## Electronic Music: A brief guide

Electronic music was born before 1945. Technology and aesthetics had already imagined a future where machines might produce music. This document outlines key stages in history, key composers and key pieces that have led to the integration of electronics in composition, performance and listening.

As we see today, the technology that we can access is something different to that which is used the theatre of war.

The development of the Radio and Radar were vital to our wartime successes. Knowledge and understanding eventually trickle to the public domain. Early Electronic Musical Instruments included the Theremin and the Ondes Martenot.

In August 1920 *Leon Theremin (Lev Termen) - (b St Petersburg, 15 Aug 1896; d Moscow, 3 Nov 1993)* demonstrated the aetherphone later called the Theremin. In 1927 Theremin arrived in New York. His first appearance was a private demonstration concert to guests including Joseph Szigeti, Arturo Toscanini and Sergei Rachmaninoff. Theremin sold the licence for manufacture to the Radio Corporation of America (RCA). Unfortunately, probably due to the technique required to make it sound 'musical', the device never really took on.

However, some decided to conquer the theremin. The first virtuoso theremin player was Clara Rockmore, a violinist who arrived from Russia in 1927. In 1938 Theremin was abducted by Soviet agents and lived in Moscow for the majority his life. (http://www.thereminworld.com/)

The theremin uses a "beat frequency oscillator" to combine the output from two radio frequency oscillators, a process known as.  One oscillator operates at a fixed frequency, which can be anything from 170,000 Hz to 282,000 Hz, depending on the theremin model in question. The Ondes Martenot works in a similar fashion. [Maurice Martenot (*b* Paris, 14 Oct 1898; *d* Clichy, nr Paris, 8 Oct 1980)]
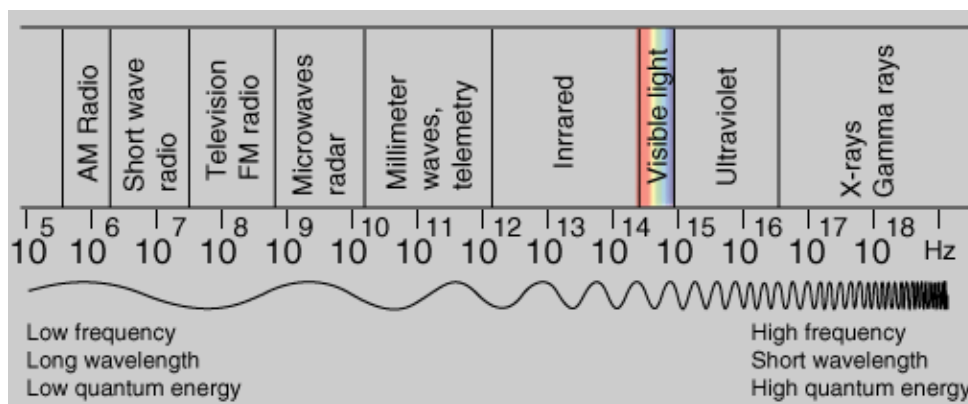
<u>A division along three Countries.</u>
*France* (particularly Paris) Musique Concrète (Pierre Schaeffer, Pierre Henry) but later IRCAM (Pierre Boulez)
*Germany* (particularly Cologne and Darmstadt) Elektronische Musik (Karlheinz Stockhausen)
Electronic Music in the *USA* (East and West coast flavours) (Babbitt, Cage, Subotnick, the Barrons).


<u>A division based upon technology</u>
Music made with tape machines + effects (USA 'music for magnetic tape')
Music made with voltage control synthesizers (Europe, GB – EMS with Zinovieff / USA: Robert Moog and Donald Buchla)
Music made with Computers (USA: Bell labs, Max Mathews and Jean-Claude Risset)
Today - Music made with computers live (laptronica/glitch); Music stored on fixed media (acousmatic); Music where the computer 'listens' to performers. Proliferation of genres.

<u>Precursors</u>
Satie - Parade (May 18th 1917: typewriters and sirens – incorporation of found sounds)
Respighi - Pines of Rome (1924: playback of a recording of nightingales.)
Cage - Imaginary landscape #1 (1939), RCA test records and variable speed turntables (live EA if you like). Imaginary Landscape #3 (1942) tin cans and oscillators, Imaginary landscpae #4 (1951) for 12 radios..the use of the readymade (after Marcel Duchamp).

<u>Texts</u>
Luigi Russolo's manifesto of March 11, 1913 *l'Arte dei Rumori* (The Art of Noises). Characterisation of noise: noise machines called *Intonarumori*.
Feruccio Busoni (1866-1924 also a great composer): *Sketch of a New Aesthetic* (1907) greatly influenced Varèse.
Francis Bacon (1624): *New Atlantis*. "we have also Sound-Houses, where we practise and demonstrate all Sounds".

