HISTORY OF ELECTRONIC AND COMPUTER MUSIC
INCLUDING AUTOMATIC INSTRUMENTS AND COMPOSITION MACHINES

1898 Valdemar Poulson (1869-1942) patented his "Telegraphone," the first magnetic recording machine.

1906 Thaddeus Cahill invented the Dynamophone, a machine that produced music by an alternating current running dynamos. This was the first additive synthesis device. The Dynamophone was also known as the Telharmonium. The instrument weighed over 200 tons and was designed to transmit sound over telephone wires; however, the wires were too delicate for all the signals. You can sort of consider him the 'Father of Muzak.' The generators produced pure tones of various frequencies and intensity; volume control supplied dynamics. Articles appeared in *McClure's Magazine* that stated "democracy in music...the musician uses keys and stops to build up voices of flute or clarinet, as the artist uses his brushes for mixing color to obtain a certain hue...it may revolutionize our musical art..."

1920 ✓ Leon Theremin, Russia, invented the Aetherophone (later called the Theremin or Thereminovox). The instrument used 2 vacuum tube oscillators to produce beat notes. Musical sounds were created by "heterodyning" from oscillators which varied pitch. A circuit was altered by changing the distance between 2 elements. The instrument had a radio antenna to control dynamics and a rod sticking out the side that controlled pitch. The performer would move his/her hand along the rod to change pitch, while simultaneously moving his/her other hand in proximity to the antenna. Many composers used this instrument including Varese.

1922 Darius Milhaud (b. 1892) experimented with vocal transformation by phonograph speed changes.

1926 Jorg Mager built an electronic instrument, the Spharophon. The instrument was first presented at the Donaueschingen Festival (Rimsky-Korsakov composed some experimental works for this instrument). Mager later developed a Partiturophon and a Kaleidophon, both used in theatrical productions. All of these instruments were destroyed in W.W.II.

1928 ✓ Maurice Martenot (b. 1928, France) built the Ondes Martenot (first called the Ondes Musicales). The instrument used the same basic idea as the Theremin, but instead of a radio antenna, it utilized a moveable electrode was used to produce capacitance variants. Performers wore a ring that passed over the keyboard. The instrument used subtractive synthesis. Composers such as Honegger, Messiaen, Milhaud, Dutilleux, and Varese all composed for the instrument.

1929 Laurens Hammond (b. 1895, USA), built instruments such as the Hammond Organ, Novachord, Solovox, and reverb devices in the United States. The Hammond Organ used 91 rotary electromagnetic disk generators driven by a synchronous motor with associated gears and tone wheels. It used additive synthesis.

1935 Allegemeine Elektrizitats Gesellschaft (AEG), built and demonstrated the first Magnetophon (tape recorder).

1930s Plastic audio tape was developed.

1941 The Ondioline was built. The Ondioline, a monophonic vacuum tube instrument, consisted of a single oscillator and a small eight octave touch sensitive keyboard (switchable through six octaves and tuneable via an octave transposer). It was possible to create complex waveforms via a series of filters and the sound wave could be shaped with the use of a touch wire, effecting the attack with a vertical finger movement or adding glissando or modulation by horizontal movement. The overall volume of the machine was controlled by a knee lever.

1944 Percy Grainger and Burnett Cross patented a machine that "freed" music from the constraints of conventional tuning systems and rhythmic inadequacies of human performers. Mechanical invention for composing "Free Music" used eight oscillators and synchronizing equipment in conjunction with photo-sensitive graph paper with the intention that the projected notation could be converted into sound.

1947 Bell Labs developed and produced the solid state transistor.

The Solovox and the Clavioline were created. The Clavioline was a monophonic, portable, battery powered keyboard instrument designed by M. Constant. Martin in 1947 at Versailles, France. The Clavioline consisted of two units: the keyboard with the actual sound producing unit with controls and a box with amplifier and speaker. By using an octave transposer switch the single oscillator could be set within a range of five octaves (six in the Bode version). The keyboard unit had 18 switches (22 in the Selmer version) for controlling timbre (via a high pass filter and a low pass filter), octave range and attack plus two controls for vibrato speed and intensity, the overall volume was controlled by a knee lever.

The Solovox was designed by Alan Young of the Hammond Organ Co and manufactured in the United States between 1940 and 1948.The Hammond Solovox was a monophonic keyboard attachment instrument intended to accompany the piano with organ type lead voices. The 3 octave short keyed keyboard was stored on a sliding mounting under the piano keyboard with a knee operated volume control. On the front of the instrument below the keyboard there were a series of large thumb operated buttons for oscillator range (switchable +/- 3 octaves: 'soprano', 'contralto', 'tenor' , 'bass'), vibrato, attack time, 'deep tone', 'full tone', '1st voice', 2nd voice', 'brilliant' and a switch for selecting woodwind, string sound or mute. The Solovox was able to create a range of string, woodwind and organ type sounds and was widely used in light music of its time.

1948 Pierre Schaeffer (b. 1910), a sound technician working at Radio-diffusion-Television Francaise (RTF) in Paris, produced several short studies in what he called *Musique concrete*. October, 1948, Schaeffer's early studies were broadcast in a "concert of noises."

1949 ✓ Pierre Schaeffer and engineer Jacques Poullin worked on experiments in sound which they titled "Musique concrete." 1949-50 Schaeffer and Henry (1927-96), along with

Poullin composed *Symphonie pour un homme seul* (Symphony for a Man Alone); the work actually premiered March 18, 1950.

Olivier Messiaen composed his *Mode de valeurs et d'intensities* (Mode of Durations and Intensities), a piano composition that "established 'scales' not only of pitch but also of duration, loudness, and attack."

