "sound object" and "musical structure"; critique of classical notions of timbre and parameters that seek to describe in a useful way the phenomena of sound, and a counter-proposal of seven principal perceptive criteria, perceived in the triple "perceptive field" natural to the ear; and the use of all this to achieve a large program of musical research, for which the Traité would serve as a preamble. The "T.O.M." more particularly illustrates the double thesis: that music is made to be listened to (a challenge to all a priori conceptions of music as composition on paper, which neglect the perceptive factor); and that music has two sides: a cultural side, of course, as everyone agrees, but also a natural quality, which is to say that music depends on the natural perceptive properties of the ear (the octave phenomenon, for example) that are understood in traditional music and that contemporary developments cannot ignore with impunity.

Based on an article by Michel Chion, in Larousse de la Musique.
Otto LUENING (1900 -1996, United States)

Low Speed

This piece was commissioned by Leopold Stokowski and Oliver Daniel, for their premiere at The Museum of Modern Art, New York City, October 26, 1952. The sound source for this piece is a flute, played by the composer. He has used acoustic relationships and the tape recorder to modify the sound and to highlight certain overtones. This treatment brings out new characteristics from the instrument. As to the musical content of the piece, the attempt was to produce a solemn, perhaps religious, feeling.

-Otto Luening’s notes for the Electronic Music Center of Columbia and Princeton Universities

Karlheinz STOCKHAUSEN (1928 - 2007, Germany)

Electronic Studie I

For STUDIE I, I recorded individual sine waves on magnetic tape (76.2 cm per second), played them back two at a time using 2 tape recorders, and recorded them on a 3rd tape recorder, etc. After this, I hand-measured, cut, and spliced each of these note-mixtures onto the others or onto white tape (using liquid acetone), before copying the resulting tape collages on top of each other to form polyphonic structures.

The sequence-echoes were produced in a natural echo chamber: a sequence of sounds on tape was played back over a loudspeaker in the echo chamber and with a microphone there, recorded in the studio, then cut and spliced onto the non-reverberated sequence. (Excerpt from Work Report 1953 : The Genesis of Electronic Music, TEXTE zur Musik, Volume 1, DuMont-Buchverlag, Cologne.)

An irrevocable step became necessary: I returned to the element which is the basis of all sound multifariousness: to pure vibration, which can be produced electrically and which is called a sine wave. Every existing sound, every noise is a mixture of such sine waves - a spectrum. Proportions of numbers, intervals and dynamics of such sine waves determine the characteristics of each spectrum. They determine the timbre. And thus, for the first time, it was possible to compose - in the true sense of the word - the timbres in a music, i.e. to synthesize them from elements, and by so doing, to let the universal structural principle of a music also effect the sound proportions. The world premiere of STUDIE I took place on October 19th 1954 at the West German Radio, Cologne.
Karlheinz STOCKHAUSEN (1928 – 2007, Germany)

Electronic Studie I

Hypothesis

A "serial system" for sensorially evaluated frequency differences will begin in the middle of the auditory range and extend to the limits of pitch audibility.

The duration of each note will be inversely proportional to its thus defined frequency difference, so that as the distance from the middle frequency range increases, the duration decreases.

The amplitude series is to decrease proportionally to duration, as the frequency difference increases. Thus the tendencies away from the middle register towards the lower and upper limits of audibility will be perceptible from the correspondingly decreasing duration and amplitude of the notes.

The derivation of series of notes stops when the limits of pitch audibility are reached. These limits lie where it is still just possible to differentiate between pitches i.e. where the recognition time for each note, dependent on frequency, and the frequency-loudness curve (Fletcher-Munson), indicate fringe values. The movement towards these limits is not to be understood as development, i.e. as continuous progressive evolution, but rather as a contiguity that is possible at any moment during the passage of time in the composition.

Frequencies

The ratios in the following series are intervals drawn from the overtone series: descending minor tenth; rising major third; descending minor sixth; rising minor tenth; descending major third:

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12 & 4 & 8 & 5 & 5 & 5 \\
5 & 5 & 5 & 12 & 4
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If a given initial frequency is multiplied by these factors in succession, a sequence of 6 notes results.
**Karlheinz STOCKHAUSEN** (1928 – 2007, Germany)

**Electronic Studie I**

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Karlheinz STOCKHAUSEN (1928 – 2007, Germany)

Kontakte

Kontakte (Contacts) is a four-channel work that exists in two forms: (1) for electronic sounds alone, designated "Nr. 12" in the composer's catalog of works, and (2) for electronic sounds, piano, and percussion, designated "Nr. 12½". The work is a realization of Stockhausen's goal of integral serialism (also known as total serialism), where all aspects of the music (frequency, rhythm, dynamics, timbre) are determined by pre-compositional design.

The title, Kontakte, "refers both to contacts between instrumental and electronic sound groups and to contacts between self-sufficient, strongly characterized moments. In the case of four-channel loudspeaker reproduction, it also refers to contacts between various forms of spatial movement."

Find Kevin Austin's excellent analysis (with sound examples and an annotated listening guide) here: http://cec.sonus.ca/econtact/12_4/kontakte/index.php

Score Excerpt from Kontakte
Philomel

Milton Babbitt talks about "Philomel"
by Jason Gross (April 2000)

Still going strong at age 84, renowned composer Milton Babbitt was a founding member of the Columbia-Princeton Electronic Center (see related article) where he created "Philomel," one of the first compositions of the synthesizer (available on New World Records).

Q: What was the origin of "Philomel"?

John Hollander, the poet at Yale, knew a great deal about music and had written a lot about it. He wrote a piece for me where I would know exactly what the conditions would be: it would be for solo soprano, there would be at least four sets of speakers around the hall and that it would be a work in which I would record her voice and fabricated and modulated through the synthesizer. It was planned as a twenty minute piece at the Metropolitan Museum of Art, funded by the Ford Foundation. At the time, there were funding four or five works a year— it's indicative of our time that they (or the Rockefeller foundation) don't go near music anymore.