<u>Edgard Varèse</u>
Equatorial (1934)
Déserts (1950-54 ) Premiered on 2nd December 1954. <u>The Musical Quarterly</u> > <u>Vol. 76, No. 4</u> (Winter, 1992), pp. 557-583
Poèm Électronique (1958)

Varèse, having moved to the United States in 1915 had not been easily accepted. After Density 21.5 (1936) – he produced nothing for 18 years. In 1953 Varèse received an Ampex tape recorder and with it he recorded iron mills, saw mills and other factory noises in Philadelphia and used them back at his house in Greenwhich, New York. In 1954 Varèse received an invitation to go to Radiodiffusion-Télévision Française (RTF) studios from Pierre Schaeffer to complete the tape parts of Déserts.

Varèse went back to New York in 1955 and returned to Europe in 1957 to work on the Poème électronique at the Philips laboratories in Eindhoven. This composition, for tape alone, was designed to fill Le Corbusier's pavilion for the Philips firm at the Brussels Exposition Universelle of 1958 and was played alongside Concrete PH by Xenakis.

*[project] History of magnetic tape. Part history of development and business that made machines and tape, part history of composers that used tape in ingenious ways (loops etc.), part what are people doing with tapes today (archiving them, BBC)?*

Pierre Schaeffer (1910-1995) and the GRM.

Names Studio d'Essai under German occupation1942 / Club d'Essai in 1946. the Groupe de Recherche de Musique Concrète (GRMC) in 1951 and finally Groupe de Recherches Musicales (GRM) in 1958.

*Cinq études de Bruits* (1948) - Concert de Bruits 1948 broadcast by RTF on 5 Octoer 1948. *Étude aux chemins de fer* - recordings from the Gare des Batignolles, Paris. Repetition of objects such as whistles and trains over joints in the tracks. Schaeffer's real interest was the acoustic properties of sound and how sounds entered the musical domain. He is perhaps best known for his Traité des objets musicaux TOM (Paris, 1966).

In 1952 Schaeffer produced a definitive syntax - 'Esquisse d'un solfège concret'. This appeared in the last section of a book 'Á la recherche d'une musique concrète'. Section 1 is a typology of 'objects sonores' along with some basic processes. Section II takes the definitions of objects sonores and aims to construct an operational language - the beginnings of musique concrète.

Pierre Henry (1927) was appointed to the Club in 1949 along with Jacque Poulilin - an engineer). *Symphonie pour un homme seul* (1950) was a ground breaking work. Longer, more sounds, mixing human sounds and a prepared piano. The rhythms are taken from the shape of spoken words or phrases. First performance - hall of the École Normale de Musique, Paris on 18 March 1949. Even in the 50s they had sound diffusion. The potentiomeètre d'espace worked in conjunction with a 5 channel recorder (4 channels fixed the fifth was moveable with this Theremin like device).

As Henry departed the studios, Luc Ferrari joined and they renamed themselves the GRM (1958). Iannis Xenakis was there at that time too. Many composers of note passed through the studios, even Boulez and Stockhausen. However, not all got along with Schaeffer.

| | |
|---|---|
| 1951 – P. Boulez in the studio | Etude I sur un Son |
| 1952 – "" | Etude II sur sept Sons |
| 1952 – Messiaen | Timbres-Durées (over 10 minutes long) |
| 1952 – Stockhausen | Etude |

In composing *Diamorphoses* (1957), Xenakis used the sounds of Jet engines, car crashes, earthquake shocks, textures of sliding pitches, and other noiselike sounds. Of Diamorphoses, Messiaen said, 'the preliminary calculations of these huge spider webs are transformed into a musical delight of the utmost poetic nature'. A surprisingly long work at over six minutes. *Concrete PH* (PH for Hyperbolic Paraboloids, the arch forms of the Philips Pavilion) used the sounds of burning charcoal, with varying density and register achieved by the overlays of tapes played at different speeds.

In composing Bohor in 1962, Xenakis used the sounds of bracelets, other jewellery and a mouth organ. This work comes in at a massive 20 minutes. Dedicated to Pierre Schaeffer (who hated the work).

*It is important to remember the primitive tools in use at the time and the level of dedication in terms of time and energy that composers had to have when working in the studio. Wax cylinders held around 4 minutes mono. Magnetic tape was at first mono only, then stereo. Multitrack tape appeared shortly after. Engineers made custom build machines such as the Phonogène and Morphophone utilising multiple echo heads.*

Pierre Henry was perhaps the more musical of the Schaeffer/Henry duo. A collaboration between Henry and choreographer Maurice Béjart began in 1954 with the *Concerto des ambiguités* and continued most notably with *Haut-Voltage* (1956), *Le voyage* (1962), *La reine verte* (1963), *Variations pour une porte et un soupir* (1963), *Messe pour le temps présent* (1967 – with Michel Colombier) and *Nijinsky, clown de Dieu* (1971). Henry was, and remains a prolific producer of concert and incidental music. *Variations pour une Porte et un Soupir* (1963) example (GRMCD), "recording a door in a way that there was a form to the sound, a grain, a colour, like an instrument, and the rest was the sound of a sigh, a breath, - there was no transposition, no treatment, it was only montage and a little bit of mixing".