The Melochord was invented by H. Bode- The melochord is a monophonic keyboard instrument based on vacuum tube technology in 1947 . The keyboard used pitches derived from the traditional equal-tempered 12 note scale with switches extending the 37 note range from three octaves to seven. A foot pedal allowed overall control of the volume and a novel electronically operated envelope shaper could be triggered for each key. A later version incorporated two keyboards the second keyboard being able to control the timbre of the other, a technique used in later modular type synthesizers.

1940s The following instruments were built:

The Electronium Pi (The Electronium was designed by René Seybold and manufactured by the German company Hohner GmbH in Trossingen, Germany, from 1950 onwards. The Electronium was a monophonic electronic instrument resembling an accordion. The Electronium had a 41 note keyboard with keys or buttons and 16 'registration tabs', the overall volume being controlled by the 'bellows' of the instrument.)

The Multimonica: The Multimonika was a commercial hybrid electronic/acoustic instrument manufactured by the German company, Hohner GmbH and designed by the German instrument designer Harald Bode . The Multimonica was a two keyboard combination of a wind-blown reed harmonium instrument, controlled by a 41 note lower keyboard, and an electronic monophonic sawtoooth generator contolled by the upper keyboard.

The Polychord organ, the Tuttivox, the Marshall organ, and other small electric organs.

1951-53 Eimert and Beyer (b. 1901) produced the first compositions using electronically-generated pitches. The pieces used a mechanized device that produced melodies based on Markov analysis of Stephen Foster tunes.

1952 The Cologne station of Nordwestdeutscher Rundfunk (later Westdeutscher Rundfunk) was founded by Herbert Eimert. He was soon joined by Stockhausen, and they set out to create what they called *Elektronische Musik*.

John Cage's *4'33"* was composed. The composer was trying to liberate the performer and the composer from having to make any conscious decisions, therefore, the only sounds in this piece are those produce by the audience.

1953 ✓ Robert Beyer, Werner Meyer-Eppler (b. 1913) and Eimert began experimenting with electronically-generated sounds. Eimert and Meyer-Eppler taught at Darmstadt Summer School (Germany), and gave presentations in Paris as well.

✓ Louis and Bebe Baron set up a private studio in New York, and provided soundtracks for sci-fi films like *Forbidden Planet* (1956) and *Atlantis* that used electronic sound scores.

✓ Otto Luening (b. 1900, USA; d. 1996, USA) and Vladimir Ussachevsky (b. 1911, Manchuria; d. 1990, USA) present first concert at the Museum of Modern Art in New York, October 28. The program included Ussachevsky's *Sonic Contours* (created from piano recordings), and Luening's *Fantasy in Space* (using flute recordings). Following the concert, they were asked to be on the Today Show with Dave Garroway. Musicians Local 802 raised a fuss because Luening and Ussachevsky were not members of the musicians' union.

1953-4 Karlheinz Stockhausen (b. 1928) used Helmholtz' research as the basis of his *Studie I* and *Studie II*. He tried to build increasingly complex synthesized sounds from simple pure frequencies (sine waves).

1954 The Cologne Radio Series "Music of Our Time" (October 19) used only electronically-generated sounds by Stockhausen, Eimert, Pousseur, etc. The pieces used strict serial techniques.

✓ *Dripsody* was composed by Hugh LeCaine. The single sound source for this concrete piece is a drip of water.

1955 Harry Olson and Belar, both working for RCA, invent the Electronic Music Synthesizer, aka the Olson-Belar Sound Synthesizer. This synth used sawtooth waves that were filtered for other types of timbres. The user programmed the synthesizer with a typewriter-like keyboard that punched commands into a 40-channel paper tape using binary code.

Lejaren Hiller (1924-92) and Leonard Isaacson, from the University of Illinois composed the *Illiac String Quartet*, the first piece of computer-generated music. The piece was so named because it used a Univac computer and was composed at the University of Illinois.

1955-56 Karlheinz Stockhausen composed *Gesang der Junglinge*. This work used both concrete recordings of boys' voices and synthesized sounds. The original version was composed for five loudspeakers, but was eventually reduced to four. The text from the Benedicite (O all ye works of the Lord, bless ye the Lord), which appears in Daniel as the canticle sung by the three young Jews consigned to the fiery furnace by Nebuchadnezzar.

1956 Martin Klein and Douglas Bolitho used a Datatron computer called Push-Button Bertha to compose music. This computer was used to compose popular tunes; the tunes were derived from random numerical data that was sieved, or mapped, into a preset tonal scheme.

1957 David Seville created the Chipmunks, by playing recordings of human voices at double speed. Electronic manipulation was never really used again in rock for about ten years.

1958 ✓ Edgard Varese (1883-1965) composed *Poeme Electronique* for the World's Fair, Brussels. The work was composed for the Philips Pavilion, a building designed by the famous architect, Le Corbusier who was assisted by Iannis Xenakis (who later became well-known as a composer rather than an architect). The work was performed on ca. 425 loudspeakers, and was accompanied by projected images. This was truly one of the first large-scale multimedia productions.

Iannis Xenakis (b.1922) composed *Concret PH*. This work was also composed for the Brussels World's Fair. It made use of a single sound source: amplified burning charcoal.

Luciano Berio composed *Thema-omaggio a Joyce*. The sound source is woman reading from Joyce's *Ulysses*.

1958-60 ✓ Stockhausen composed *Kontakte* (Contacts) for four-channel tape. There was a second version for piano, percussion and tape.

1958-9 Mauricio Kagel, an Argentinian composer, composed *Transicion II*, the first piece to call for live tape recorder as part of performance. The work was realized in Cologne. Two musicians perform on a piano, one in the traditional manner, the other playing on the strings and wood. Two other performers use tape recorders so that the work can unites its present of live sounds with its future of pre-recorded materials from later on and its past of recordings made earlier in the performance.