John wrote the libretto for me and the piece was basically commissioned for a soprano, Bethany Beardsley. He gave it to me and made some modifications. John wasn't aware of the presence of audience and he didn't realize that certain conjunctions of words might sound strange. The text is highly, sonically organized. He's highly concerned about every aspect of the English language. It was very much concerned with sound, the sound of words and the relation of the sound to words to what he would knew the music would be, even when he knew what the electronic instrumentation would be.

He also understood that the synthesizer could do anything. It was no longer a question of whether it could be played or whether it could be heard. So he kept very close to me, to what the surrounding singer would do and how I laid it out. So it was very much a collaboration between the two of us. It took me about a year and I could have used more time. It was very, very difficult because first of all, I had to create the sounds from the synthesizer. Then I had to tape her voice for sections. A great deal of the time, she's singing straight but also a great deal of the time, she's answering herself as she is recorded. Of course, these are things that one really can't get on a record. Usually, it was written, as most of my music was at the time, on four tracks. We had this marvelous set up at the Macmillan Theatre where had not only four tracks but we have had any number of tracks distributed in different ways. It makes a lot of difference, it's not for a great deal of electronic fantasy. It's for clarity— clarifying lines coming out of four different speakings, heard separately and then trying to compound them, you lose a great deal. You're going to get a certain amount of masking and it's not the original but what are you going to do?

Q: How do you look back at the piece today?

My thoughts are 'I wish I had my synthesizer.' (laughs) When you're walking into the studio up at 125th Street (Columbia) with a piece in your head and eventually, you're able to walk out with a finished piece and a tape under your arm, it's an unparallelled experience. You're not dependent on anyone but yourself. That's a slight exaggeration because you get into the hall and your dependent on the speakers and the amplifier. Remember, all of this is analogue. We were not working digitally, for which I am most grateful. In the most serious sense, it's a matter of just being the master of everything. Your decisions are your decisions. You convey them to a machine of course. Learning how to convey them to a machine was a big problem at the time. I could walk into the studio and could spend the day...
getting NOTHING that I wanted because musically, I had to get some of those things. The machine was totally neutral. There were no set-ups or samplers. We had to start from scratch and do everything from the beginning. Remember, I started working with the machine in 1957 and I didn't produce a piece with it until 1961. "Philomel" was from 1963 and that took me a long time to do. I did a number of pieces after that, some of which are much more intricate electronically.

But "Philomel" is very near and dear to my heart. Part of it is because of Bethany Beardsley, an incomparable performer and wonderful musician who I've spent a great deal of my creative life with. It's also because that was made on my own with the synthesizer in that studio. It's gone and I miss it very much. It's not because I want to eliminate performers. I've worked with performers all my life. We didn't want to reduce the dimensions of music, we just wanted to enhance them. And we did but the problem was that it was a monster of a machine. It was the size of a whole room, a huge affair. There was no question of replicating it because it cost RCA half a million dollars. They were never going to replicate it. But our studio was invaded. They didn't steal much of the synthesizer because they wouldn't know what to do with it. They took amplifiers and tape machines. To rewire all of that, the synthesizer would have never got back into shape. In fact, I had a piece in progress at the time which never got finished- I finished composing the piece but never finished the electronics. It's a sad day in my life.

I never went to computers. I could have started with computers with Bell Labs with Max Matthews in 1957. But you couldn't imagine what it was like at that time. With the turnaround time, you might as well have gone out and hired an orchestra. You had the punch cards and the mainframe computer in which you had to pour your work into. I knew enough about it to know that this was not for me.

You'd be amused to know that RCA (who build the synthesizer) asked me to put out a record originally because all of their programs were highly mathematical. It was machine-language programs so I got someone else who knew more mathematics to work with them. So they put together a private collection called Music From Mathematics where an engineer there synthesized "A Bicycle Built For Two" and you get the picture. It's an interesting piece that he did- as far as I know, it's the first computer generated piece.

I just decided that I couldn't do anything like that. Life is too short. I haven't done any electronic music since. In 1975, I turned back to instrumental music, not that I wasn't always writing that.

Q: How do you think "Philomel" fits into your work overall?

That's a good question. It doesn't. The things that I did in that piece were so determined by what was possible electronically. Remember, I didn't turn to the electronic medium for 'new sounds.' Nothing gets as old quickly as 'new sounds.' It wasn't for the superficial titillation of sounds. It was for, above all, music time, the way you can control time. There's such a difference between being able to produce a sound as a performer, being able to strike the keyboard, it's automatic.

To produce a duration, it's totally different. Teaching a child to imagine rhythm, a succession of durations, is so much more difficult than teaching someone who to put their finger down in the right place on an instrument. Time has always created problems with contemporary music- that's why the music wasn't performed and when it was performed, it was done sloppily. We were tired of this. The idea that we could control time as we wanted...

For example, the people working with tapes. I should have mention that I never worked with tapes like my colleagues Otto Luening and Vladimir Ussachevsky. They had to sit there and splice tapes of various durations. On a synthesizer, you could specific durations by punching it in like everything else. So that was the first thing, the control of time. What that led to was teaching us how to hear and perceive time. I could produce things faster than any pianist could play or
any listener could hear. We were able to work with greater speeds. That was one of the things that interested me the most: the timbre, the rhythmic aspect. And we learned a great deal. It was an analogue device and it was given digital information and switching instructions (for envelope, specter and other aspects of tone) passing over very expensive gold wires that scanned the information and then recorded it on tape. I could change certain qualities of a tone while keeping other qualities, like the pitch, consistent. I could hear what I was playing as I was playing it, using trial and error. We had no precedent and we were extrapolating from no known theory. Theories about what could be heard and what couldn’t be heard were essentially wrong because they had never been tested in those conditions.

It’s had an effect on what I write now for instruments. Sometimes I write rhythms that are considered very difficult to play. They can be achieved and they have been achieved by performers willing to do it. There was a time that I would write out on the synthesizer and let them hear what I would want them to be producing on their instruments. It has changed the way I wrote.