Max Mathews, at Bell Labs, began experimenting with computer programs to create sound material. Mathews and Joan Miller also at Bell Labs, write MUSIC4, the first wide-spread computer sound synthesis program. Versions I through III were experimental versions written in assemble language. Music IV and Music V were written in FORTRAN. MUSIC4 did not allow reentrant instruments (same instrument becoming active again when it is already active), MUSIC5 added this. MUSIC4 required as many different instruments as the thickest chord, while MUSIC5 allowed a score to refer to an instrument as a template, which could then be called upon as many times as was necessary.

The Columbia-Princeton Electronic Music Center was formally established. The group had applied through the Rockefeller Foundation, and suggested the creation of a University Council for Electronic Music. They asked for technical assistants, electronic equipment, space and materials available to other composers free of charge. A grant of $175,000 over five years was made to Columbia and Princeton Universities. In January, 1959, under the direction of Luening and Ussachevsky of Columbia, and Milton Babbitt and Roger Sessions of Princeton, the Center was formally established.

The RCA Mark II synthesizer was built at Columbia-Princeton Electronic Music Center (the original version was built for the artificial creation of human speech). The Mark II contained oscillators and noise generators. The operator had to give the synthesizer instructions on a punched paper roll to control pitch, volume, duration and timbre. The synth used a conventional equal-tempered twelve-note scale.

1960 Composers of more traditional orchestral music began to rebel. Many composers tried to get quasi-electronic sounds out of traditional instruments. Bruno Bartelozzi, wrote new book on extended instrumental techniques.

Morton Subotnick, Pauline Oliveros, and Ramon Sender established the San Francisco Tape Music Center.

John Cage composed *Cartridge Music*, an indeterminate score for several performers applying gramophone cartridges and contact mics to various objects.

1961 The first electronic music concerts at the Columbia-Princeton Studio were held; the music was received with much hostility from other faculty members.

✓ Fortran-based Music IV was used in the generation of *Bicycle Built for Two* (Mathews).

Robert Moog met Herbert Deutsch, and together they created a voltage-controlled synthesizer.

Luciano Berio composed *Visage*. This radio composition is based on the idea of non-verbal communication. There are many word-like passages, but only one word is spoken during the entire composition (actually heard twice), *parole* (Italian for 'word'). Cathy Berberian, the composer's wife, was the performer.

1962 Bell Labs mass produces transistors, professional amplifiers and suppliers.

PLF 2 was developed by James Tenney. This computer program was used to write *Four Stochastic Studies*, *Ergodos* and others.

Iannis Xenakis composed *Bohor* for eight tracks of sound.

Milton Babbitt composed *Ensembles for Synthesizer* (1962-64) at the Columbia-Princeton Studio.

At the University of Illinois, Kenneth Gaburo composed *Antiphony III*, for chorus and tape.

1963 Lejaren Hiller and Robert Baker composed the *Computer Cantata*.

Babbitt composed *Philomel* at the Columbia-Princeton Studio. The story is about Philomel, a woman without a tongue, who is transformed into a nightingale (based on a story by Ovid).

Mario Davidovsky composed *Synchronism I* for flute and tape. Davidovsky has since written many "synchronism" pieces. These works are all written for live instrument(s) and tape. They explore the synchronizing of events between the live and tape.

1964 The fully developed Moog was released. The modular idea came from the miniaturization of electronics.

Gottfried Michael Koenig used PR-1 (Project 1), a computer program that was written in Fortran and implemented on an IBM 7090 computer. The purpose of the program was to provide data to calculate structure in musical composition; written to perform algorithmic serial operations on incoming data. The second version of PR-1 completed, 1965.

Karlheinz Stockhausen composed *Mikrophonie I*, a piece that required six musicians to generate. Two performers play a large tam-tam, while two others move microphones around the instrument to pick up different timbres, and the final two performers are controlling electronic processing.

Ilhan Mimaroglu, a Turkish-American composer, wrote *Bowery Bum*. This is a concrete composition, and used rubber band as single source. It was based on a painting by Dubuffet.

1965 Karlheinz Stockhausen composed *Solo*. The composition used a tape recorder with moveable heads to redefine variations in delay between recording and playback, live manipulation during performance.

1966 The Moog Quartet offered world-wide concerts of (mainly) parlor music.

1967 Walter Carlos (later Wendy) composed *Switched on Bach* using a Moog synthesizer.

Iannis Xenakis wrote *Musiques Formelles* (Formalized Music). The first discussion of granular synthesis and the clouds and grains of sound is presented in this book.

Leon Kirschner composed *String Quartet No. 3*, the first piece with electronics to win the Pulitzer Prize.

Kenneth Gaburo composed *Antiphony IV*, a work for trombone, piccolo, choir and tape.

✓ Morton Subotnick composed *Silver Apples of the Moon* (title from Yeats), the first work commissioned specifically for the recorded medium.

The Grateful Dead released *Anthem of the Sun* and Frank Zappa and the Mothers of Invention released *Uncle Meat*. Both albums made extensive use of electronic manipulation.

1968 Lejaren Hiller and John Cage composed *HPSCHD*.

1969 Terry Riley composed *Rainbow in Curved Air*

late 1960s The Sal-Mar Construction was built. The instrument was named for composer Salvatore Martirano and designed by him. The Sal-Mar Construction weighed over fifteen hundred pounds and consisted of "analog circuits controlled by internal digital circuits controlled by the composer/performer via a touch-control keyboard with 291 touch-sensitive keys."

Godfrey Winham and Hubert Howe adapted MUSIC IV for the IBM 7094 as MUSIC4B was written in assembly language; MUSIC4BF (a Fortran-language adaptation of MUSIC4B, one version was written by Winham, another was written by Howe).

Music V variants include MUSIC360 and MUSIC11 for the IBM360 and the PDP11 computers, these were written by Barry Vercoe, Roger Hale, and Carl Howe at MIT, respectively.

GROOVE was developed by Mathews and F. Richard Moore at Bell Labs, and was used to control analog synthesizers.

1970 Charles Wuorinen composed "Times Encomium," the first Pulitzer Prize winner for entirely electronic composition.

1972 Pink Floyd's album *The Dark Side of the Moon* was released; it used ensembles of synthesizers, also used concrete tracks as interludes between tunes.

1973 SAWDUST, a language by Herbert Brun, used functions including: ELEMENT, LINK, MINGLE, MERGER, VARY, and TURN.

1974 The Mellotron was built. The instrument was an early sample player that used tape loops. There were versions that played string sounds or flute sounds, and the instrument was used in movie soundtracks and on recordings.

1976 Composer Philip Glass collaborated with librettist Robert Wilson on *Einstein on the Beach*. This was a large-scale multimedia 'opera' in the minimalist style.

1977 Systems Concepts Digital Synthesizer (SCDS), built by Peter Samson for CCRMA, signal generating and processing elements all executing in parallel, and capable of running in real time. There are 256 digital oscillators, 128 signal modifiers (filters, reverb, amplitude scalers), a scratch-pad memory for communicating values between processing elements, and a large memory for reverberation and table storage.

1981 Larry Austin composed *Canadian Coastlines*, a composition that used a land map of Canada in order to determine textural, rhythmic, and melodic content.

Music V variants: newer developments include Cmusic (by F.R. Moore), so named because it is written entirely in C programming language.

1985 HMSL, Hierarchical Music Specification Language was released. The basic organization of HMSL is a series of data structures called "morphs" (named for the flexible or morphological design of the software). Within the superstructure of these morphs there exist other data substructures named shapes, collections, structures, structures, productions, jobs, players, and actions. These secondary types of morphs are used to control aspects of higher level scheduling and routines.

Interactor, by Morton Subotnick and Mark Coniglio, was designed specifically for live performance and score-following capabilities.

1986 Another Music V variant was release--CSound, by Barry Vercoe of MIT.

Jam Factory written by programmer David Zicarelli. He was trying to create a program that would listen to MIDI input and 'improvise' immediately at some level of proficiency, while allowing (Zicarelli) to improve its ability.

Joel Chadabe, Offenhartz, Widoff, and Zicarelli began work on an algorithmic program that could be used as an improvisation environment. The performer could be seated at the computer and shape data in real time by "a set of scroll bars that changed the parameters of this algorithm, such as the size of the jump from one note to another, the lowest and highest note, etc." The original version was to be named "Maestro," then "RMan" (Random Manager), and finally, "M."

The Max program was written in the C language and was developed at IRCAM by Miller Puckette. It was later scheduled for distribution by Intelligent Music (the company that also distributed M and Jam Factory), but it was the Opcode company that eventually released it. Miller Puckette's original intention was to build a language that could control IRCAM's 4X synthesizer, and there was no need for the graphical implementation. The graphics were added after a version of Max for Macintosh computer using MIDI was proposed. Since 1989, David Zicarelli has updated and expanded the program for the Macintosh environment.

Dolby SR introduced

R-DAT spec announced

1987 Apple introduced MacII

First consumer DAT decks available

1988 Steve Reich composed *Different Trains* for string quartet and tape.

1989 Digidesign introduces Sound Tools

1990 Sony introduces writeable CD

1991 Sony develops MiniDisc

Alesis ADAT introduced

1992 Sony announces multimedia CD-ROM

1994 DVD introduced

1996 first MiniDisc multitracks introduced

1997 DVD-Audio standard develops

Listening Guide

1. Clara Rockmore playing the Theremin (1920) in Tchaikovsky's ***Valse Sentimentale***
2. Oliver Messiaen's ***Oraison*** for Ondes Martenot (1937).
3. ***Etude aux Chemins de Fer***- Pierre Schaeffer (1937).
4. ***Klangstudie II*** by Hebert Eimert (1952)
5. ***Low Speed*** by Otto Lueing (1952)
6. ***Dripsody*** by Hugh Le Caine (1955)
7. Main title from ***Forbidden Planet*** by Louis and Bebe Barron (1956)
8. ***Poem Electronic*** by Edgard Varèse (1958)
9. ***Kontakte*** by Karlhein Stockhausen (1959-60)
10. ***Bicycle Built for Two*** by Max Mathews (1961)
11. ***Silver Apples of the Moon*** by Morton Subotnick (1967)
12. ***He Destroyed Her Image*** by Charles Dodge (1972)
13. ***Appalachian Grove I*** by Laurie Spiegel (1974)
14. ***On the Other Ocean*** by David Behrman (1977)
15. ***Six Fantasies on a Poem by Thomas Champion: Her Song*** by Paul Lansky (1978)
16. ***Unfamiliar Wind*** by Brian Eno (1982)

Taken from the web site: http://www.obsolete.com/120_years/

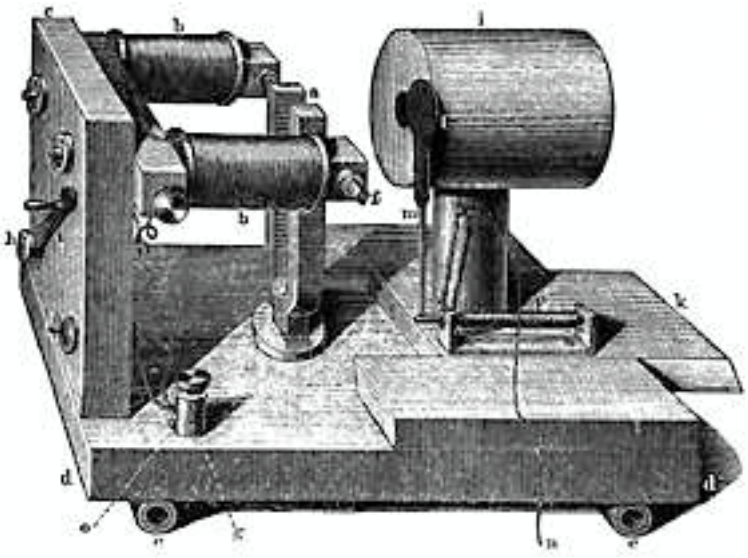
120 Years Of Electronic Music Introduction

This site charts the development of electronic musical instruments from 1870 to 1990. For the purposes of this project electronic musical instruments are defined as instruments that synthesise sounds from an electronic source. This definition leaves out a whole section of hybrid electronic instruments developed at the end of the last century that used electronics to manipulate or amplify sounds and tape recorders/ Musique Concrete, it has been decided to leave in some non electronic instruments such as the Futurists "Intonarumori" due to their importance in the history of modern music.