The things I did in that piece, I have never used since. The vocal part is fairly straightforward. It had to be since she was producing that in the confines of the human voice. I wrote things for her that I would not have wrote otherwise because so much of it depending on what was going on electronically. Sometimes the matching of lambres or the rhythm of the ensemble and her own rhythmic part was all taken together. This was something that you would never dare try with live performers.

**Morton SUBOTNICK** (1933, United States)

**The Wild Bull**

Development in music composition is often linked with the evolution of instruments. The modern piano, for example, is the product of collaborations between numerous artists and artisans, from Mozart and Stein, to Beethoven and Streicher, Chopin and Pleyel, and Liszt and Erard (Cohen-Levinas 1991). In 1962, the year that composer Morton Subotnick met instrument designer Donald Buchla, only a handful of electronic music studios existed. A typical studio contained a few pieces of laboratory test equipment, some microphones, and one or more bulky tape recorders. The test gear had never been designed for music. It was limited to generating basic signals like sine waves or pulses, or filtering fixed frequency bands. The microphone offered an alternative: recording acoustic sounds, leading to the *musique concrete* approach. By manual tape splicing and looping techniques developed in the 1950s - a patient composer could assemble sequences and layers of recorded sounds. But fluid control of these materials - their dynamics, time-varying spectra and spatial characteristics - escaped easy solutions. Most composers merely dabbled in the electronic medium, abandoning it when they realized it would never be as easy - or as acceptable to the music establishment - as the silent trade of inscribing ink on staff paper. The collaboration between Buchla, Subotnick, and their colleague Ramon Sender resulted in an entirely new type of electronic instrument - one that could be played onstage, or could greatly enhance studio composition. It came to be known by the general term *modular voltage* controlled synthesizer. "Modular" because it was divided into different units that could be interconnected via patch cords. "Voltage-controlled" because one module could control another, leading to programmable musical gestures. Buchla disliked the term "synthesizer", partly because of its associations with the chimera of a universal musical engine. The gigantic RCA Synthesizer, for example, introduced in the 1950s, was advertised wishfully as being "capable of creating sound that has ever been produced and any sound that may be imagined by the human mind" (Radio Corporation of America 1956). Such was never the aim of Buchla's handcrafted instruments, which he preferred to call more modestly "Electric Music Boxes". For Buchla, the musician's interface - the physical layout of the front panel and the logic of musical control - was always at least as important as the means of sound generation: *The tendency is for engineers to build musical instruments, and ... being engineers, they design from the inside out. They
design the circuits, and then they put knobs on them. But if a designer expects to design legitimate instruments, he has to design them from the outside in. This is what the musician is going to encounter. Donald Buchla, quoted in Aiken (1984) Encounter it the musician did, and intensely. By the time Silver Apples of the Moon was created, Morton Subotnick was 34 years old. It was the prolific composer's 21st work. My approach to composition was to go to my studio every day, six days a week, twelve hours a day, and simply create. All the works somehow came together through editing and splicing and thinking and then I would have a piece that was that year's work. That was the way that 'Silver Apples of the Moon', 'The Wild Bull', and 'Touch' were realized. Morton Subotnick, in Roads (1988)

The pieces presented here, along with Touch (Wergo 2014-50, 1989), should be seen in the light of the collaboration with Buchla and his instrument. Not since Oskar Sala's compositions for the Mixtur-Trautonium (Wergo Spectrum, 1983) do we find an artist so at one with an electronic instrument. (The analogy with Sala goes further, if we consider their common use of pyrotechnical gestures and motorized rhythms.) From the first instants of Silver Apples of the Moon we are transported to a sound garden under the regime of voltage control, amidst the chirping and warbling of sequencers, gates, and sample and hold circuits - the unmistakable domain of the Electric Music Box. It is not just the colors that are distinctive, it is the gestures: jittering lines, sweeping glissandi, sudden interruptions, and sound objects scattering like colliding particles. Part II highlights repeating or looping sequences. Programmed sequences are central to Morton Subotnick's manner of working. Although electronic sequencers were quite new when Silver Apples of the Moon was composed, the concept of musical sequencing dates back centuries (Chapuis 1955; Buchner 1978). The sequencers of the Buchla Electric Music Box consisted of 8 or 16 stages, each of which could be hand-tuned by the composer to specific voltage levels. When triggered, the sequencer stepped through successive stages, at a rate set by the composer. If desired, it could repeat continuously, sounding like a tape loop. Most importantly, the sequence could not only control pitch, but also other aspects of the sound, such as its amplitude, timbre, or spatial location.

In Morton Subotnick's music of the 1960's, sequences serve as combustion engines for the middle layer of musical structure. He uses sequencing as an alternative to tape splicing - for rapid-fire phrases - but then later splices taped fragments into, out of, and around (simultaneous with) repeating sequences, often leading to wildly disjoint tags at the end of a pulsating section. In one of the too-rare joyful moments of electronic music, the composer unleashes a grateful sequencer in Part II, letting its driving, exhilarating pulse take over. One cannot forget that Silver Apples of the Moon was composed in 1967, when it was as likely to hear a Subotnick piece projected in New York's Electric Circus - a temple of counter culture and experimental rock music - as it was in a traditional concert hall. The Wild Bull (1968) reflects a more sombre side, the title derived from a poem of mourning. Sinking glissandi in the opening set the tone, and the murky, lumbering sections seem to paint images of ancient life. Ironically, the futuristic instrument of Silver Apples of the Moon is equally adept at portraying antiquity in The Wild Bull. How is this? It reflects Morton Subotnick's performance, as much as his compositional structures. In the electronic music studio, one must often play two roles: composer and performer. Expressive hand-tuned gestures abound in The Wild Bull, filling out the work like brushstrokes in a painting. The composer deploys the sequencers, but often assigns them to more subtle musical roles, such as control of tone color. In this technique, the sequencer selects different channels of a filter bank, isolating various parts of the spectrum in their turn. Fitting the elegiac mood of the work, the sound palette of The Wild Bull tends toward extremes: filters that squeeze out all but a narrow residue of the original waveform, dense modulations, and thick, massive sonorities, as in the horn-like voicings opening Part II. Hearing Silver Apples of the Moon and The Wild Bull three decades later, one is less distracted by the novelty of the electronic sonorities or the metric precision of sequenced gestures. We come to appreciate these works more from a directly compositional standpoint - the balance and clarity of their macrostructures, the attention to counterpoint, the inevitability of forward motion (yet the unpredictability as to how it will unfold), and of course, their originality. Here are two classics by a master of pure electronic music!
THE WILD BULL

The wild bull, who has lain down, lives no more,
the wild bull, who has lain down, lives no more,
Dumuzi, the wild bull, who has lain down, lives no more,
the wild bull, who has lain down, lives no more.
O you wild bull, how fast you sleep!
How fast sleep ewe and lamb!
O you wild bull, how fast you sleep!
How fast sleep goat and kid!
I will ask the hills and the valleys,
I will ask the hills of the Bison:
"Where is the young man, my husband?"
"He whom I no longer serve food"
"He whom I no longer give to drink"
"And my lovely maids"
"And my lovely young men?"
"The Bison has taken thy husband away,
up into the mountains!"
"The Bison has taken thy young man away,
up into the mountains!"
I will say,
I will say,
I will say,
"Bison of the mountains, with the mottled eyes!
Bison of the mountains, with the crushing teeth!
Bison! - He sleeps sweetly, he sleeps sweetly,
He whom I no longer serve food sleeps sweetly,
He whom I no longer give to drink sleeps sweetly,
My lovely maids sleep sweetly,
My lovely young men sleep sweetly!"
"My young man who perished from me
My young Ababa who perished from me
Will never more calm me (with) his loving glance
Will never more unfasten his lovely bright clasp
On his couch you made the jackals lie down,
In my husband's fold you made the raven dwell,
His reed pipe - the wind plays it,
My husband's songs - the north wind sings them".
(at the hands of) your men,
(at the hands of) your men,
(at night)

Sumerion, c. 1700 BC, translated by Thorkild Jacobsen. From Most Ancient Verse, selected and translated by Thorkild Jacobsen & John A. Wilson, published by the Oriental Institute of the University of Chicago (U. of Chicago Press). Reprinted with permission of Professor Jacobsen and The Oriental Institute, whose kind cooperation is gratefully acknowledged.

Max MATHEWS (1926 – 2011)

Bicycle Built for Two (Daisy Bell)

"Computer performance of music was born in 1957 when an IBM 704 in NYC played a 17 second composition on the Music I program which I wrote." - Max Mathews

Max Mathews and Joan Miller were both acoustic researchers working at Bell Labs in New Jersey. In 1957, Max Mathews figured out how to digitally synthesize sound on a digital computer, and wrote Music I, the first in a long line of music programming languages to which all digital synthesis has its root. By 1961, they had gotten up to Music IV, which they used to create a fully digitally synthesized version of "Daisy Bell" by Harry Dacre, also known as "Bicycle Built for Two".

In 1962 John Kelly created one of the most famous moments in the history of Bell Labs by using an IBM 704 computer to synthesize speech. Kelly's voice recorder synthesizer vocoder recreated the song Daisy Bell, with musical accompaniment from Max Mathews. Arthur C. Clarke of 2001: A Space Odyssey fame was coincidentally visiting friend and colleague John Pierce at the Bell Labs Murray Hill facility at the time of this remarkable speech synthesis demonstration and was so impressed that he used it in one of the climactic scenes of his novel and screenplay for 2001: A Space Odyssey, where the HAL 9000 computer sings the same song as he is being put to sleep by astronaut Dave Bowman.
**Vladimir USSACHEVSKY** (1911 - 1990, Manchuria/United States)

**Computer Piece No. 1**

This piece was put together in an analog electronic music studio, using the sound materials produced with digital computers at the Bell Telephone Laboratories. Computer Piece No. I was composed from three types of materials: material initially generated on the GE 635 computer by composer-physicist Jean-Claude Risset; a succession of four note clusters originally synthesized for Ussachevsky by F.R. Moore; and material from several "concrete" sources: a gong, Alice Shields' distorted speaking voice, and a highly modulated passage of electronic origin. The composition could have been totally pre-programmed, were it not for the fact that Ussachevsky transformed the timbres after the generation of the piece by using analog devices: the Bode frequency shifter and EMT reverberation. As such, it is an example of electronic music from computer-generated and computer processed sound materials, modified and assembled according to "classical studio" analog techniques devices.

**Jean-Claude RISSET** (1936, France)

**Mutations** (4:55, edit)

"Mutations" was entirely synthesized by computer at Bell Labs in 1969, using Max Mathews's Music V program, adapted by Pierre Ruiz and me on a dedicated computer. It uses mostly additive synthesis. Thanks to John Chowning, it is also the first work using FM sounds. Special algorithms produce harmonic arpeggios as well as occasional twelve-tone rows. The title refers to the gradual transformation from pitches in a scale to a continuous glide. At the beginning a melodic motive turns into a chord, which is then prolonged into a timbre. By adding harmonics, like the organ "mixture" or "mutation" stops, and adding pitches erratically, a dense network of frequencies dissolves into a continuum of pitches, an ever-ascending glissando. The work was among the winners of the 1970 Dartmouth Electronic Competition. Lillian Schwartz used the music for her abstract film *Mutations*, which won the Golden Eagle Award in 1973.