The main focus of the site is on instruments developed from the beginning of the century until the 1960's. The more modern and current Synthesiser companies have been included for the sake of 'historical completeness' but are already well documented elsewhere on the internet, a comprehensive set of links are provided. To browse the site it is recommended that you leave open both windows as the main menus page will take time to redraw, clicking on the links on the main menu will open a page in the same window.

'120 Years Of Electronic Music' is an ongoing project and the site will be updated on a regular basis (currently v3.0 feb 1998). Most of the sections have been updated in this revision and a links page and bibliography have been added.

'120 Years Of Electronic Music' A Condensed History



The Helmoltz Resonator

Origins:
The origins of electronic music can be traced back to the audio analytical work of Hermann Ludwig Ferdinand von Helmholtz (1821-1894) the German physicist, mathematician and author of the seminal work "SENSATIONS OF TONE: Psychological Basis for Theory of Music" (c1860). Helmholtz built an electronically controlled instrument to analyse combinations of tones the "Helmholtz Resonator", using electromagnetically vibrating metal tines and glass or metal resonating spheres the machine could be used for analysing the constituent tones that create complex natural sounds. Helmholtz was concerned solely with the scientific analysis of sound and had no interest in direct musical applications, the theoretical musical ideas were provided by Ferruccio Busoni, the Italian composer and pianists who's influential essay "Sketch of a New Aesthetic of Music" was inspired by accounts of Thaddeus Cahill's 'Telharmonium'.

1870-1915: Early Experiments
The first electronic instruments built from 1870 to 1915 used a variety of techniques to generate sound: the tone wheel (used in the Telharmonium and the Chorelcello)- a rotating metal disk in a magnetic field causing variations in an electrical signal, an electronic spark causing direct fluctuations in the air (used uniquely in William Duddell's "Singing Arc' in 1899) and Elisha Grey's self vibrating electromagnetic circuit in the 'Electronic Telegraph', a spin-off from telephone technology. The tone wheel was to survive until the 1950's in the Hammond Organ but the experiments with self oscillating circuits and electric arcs were discontinued with the development of vacuum tube technology.

1915-1960: The Vacuum Tube Era.
The engineer and prolific US inventor Lee De Forest patented the first Vacuum tube or triode in 1906, a refinement of John A. Fleming's electronic valve. The Vacuum tube's main use was in radio technology but De Forest discovered that it was possible to produce audible sounds from the tubes by a process known as heterodyning. twentieth century by radio engineers experimenting with radio vacuum tubes. Heterodyning effect is created by two high radio frequency sound waves of similar but varying frequency combining and creating a lower audible frequency, equal to the difference between the two radio frequencies (approximately 20 Hz to 20,000 Hz). De Forest was one amongst several engineers to realise the musical potential of the heterodyning effect and in 1915 created a musical instrument, the "Audion Piano" . Other instruments to first exploit the vacuum tube were the 'Theremin' (1917) 'Ondes Martenot' (1928), the 'Sph`raphon' (1921) the 'Pianorad' (1926). The Vacuum tube was to remain the primary type of audio synthesis until the invention of the integrated circuit in the1960's.

1960-1980: Integrated Circuits.
Integrated Circuits came into widespread use in the early 1960's. Inspired by the writings of the German instrument designer Harald Bode, Robert Moog, Donald Buchla and others created a new generation of easy to use, reliable and popular electronic instruments.

1980-present: Digital.
The next and current generation of electronic instruments were the digital synthesisers of the 1980s. These synthesisers were software controlled offering complex control over various forms of synthesis previously only available on extremely expensive studio synthesisers. Early models of this generation included the Yamaha DX range and the Casio CZ synthesisers.

120 Years of Electronic Music

Electronic Musical Instrument 1870 - 1990

Instrument	Inventor	Country	Date
			
	1 8 7 0		
The Musical Telegraph	Elisha Grey	USA	1876
The Singing Arc	William Duddel	United Kingdom	1899
The Telharmonium	Thaddeus Cahill	USA	1897
			
	1 9 0 0		
The Choralcello	Melvin Severy	USA	1909
The "Intonarumori"	Luigi Russolo	Italy	1913
The Audion Piano	Lee De Forest	USA	1915
The Optophonic Piano	Vladimir Rossiné	Soviet Union	1916
The Theremin	Leon Termen	Soviet Union	1917
	1 9 2 0		
The Sphäraphon	Jörg Mager	Germany	1921
The Staccatone	Hugo Gernsbak	Germany	1923
The Pianorad	Hugo Gernsbak	Germany	1926
The Dynaphone	René Bertrand	France	1927
The Celluphone	Pierre Toulon & Krugg Bass	France	1927
The Clavier à Lampes	A.Givelet & E.Coupleaux	France	1927
The Ondes-Martenot	Maurice Martenot	France	1928
Piano Radio-Electrique	A.Givelet & E.Coupleaux	France	1929
The Givelet	A.Givelet & E.Coupleaux	France	1929
The Sonorous Cross	Nikolay Obukhov	France	1929
The Hellertion	B.Helberger & P.Lertes	Germany	1929
			