-Jean-Claude Risset

**John CHOWNING** (1934, United States)

**Stria** (5:11, edit)

It's a strange sensation that I have about that piece. I was away from Stanford for several years, and I really couldn't do any experiments. In 1977, when I managed to get back to use the computers, I wrote the whole piece then, and I wrote programs that allowed me to control the procedures, to specify the phrase level and highly tune these procedures, I realized the whole piece in two months. It was one of these pieces that a lot of pre-thought went into, and when it finally came to realizing it, it fell right together. In all of my pieces, I've been extremely interested in the question of timbre and timbral transformation. In earlier pieces, there are many transferences from one timbral domain to another. But I think "Stria" is different because it doesn't have a central focus, it's nonreferential. It's a completely abstract construction. It's something that could be done by a computer but could not be done by any other electronic device. With any sort of analog synthesizer, I don't think it's possible just because they don't have the precision or the programming as part of their structure. It's a piece that is most uniquely tied to the digital domain.

-John Chowning
Speech Songs: He Destroyed Her Image

Though vocoders and voice-guitar devices became common in popular music in the ’70s, Dodge was a pioneer of voice-synthesis experiments before any of that, as witnessed in his series of "Speech Songs" compositions (available on Any Resemblance Is Purely Coincidental on New Albion).

In the early days of computer music in the sixties, one of the few places to actually hear what you were doing was at the Bell Laboratories (in New Jersey). In those days, it was a very special piece of equipment called the digital-analog converter that was used for that purpose. Bell was a friendly benevolent monopoly at this stage. The inventor of computer music, Max Matthews, was there. He encouraged some of us who had access to university computers to make musical sound in digital form on the computers and to listen to it and convert it to a form that could be heard in his laboratory.

That lab was used in the daytime for speech research. When you went there to listen to your music, you often heard speech research going on in the hall. I was fascinated by that and was so struck how much more interesting were the sounds of synthesized speech which were made by the researchers were than the attempts at musical sounds that my friends and I were making.

At some point in the early ’70’s, I had the opportunity to work at the Bell Labs in the evening, after hours, in an attempt to make music using some of the software there that had been developed for speech research. I had access to software written by a researching named Joseph Olive, who had a musical background and an interest in music composition. With Matthews’ permission and Olive’s active help, I was able to go to Bell after the workers had gone home and use the same computers that were used for speech research for music. That was the genesis of the speech synthesis techniques that were used in those pieces.

The poems themselves were sketches by Mark Strand, who was a friend of mine. We were both teaching at the School of Arts at Columbia University at the time. I asked him if he had any texts that I would be able to use and he suggested these. He had a whole bunch of them which he read over the phone and I copied down a few of them. I ended up using four of the surrealistic poems that he had written.

It was really fun to do it helped me discover… I’d never been able to write very effective vocal music and here was an opportunity to make music with words. I was really attracted to that. It wasn’t singing in the usual sense. It was making music out of the nature of speech itself. With the early speech-synthesis computers, you could do two things: you could make the voice go faster or slower than the speed in which it was recorded at the same pitch or you could shift the pitch independent of the speech rhythm. That was a kind of transformation that you couldn’t make in the usual way of making tape music. It was fascinating to put my hands on two ways of modifying sound that were completely, newly available.

I’ve always liked humor and had an attraction to the bizarre, the surreal. These poems were almost dream-like in their take on reality. So that made me feel very at home somehow. This unreal voice taking about unreal life situations was a very congruent. The voices are very cartoon-like and that really pleased me- I was very interested in pop art like Lichtenstein. To make a cartoon-like voice, really struck a chord with the art at the time. People would listen to this and just giggle. It was really fun to be a part of that.

For "He Destroyed Her Image," I was interested in changing the timbre of the voice. That reversal from looking outside to being inwardly confused in the poem, I tried to depict with the changes of tone quality in the voice, back and forth between an electronic phrase that sounds speech-like (you can understand the words) and an electronic phrase that’s less speech-like (where you can’t understand the words). This happens even though the two the two have same pitch pattern.

-Charles Dodge
When Lansky started work on the piece “Idle Chatter” in 1985, he was still quite concerned with Perle’s 12-tone system. Yet, as the piece took shape, he found that he merely sustained an F for a long period, which was eventually joined by a D and a B-flat. That was all he felt the piece needed, rather than push through chromaticism and serialism. It would be his first specifically tonal piece (Perry 49, 52).

The computers that existed at the time were incredibly demanding to learn how to use. His first piece, "Mild und Leise" was composed using a series of punch cards, and the IBM 3081 mainframe used to make “Idle Chatter” filled an entire room. As a result, the construction of complex pitch relationships became less important to Lansky than learning how to write computer programs to achieve the results he desired, dealing with the nuts and bolts of pure, recorded sound (Cody 19). Importantly, Lansky did not want to listeners to come away from his pieces with more curiosity about the technology used than about the textural aural landscapes he created, which required intensive mastery of the machinery (Perry 45, 57).

The follow-ups to “Idle Chatter” were “just_more_idle_chatter” and “Notjustmoreidlechatter” from 1987 and 1988, respectively. These two pieces were made on the DEC MicroVaxII, which was about the size of a washer and dryer. All three pieces were made using a process called linear predictive coding, an analysis tool that essentially breaks down the digitally recorded human voice into sibilants, plosives, and the remaining buzz of the vocal chords, and granular synthesis, where sounds are broken down into 1 to 50 ms ‘grains’ and then transposed and layered [2].

Similar to the work of John Cage, Lansky's goal was to tap into the musicality inherent in common sounds. In his own words, he was “interested in harnessing the world-building power of familiar musical conceptions to enhance our perceptions of the sounds of the world” (Perry 43). All three tracks were produced with the same basic material: samples of the voice of Lansky's wife Hannah MacKay processed and arranged [3]. Audibly, Lansky became more comfortable with the computers used as time he moved through what could be seen as three attempts at making the definitive version of a track.
James TENNEY (1934 – 2006, United States)

Dialogue

THIS IS THE FIRST recorded collection of James Tenney's music of the 1960s. Much of this work was realized at Bell Telephone Laboratories from 1961 to 1969, where Tenney used Max Mathews' groundbreaking digital synthesis program, which eventually became Music IV. This program was the model for many of the common computer music environments of the last thirty years, and the first system of its kind available to composers.

TENNEY’S PIECES FROM 1961–64 probably represent the first significant and developed body of work making use of digital synthesis by an American composer. Prior to Tenney's arrival at Bell Labs, Mathews and John Pierce had each made a few musical studies with the program, and the composer David Lewin had realized some short pieces by sending scores to Mathews to enter into the computer. However, according to Mathews, Tenney was the first composer to come to Bell Labs and work directly with the program on an extended basis.

TENNEY WAS A YOUNG COMPOSER when he wrote these pieces. He was working with a new medium, a technology which was still being developed, and a new aesthetic as well. it is perhaps easy to overlook the importance of the latter in the light of the tremendous technical and historical importance of these pieces – but it is characteristic of Tenney that he would not be content to explore simply the sonic and technical capabilities of a new technology. His work from this period remains to this day an important example for composers who work with new technologies: the new world of "computer music" needed a radically new definition of music itself.

HALF OF THE PIECES ON THIS CD were not only synthesized, but composed with the aid of the computer. Tenney was not the first composer to work with computer-assisted composition, although he is certainly one of the earliest and most important figures in this area. He pioneered the concepts of hierarchical organization and stochastic generation of various musical parameters in composition, and developed techniques to realize them. Many of his most important musical and theoretical ideas are just now beginning to be understood. His landmark theoretical work, Meta °– Hodos (Frog Peak Music), was written in 1961 while he was still a graduate student, just prior to his working at Bell Labs. it establishes many of the principles of temporal and hierarchical gestalt formation that Tenney later used so effectively in pieces like Dialogue, Phases, and Ergodos I and //.

TENNEY HAS SAID that he brought with him to Bell Labs a certain amount of "musical and intellectual baggage," including: "... numerous instrumental compositions reflecting the influence of Webern and Varèse; ... two tape pieces... employing familiar, 'concrete' sounds [one of those is Blue Suede]... a long paper (Meta °– Hodos) in which a descriptive terminology and certain structural principles were developed borrowing heavily from gestalt psychology... a dissatisfaction with all the purely synthetic electronic music that I had heard up to that time, particularly with respect to timbre; ideas stemming from my studies in acoustics, electronics, and – especially – information theory begun in [Lejaren] Hiller's class at the University of Illinois; and finally, a growing interest in the work and ideas of John Cage." (from Tenney's 1969 article "Computer Music Experiences")

TENNEY SAYS HE LEFT Bell Labs in 1964 with two important things:

"... six tape-compositions of computer-generated sounds, of which all but the first [Noise Study] were also compose by means of the computer... [and] a curious history of renunciations of one after another of the traditional attitudes about music, due primarily to a gradually more thorough assimilation of the insights of John Cage." (from "Computer Music Experiences")
Iannis XENAKIS (1922 – 2001, Greece/France)

ST/48 for 48 players

First Performance: October 26th. 1968, Paris · Orchestre Philharmonique de l'O.RTF · Lukas Foss conductor

Explanation of the title, as shown by its components (full title: ST/48 - 1.240162): ST = stochastic music; 48 = 48 instruments; 1 = the first work for this number of players; 240162 = 24th of January 1962, the date on which this work was calculated by the electronic brain. This work was calculated by the 7090 IBM electronic brain in Paris in obedience to a special stochastic (probabilist) »programme« devised by Xenakis.

This »programme« was derived from the thesis of »Minimum of Rules of Composition« which had already been formulated in Achorripsis, but it was not until several years later that it became possible to have it »mechanised« at IBM-France.

The »program« is a complex of stochastic laws which the composer had been introducing into musical composition for a number of years. It orders the electronic brain to define all the sounds of a sequence, previously calculated, one after the other. First the time of its occurrence next its class of timbre (arco. pizzicato. glissando. etc.), its instrument. its pitch. the gradient of its glissando where that occurs. the duration and dynamic of the emission of the sound. The complete computer program, written in FORTRAN, has been published in the journal Gravesaner Blatter. 26 (1965).

Gottfried Michael KOENIG (1926, Germany)

Funktion Rot

Funktionen. - The series of pieces with th is collective title occupy a special position. Klangfiguren, Essay and Terminus were produced with the manually operated equipment of the 'classic' electronic studio: melodic configurations could only be achieved by editing the tape. At the Institute of Sonology, a voltage control system was developed which opened up new vistas, not only of sound production but also of shaping form , which by my standards are closely linked. As well os by the increased technical possibilities I was particularly fascinated by the idea of treating control signals in the same way as sound signals, of taping them and using them for various purposes. W ith a sequencer developed during this same period (and known at the Institute as a variable function generator, voltage levels could be set ond scanned at different speeds or by random control. This took me a step closer to my goal of restricting tape manipulation to a minimum.

And indeed, the sound material for the Funktionen was generated fully automatically by a single preset curve on the function generator. All other derivations were obtained by using control signals produced from that same curve and taped . I relied to a greater extent than in Terminus on the formotive power of sound structures which in 011 their material ond formal aspects proved to be 'permeable': by permeability I mean 0 property of sound sequences that renders them parous and hence interpretable by other, simultaneous sound sequences. I have, always regarded this permeability as paramount for algorithmic composition, as long as the composition progress is not based on psychological criteria but on material criteria , and on properties of acoustic material which the history of music has endowed wi th meaning. The arrangement of the sounds constituting the Funktionen was consequently left largely t9 chance. (As well as the Funktionen Rot, Grau, Violett, Blau and Indigo on this CD, Koenig produced Funktionen Griin, Gelb and Orange at the Institute of Sonology.)
Karlheinz STOCKHAUSEN (1928 – 2007, Germany)

STUDIE II

A second fundamental method of producing electronic sound is based not on superimposing sine waves to make stationary sounds and note-mixtures, but on breaking down white noise into coloured noise. To do this one needs filters which break down the white noise into noise-bands of any desired width and density – in much the same way that a prism breaks white light down into coloured light. In STUDIE II, a special procedure for obtaining non-stationary sound events was used (owing to the lack of sufficiently refined filter systems), which made it possible to integrate the family of noises into composition.