	1 9 3 0		
The Trautonium	Dr Freidrich Trautwein	Germany	1930
The Ondium Péchadre	H. Péchadre	France	1930
The Rhythmicon	Henry Cowell & Leon Termen	USA	1930
The Theremin Cello	Leon Termen	USA	1930
The Westinghouse Organ	R.C.Hitchock	USA	1930
The Sonar	N.Anan'yev	Soviet Union	c1930
Saraga-Generator	Wolja Saraga	Germany	1931

The "Ekvodin"	Andrei Volodin & K.Kovalski	Soviet Union	1931
The Trillion Tone Organ	A. Lesti & F. Sammis.	USA	1931
The Variophone	Yevgeny Sholpo	Soviet Union	1932
The Emiriton	A.Ivanov & A.Rimsky-Korsakov	Soviet Union	1932
The Emicon	N.Langer	USA	1932
The Rangertone Organ	Richard H.Ranger	USA	1932
L'Orgue des Ondes	Armand Givelet	France	1933
Syntronic Organ	I.Eremeef & L.Stokowski	USA	1934
The Polytone Organ	A. Lesti & F. Sammis	USA	1934
The Hammond Organ	Laurens Hammond	USA	1935
The Electrochord	-	USA	1936
The sonothèque	L. Lavalée	France	1936
The Heliophon	Bruno Hellberger	Germany	1936
The Grosstonorgel	Oskar Vierling	Germany	1936
The Welte Licht-Ton-Orgel	E.Welte	Germany	1936
The Singing Keyboard	F. Sammis	USA	1936
The Warbo Formant organ	Harald Bode & C. Warnke	Germany	1937
The Kaleidophon	Jörg Mager	Germany	1939
The Novachord	L Hammond & C.N.Williams	USA	1939

1940

The Voder & Vocoder	Homer Dudley	USA	1940
The Univox	Univox Co.	UK	1940
The Multimonica	Harald Bode	Germany	1940
The Pianophon	-	-	1940
The Ondioline	Georges Jenny	France	1940
The Solovox	Hammond Organs Company	USA	1940
The Electronic Sackbut	Hugh Le Caine	Canada	1945
The Tuttivox	Harald Bode	USA	1946
Hanert Electric Orchestra	J. Hanert	USA	1945
The Minshall Organ	-	USA	1947
The Clavioline	M. Constant Martin	France	1947
The Melochord	Harald Bode	Germany	1947
The Monochord	Dr Freidrich Trautwein	Germany	1948
The Free Music Machine	Percy Grainger & Burnett Cross	USA/Australia	1948

1950

The Electronium Pi	René Seybold	Germany	1950
The Polychord Organ	Harald Bode	USA	1950

Dr Kent's Electronic Music Box	Dr Earle Kent	USA	1951
The Clavivox	Raymond Scott	USA	1952
The RCA Synthesiser I & II	Harry Olsen & Hebert Belar	USA	1952
The Composertron	Osmond Kendall	Canada	1953
MUSIC I-V Software	Max Mathews	USA	1957
Oramics	Daphne Oram	United Kingdom	1959
The Siemens Synthesiser	H.Klein & W.Schaaf	Germany	1959
The Side Man	Wurlitzer	USA	1959

1960

Milan Electronic Music Studio	director: Luciano Berio	Italy	1960
Moog Synthesisers	Robert Moog	USA	1963
The Mellotron & Chamberlin	Leslie Bradley	United Kingdom	1963
Buchla Synthesisers	Donald Buchla	USA	1963
The Donca-Matic DA-20	Keio Corp	Japan	1963
The Synket	Paul Ketoff	United Kingdom	1963
Tonus/ARP Synthesisers	Philip Dodds	USA	1964
PAiA Electronics, Inc	John Paia Simonton	USA	1967
MUSYS Software	David Cockrell & Peter Grogno	United Kingdom	1968
EMS Synthesisers	Peter Zinovieff & David Cockrell	United Kingdom	1969

1970

GROOVE System	Max Mathews	USA	1970
The Optigan	Mattel Inc.	USA	1970
The Electronium-Scott	Raymond Scott	USA	1970
Con Brio Synthesisers	-	USA	1971
Roland Synthesisers	Roland Corporation	Japan	1972
Maplin Synthesisers	Trevor G Marshall	Australia/USA	1973
The Synclavier	New England Digital Corporation	USA	1975
Korg Synthesisers	Korg	Japan	1975
EVI wind instrument	Nyle Steiner	USA	1975
EDP Wasp	Chris Hugget	UK	1978
Yamaha Synthesisers	Yamaha Corp	Japan	1976
PPG Synthesisers	Wolfgang Palm	Germany	1975
Oberheim Synthesisers	Thomas Oberheim	USA	1978
Serge Synthesisers	-	-	1979
The Fairlight CMI	Peter Vogel & Kim Ryrie	Australia	1979

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Simmons Drum Synthesisers	Simmons	UK	1980
Casio Synthesisers	Casio Ltd	Japan	1981
The McLeyvier	David McLey	USA	1981
Kawai Synthesiser	Kawai Musical Instrument Co	Japan	-
The Emulator	Emu Systems	USA	1981
Waldorf		Germany	-
Oxford Synthesiser Company	Chris Hugget	United Kingdom	1983
Akai Musical Instruments	Akai Corporation	Japan	1984
Ensoniq Synthesisers & Samplers	-	USA	1985
Steinberg Software	Steinberg	Germany	-
GEM Synthesisers	-	-	-
Crumar Synthesisers	-	-	-
Kurzweil Synthesisers/Samplers	Raymond Kurzweill	USA/Korea	1983
Sequential Circuits	-	USA	-
Alesis Corporation	Keith Barr	USA	1984

1 9 9 0

Musique Concrète

In 1948 Paris, history was made. Pierre Schaeffer, a French radio broadcaster, working for the Radiodiffusion-Television Francaise (RTF), created the first electronic music studio. With a multitude of microphones, phonographs, variable speed tape recorders, and sound effect records he created a new art form, musique concrete, and with it a world of new music opened up -- the world of electronic music. Schaeffer chose to name his new art *musique concrete* to differentiate it from normal music, *musique abstraite*.