STUDIE II does not strive after a great variety of, or particularly unusual sounds - on the contrary it aims at maximum unity of the sound material and its form.
Joji YUASA (1929, Japan)

Projection Esemplastic for White Noise

To me, this is the fusing of internationalism and Asian (especially Japanese) artistry. Using electronics, which is international, this music expresses a Zen-like mind, becoming part of nature rather than competing with nature. It is an internal expression like a snowstorm in one's mind. I feel like it is an aural version of sumie-charcoal-ink drawing where white spaces (silence) are almost more important than the charcoal (sound).

—Kazuko Tanosaki, musician, Yuasa student

La Monte YOUNG (1935, United States)


This composition consists of only two sine waves, sustained in time. The frequency components of the sine waves are tuned to the ratio 32:31. The amplitude components are tuned to be inversely proportional to the frequencies.

"Drift Studies" is a genre of my work in which I tuned the frequency components of highly stable sine wave oscillators to ratios selected from my unpublished theory .1V0rk, "The Two Systems of Eleven Categories: A2, B2, X = (5)," and then studied and recorded the phase-angle drift of the ratio over sustained periods of time.

Before the introduction of phase-locked oscillators into my work in 1975, drift was a feature of my sound environments. With analog sine wave oscillators, the drift of the phase relationships of the individual sine waves gradually changed the algebraic sum of the amplitude of the composite sound waveform, creating audible shifts in the standing wave patterns, Not only did the sound become louder or softer with this changing algebraic sum or difference, but also at very loud levels one began to feel that parts of the body were somehow locked in sync with the sine waves and were slowly drifting with them in space and time.

I introduced the 32:31 frequency ratio into my work by 1964 in the score for "Pre-Tortoise Dream Music," again in the original tuning of "The Well-Tuned Piano" (April 1964), and later, in the 1980s and '90s, in large-scale sound environments and performance works, including the ongoing MELA Foundation "Church Street Dream House: Seven Years of Sound and Light."

Primes are the primeval essences of rational musical intervals, In 1964, 31 was the highest prime I had worked with in what became an expanding threshold of intervallic complexity. In 1989, I defined a set of primes that the mathematician C. C. Hennix named Young Primes, Thirty-one is included in this set of primes, and it was the intuitive use of intervals such as 31 that led me on the quest for the formula to define the set.

- La Monte Young
David TUDOR (1926 – 1996, United States)

Rainforest Version I - IV

Of the works of David Tudor, none would seem to be better known than *Rainforest IV*, his large-scale performed installation of the 1970s. Although it has received widespread and well documented public performance, *Rainforest’s* germination in the mid-1960s in elements of *Bandoneon!*(1966) and its evolution over a period of 10 years, from versions I(1968), II(1968-1969), III(1972) and IV(1973) through *Forest Speech*(1976).

According to interviews, Tudor’s interest, dating back to 1965, lay in finding a means of making objects reveal their own resonant characteristics rather than using them as instruments to be played manually. He put it this way: “One didn’t have to think of the generation of electronic music from signal source to the reproducing output, but one, instead, might just as well start from the other end and go back and arrive at a signal source.” Tudor described this revelation as an instantaneous “dream- vision of an orchestra of loudspeakers, each speaker being as unique as any musical instrument”.

Mario DAVIDOVSKY (1934 Argentina/United States)

SYNCHRONISMS NO. 5 for percussion ensemble and electronic sounds

The electronic sounds in this piece enter about 3 minutes after the beginning, and run to the end of the piece. The electronic sounds often enhance and extend the sounds of the live percussion instruments by affecting their attack or decay. There are two organizing elements. One consists of a held note, which then suddenly crescendos, and terminates in several prestissimo percussive sounds. The other element consists of a series of pitches of even duration in moderately slow tempo, with tremolo. In a highly decorated form of monophony, Davidovsky connects these two elements to each other, constantly varying timbre, and often varying tempo and dynamic. Within the variation of these two gestures, one’s attention is drawn to the rich variations of timbre, which are indeed klangfarben-melodie. An interesting point is Davidovsky’s use, at the very beginning and ending of the piece, of an opening and cadential pitch-formula: he opens the piece on an ascending minor second, and ends by cadencing down a major second from the opening pitch. These signal, of course, opening and closure, and form an interesting contrast to the non-traditional, non-developmental timbre variations they contain. Towards the end of the piece, Davidovsky also adds another signal-device from traditional development forms: there is a brief, exciting electronic crescendo with cymbals which usually would signal climax in a developmental form, but here seems to provoke our awareness of two normally contradictory formal structures going on in the same piece.
Karlheinz STOCKHAUSEN (1928 – 2007, Germany)

MIKROPHONIE I for tam-tam, 2 microphones, 2 filters with potentiometers (6 players)

In 1961 I had purchased a large tam-tam for the composition MOMENTE (MOMENTS) and set it up on the balcony and later in the garden. Time and again I would make experiments in which I excited the tam-tam using a great variety of implements - of glass, cardboard, metal, wood, rubber, plastic - which I had collected from around the house.

One day I took some equipment from the WDR Studio for Electronic Music home with me. My collaborator Jaap Spek helped me. I played on the tam-tam with every possible utensil and during this, moved the microphone above the surface of the tam-tam. The microphone was connected to an electrical filter whose output was connected to a volume control (potentiometer), and this in turn, was connected to amplifier and loudspeaker. During this, Jaap Spek changed the filter settings and dynamic levels, improvising. At the same time, we recorded the result on tape.

The tape recording of this first microphony experiment constitutes for me a discovery of utmost importance. We had not prearranged anything; I used several of the laid out implements at my own discretion while probing the tam-tam surface with the microphone, as a doctor auscultates a body with his stethoscope. Spek reacted spontaneously as well - to what he heard as the result of our joint activity. Actually, this moment was the genesis of a live electronic music with unconventional music instruments.

On the basis of this experiment I then wrote the score of MIKROPHONIE 1. Two players excite the tam-tam using a great variety of implements, two further players scan the tam-tam with microphones; an appropriate notation prescribes the distance between the microphone and the tam-tam (which influences dynamic level and timbre), the relative distance of the microphone from the point of excitation (which determines pitch, timbre and above all the spatial impression of the sound - from very distant through resonant to extremely close) and the rhythm of the movements of the microphone. Two further players - seated in the auditorium at the left and right of the middle - each operate an electrical filter and two potentiometers. They, in turn, reshape the timbre and pitch (by means of the filter setting), dynamic level and spatial effect (through the combination of filter setting and volume control) and the rhythm of the structures (by means of the temporal changes prescribed for the two pieces of equipment). In this way three mutually dependent, mutually interacting and simultaneously autonomous processes of sound-structuring are connected with each other. These were composed to be synchronous or temporally independent, homophonic or in up to six polyphonic layers.

The score consists of 33 independent musical structures, which are to be combined by the musicians for a performance, i.e. for a version, according to a prescribed connection scheme. This scheme indicates the relationships between the structures. Three musicians - 1 tam-tam player, 1 microphonist and 1 filter and potentiometer operator - form a self-contained group which plays one of these 33 structures. At a certain point they give a cue to begin the next structure to the other group, who then returns the cue after a specified time, and so on.

The relationships between these structures are determined each time in three ways: the following structure should, with respect to the one that precedes it, be similar, different or opposite; a relationship should remain constant, increase or decrease; the following structure (which in fact generally begins during the preceding one) should support, remain neutral to or destroy the preceding one.

Thus in each case the connection scheme gives three indications for each pair of adjacent structures; for example, similar should constantly support; or opposite should increasingly destroy; or different should be decreasingly neutral; and so on. The musicians thus choose the order of the composed structures - which were themselves also composed in a similar way - according to these prescribed criteria.
Although the relationships between the structures, i.e. the connection scheme, always remain the same for every performance in order to ensure a strict and directional form, the order of the structure-succession can be completely different from one version to another.

Olly Wilson (1937, United States)

Sometimes

Olly Wilson writes about Sometimes: "[This piece] was composed especially for William Brown, and is based on a contemporary interpretation of the Black spiritual 'Sometimes I Feel Like a Motherless Child.' I attempted to recreate within my own musical language not only the profound expression of human hopelessness and desolation that characterizes the traditional spiritual, but also simultaneously on another level, a reaction to that desolation that transcends hopelessness. It is for this reason that musical events associated with the original spiritual appear in a number of different ways—sometimes straightforwardly, sometimes fragmentized or extended, and sometimes in completely new relationships with one another, both on the immediate as well as the large-scale, formal, level. The relationship between the tenor soloist and the electronic tape also reflects a multitude of shifting roles. They frequently exchange solo and complementary functions in varying degrees at different times in the course of the piece. Sometimes is dedicated to my parents who, through love and patience, taught me how to sing."

Chris Chafe (1952, Switzerland/United States) and Dexter Morrill (1938, United States)

Duo Improvisation

The idea for Duo Improvisation came about when Chris Chafe and I (Morrill) decided to perform together on our own instruments: his an interesting bodyless cello · called a "celletto" · with a good signal detector for MIDI control and a sensor fitted to the bow for additional MIDI information; and mine, a normal Bb Selmer trumpet fitted with microphones and switches for connections to MIDI equipment. As young musicians, we had both studied jazz in different ways · Chris with Cecil Taylor and me with Dizzy Gillespie. But our interest in improvisation has more to do with interaction between two musicians in the MIDI domain and a spirit of finding out what we could do in the realm of live performance gestures. In this sense, the Duo has become a continuing musical conversation between two friends. For this recorded version, we used a PC/AT computer running Bruce Pennycook's MIDILIVE software, controlling a Proteus-2 and Yamaha SPX-900 with the celletto and a Yamaha TX-802 and SPX-900 controlled by the trumpet MIDI system. The celletto controls much of the sound processing for both instruments, while the trumpet controls the sequence of accompaniment.

- Dexter Morrill
Listening assignments may be accessed as streaming audio via eReserves. The student is responsible for all material addressed in and out of class. Some works not on this list will only be heard in class, and additional works may be added during the course of the semester.

Pierre Schaeffer, *Etude aux Chemins de Fer* from Cinq Etudes de Bruits (1948)
Pierre Schaeffer, *Masquerage* (1952)
Karlheinz Stockhausen, *Etude* (1952)
Vladimir Ussachevsky, *Sonic Contours* (1952)
Iannis Xenakis, *Concret PH* (1958)

Edgard Varése, *Poeme Electronique* (1958)
Hugh Le Cain, *Dripsody* (1955)
Ilhan Mimaroğlu, *Bowery Bum* (1964)
Kenneth Gaburo, *For Harry* (1966)
Iannis Xenakis, *Orient-Occident* (1960)
John Cage, *Williams Mix* (1958)
Steve Reich, *Come Out* (1966)
Steve Reich, *Violin Phase* (1967)

Joji Yuasa, *Projection Esemplastic for White Noise* (1964)


Luciano Berio, *Thema – Omaggio a Joyce* (1958)
Paul Lansky, *Six Fantasies on a Poem by Thomas Campion* (1979)


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Equal-loudness contours (red) (from ISO 226:2003 revision)
Original ISO standard shown (blue) for 40-phon
BASIC WAVEFORMS and their SPECTRAL CONTENT

Figure 1.4. TIME AND FREQUENCY DOMAINS FOR BASIC WAVEFORMS

a. Sawtooth wave

\[ A_1 = n \sin^2 \pi T \]

b. Square wave

c. Triangle wave

\[ A_1 = n \]

d. Pulse wave with 1:3 duty cycle