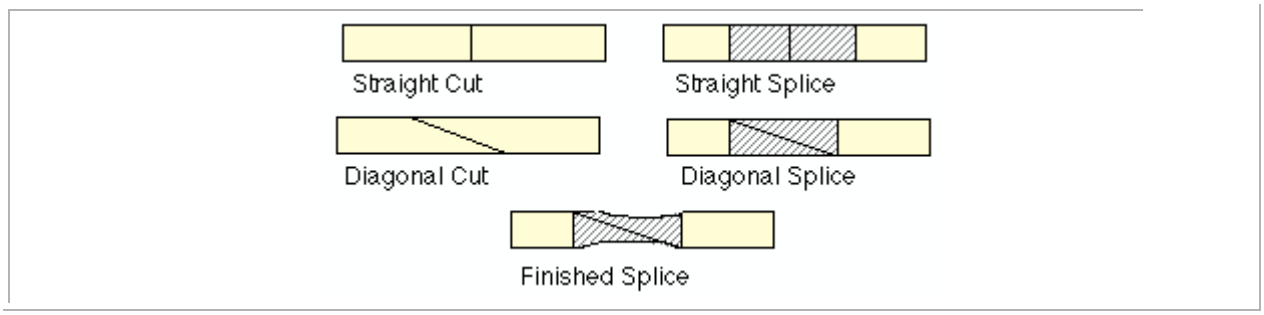
Music concrete was recorded directly to tape with real (concrete) sounds, while *musique abstraite* was the traditional way of composing by writing down the score to be played later.

Music Concrete was based on manipulation of tape. (Although the first research involved phonograph records, eventually tape technology became more available, and with it the possibilities of splicing and pasting parts together versus a non-re-recordable fixed format). It also concentrated on 'found sounds' or natural recordings rather than electronically produced sounds such as synthesizers.

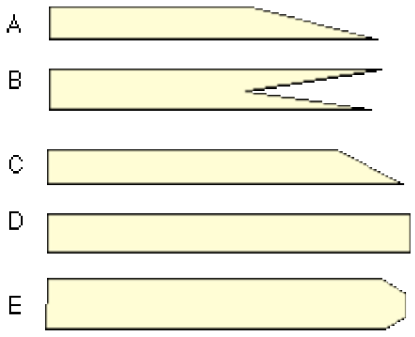
Pieces that would last only a few minutes could take months of recording, cutting and splicing to create. Here are some of the tape techniques used.

CUTTING and SPLICING TAPE

Cutting the tape at different angles was used to create different attacks and decays.



Attack and Delay Cuts



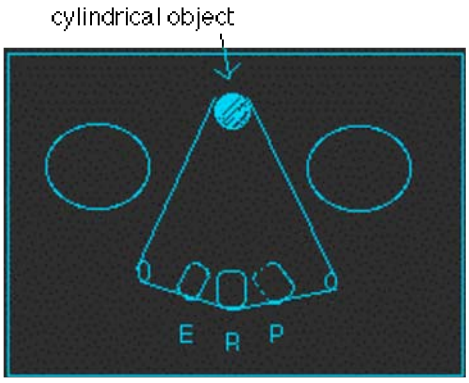
A. soft attack or decay
B. combined attack and decay of two sounds
C. medium attack or decay
D. hard attack or abrupt finish
E. softer and less abrupt than D

Not only did musique concrete composers use the cuts shown above, but they would go so far as to take a long horizontal cut , cut it into smaller calculated sizes, and splice the cuts together vertically or at different angles!

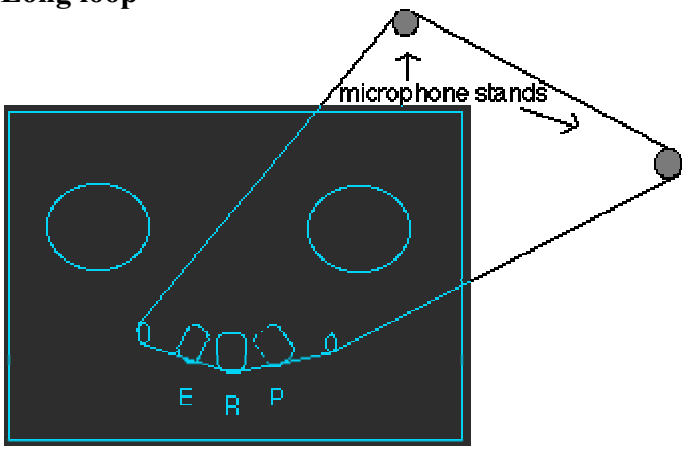
Tape Loops

Creating a loop consisted of taking tape with recorded material and splicing the ends of the tape to make a loop.

Short loop



Long loop



ECHO

Straight line delay: The simplest echo effect can be created by using a 2 channel recorder. The signal is recorded, monitored by the playback head, and sent back to the lower track of the record head. At 15 ips, the delay is around 100 milliseconds.

Feedback delay: Created by feeding the signal back into the record head of the channel originally recorded on. It may involve multiple channels and create a number of repetitions.

PITCH

Obviously changing the speed of playback will affect the pitch. Lower pitch if slower, higher if sped up. Using 2 decks, pitch changes can be recorded to tape. Early flanging effects were created by lightly touching the reel as the track is being bounced to another track.

BACKWARDS MASKING

Reversing the reels of recorded material and playing the tape backwards can be used to create reverse reverbs, attacks, etc. Recording the reversed track to another tape deck is the easiest way, although bouncing the reversed track to an empty track on a multi track can be done.

Early Tape Decks

Phonogene

Schaeffer created the phonogene. With it he was able to transpose a loop in 12 distinct steps from using a keyboard (this led to the mellotron keyboard). The keyboard selected one of 12 capstans of different diameters, like changing gears on a bike. A 2 speed motor allowed for octave transposition.

Morphophone

Used in the Paris studio. It was a specialized loop deck. It had an erase head, record head, and ten playback heads with an adjustable filter for each to create special timbre effects.

The lengths the fathers of electronic music went to create a new sound is amazing. The excitement of pushing through new frontiers of sound must have been exhilarating. We take the technologies available

today for granted...and perhaps in the far future, the technologies of today will be looked back on with the same amazement.

The Cologne Studio: Birth Place of *Elektronische Musik*

The Cologne studio was built from a collaboration of several individuals. Each individual had different skills and backgrounds which contributed to the shaping of electronic music principles that grew from Cologne.

In 1948, Dr. Werner Meyer-Eppler, a mathematician, physicist, and director of Phonetics at Bonn University, was visited by Homer Dudley, a researcher at Bell Labs. Dudley had brought a brand new invention called a vocoder (Voice Operated reCOrDER) which analyzed and synthesized speech. Meyer - Eppler was impressed. He made reference to it in an account on the history of electronic instruments (Elektrische Klangerzeugung). He demoed a tape of vocoder sounds at a lecture on electronic sound production at North-West German Music Academy. In the audience was Robert Beyer from West-German Radio.

Beyer, an inventor and author, was interested in the use of electronic in music production. He and Meyer-Eppler joined forces and gave a lecture on ' The Sound World of Electronic Music' at Darmstadt. Beyer concentrated on design and manufacturing of electronic equipment, and Meyer-Eppler concentrated on research in speech synthesis. They were joined by composer Herbert Eimert. Eimert was a devotee of 12 tone music, and saw the potential of electronic sound in creating pure 12 tone compositions, un -encumbered by the acoustic limitations of available instruments.

In 1950, Harold Bode brought a Melochord, a monophonic wave form generator with a keyboard, for them to check out. They used it to produce music by layering tracks of tones. In 1951 they presented their results at Darmstadt in a lecture entitled, 'The possibilities of Electronic Sound Production', Beyer wrote a paper on 'Music and Technology', and Eimert discussed 'Music on the borderline'. Schaeffer attended the summer program that year and the tension between Music Concrete and Electronic Music came to a boil.

1951. A radio station in Cologne broadcast an evening program called 'the Sound World of Electronic Music'. The show featured a forum between Eimert, Beyer, and Meyer- Eppler. The director of the station, Fritz Enkel, was impressed and agreed to establish a studio to research electronic music. The studio took two years to become fully operational. Eimert was named as the artistic director.

During the interim that the studio was being constructed, Meyer-Eppler gave a lecture on '"The Methods of Electronic Tone Generation' to around 2000 technologists in Bonn. The gospel of electronic music was spreading.

In 1952, composer Bruno Maderna produced 'Musica sue due Dimensioni', which featured flute, percussion, and taped tones projected through a loud speaker, which was presented at Darmstadt. In the audience was Stockhausen as well as other future electronic music composers such as Klebe, Koenig, Hambraeus, Goeyvaerts, and others. Stockhausen was also studying with Messian at this time.

Ironically, the Maderna piece was not pure electronic as it also featured natural flute and percussive instruments, revealing a softening in the hard-line principles of pure electronic music.
Beyer and Eimert composed the first all-electronic works while the studio was still in construction. *Klang im unbegrenzten Raum* (1951-1952), *Klangstudie 1* (1952), and *Klangstudie II* (1952-1953). They were ironically premiered in Paris.

The studio became partially functional and other composers began to compose. At this time Stockhausen became associated with the studio. In 1953 he was appointed to assistant director under Eimert. In 1963 he became the sole director until 1978. When he became director, the studio was reconstructed to include two production rooms. One for sound and tone generation, and the other for recording and playback. Music Concrete and Electronic Music began to merge as in Eimert's *Selecktion* (1959) in which spoken text was included (although it was manipulated beyond recognition, it still involved found sound).

"The first step to real musical control of nature has been taken by electronic music. Its dependence for reproduction on the loudspeaker - which moreover has brought about an as-yet-scarcely-noticed subterranean revolution in hearing- at last permits risking the hypothesis that the symphony fixed on disk or tape may be the *surrogate* and electronic music *the true music* . Here, we may surmise, is the point at which the true order of music is revealed."

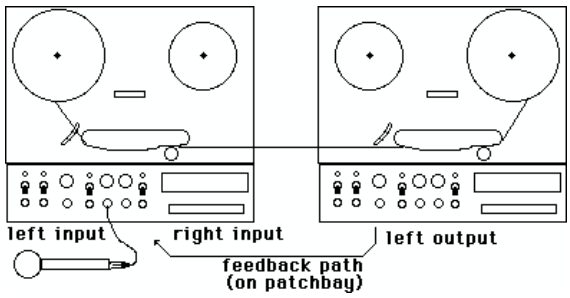
Tape Loops

The tape loop is a loop spliced end to its beginning. The tape must be kept in the proper relationship to the heads and cutoff sensor without benefit of the take-up or supply reels.

Tape Echo

Tape echo is developed by the distance between the record and play heads on a tape deck. The tape must take some time to travel this distance. Therefore, if you are listening to the tape as you are recording you hear the recorded sound a little later than the original.

Multiple echoes are achieved by using a mixer to combine some of the playback signal with whatever is being recorded. This is a feedback situation and care must be taken to see that echoes diminuendo as they come around rather than build up.



The most interesting applications of tape delay involve processing the feedback signal. This is simple to add, merely patch from output to input by way of some processing device. Now whatever that device does will be doubled for each echo, often with startling results. I leave the various possibilities to your experimentation.