Michel Chion has compared Henry's huge catalogue (over 150 works) to the torrential output of Victor Hugo, from whom Henry borrowed several thousand lines of verse of Dieu and to whom he dedicated his Hugosymphonie (1985). According to Chion, Henry's outstanding qualities are 'fecundity, forcefulness and a wide-ranging palette, an impeccable and sumptuous technique and a taste for excess and the bold mingling of the grotesque and the sublime'. The length of his works at first seems forbidding, they need time and space to unfold and reveal their secrets; he has written few short or medium-length pieces.

In 1960 François Bayle joined the GRM Team. As Schaeffer moved more towards the writing of his Traité des Objects Musicaux (1966) so Bayle became the administrator of the GRM.

Working at the GRM at roughly the same time was an engineer by the name of Bernard Parmegiani. His direct, hands-on approach to musical sound sculpture has influenced many electronic music composers of the 20th and 21st centuries.

Portions of two of his key works, *De Natura Sonorum* and *Dedans Dehors* can be located at http://adrian-moore.staff.shef.ac.uk/teaching/mus355/repository/mp3list.html (username = music, password = usss)

Programme notes and spectral plots of the movements for Dedans Dehors are available http://adrian-moore.staff.shef.ac.uk/teaching/mus355/repository/dedans-dehors.html The spectral plots show time along the x-axis, frequency content along the y-axis and intensity as pixel density.

The Cologne studios

Stockhausen's (1928-2007) intro into sound was at an offshoot of the Club d'Essai. Timbral analyses of glass, wood and metal sounds and other exotic instruments. Then he too began work on a concrète étude (1952).. He wrote to Goeyvaerts that he wanted to make a "sound-atom". Concrete Etude – six different timbres obtained from damping piano strings and then cut at a fixed length into the attack (to loose the action noise of the piano). Thus the piece was a permutation of timbres and duration.

Key figures at the beginnings of the studios were:
1948: Dr. Werner Meyer-Eppler, director of the department of Phonetics at Bonn University.
Homer Dudley, a researcher at Bell Telephone Labs, New Jersey, USA demonstrating the Vocoder (Voice Operated reCOrDER).
1950: Herbert Eimert (1897 - 1972)
1952: Robert Beyer (1901-1989) who made Klangstudie II (1952) in the studios.

The aesthetic was lead by Eimert who saw Elektronische Musik as an extension of serialism.

1.      demonstrate the analysis and synthesis of timbres:...
2.      establish finely graduated scales between tone and noise
3.      demonstrate the unity of musical time by creating graduated transitions between pitch and rhythm
4.      use differentiated scales of loudness and reverberation to create a multi-layered spatial perspective.

1953: Stockhausen made his Elektronische Studie I.
Sounds being built up from first principles (Fourier after Helmholz). Equipment resource consisted of a sine wave generator, a white noise generator, a melocord, and a monochord (a modified Trautonium built by Trautwein). Most people (including KS) preferred to use the sine wave generator and a multitrack tape recorder.

*Studie I* "pure, controllable sounds determined in every aspect by a consistent series of proportions".

<u>Technique</u>
1920Hz multiplied by a ratios: 12/5, 4/5, 8/5, 5/12, 5/4
(descending minor tenth, rising major third, descending minor sixth, rising minor tenth, falling major third). This process is then repeated on the result. The tones were then grouped together using the following row:

4 5 3 6 2 1.

1920 800 1000 625 1500 1200
800 333 417 260 625 500
1000 417 521 325 781 625
625 260 325 203 488 390
1500 625 781 488 1170 937
1200 500 625 390 937 750

800 333 417 260 625 500
333 138 173 108 260 208
417 173 217 135 325 260

(Manning, 1995, 51)

The mixtures of the sounds are not specifically inharmonic as they are based upon natural ratios but do give bell like sounds. Volume: a series of volume mappings was used, each time a frequency was repeated it was given a different volume through a rotation series. The notes from the table are used 6 times throughout the piece but each note will at some stage be the loudest constituent. Each group of notes also has maximum amplitude scale based upon the series 3 4 2 1 6 5 which regulates the volume of individual notes. Also affecting amplitude is a sequence of envelope curves ($<$ $>$ none, with, without reverberation).

Duration was proportional to frequency / 10 with 1920hz being the base frequency. (So low frequencies were short).

*Studie II* 1954

This time frequencies occupied an un-tempered but constant range 1: 25th root of 5 starting from 100 hz. Pitch complexes were looped and reverberated to create longer or shorter complex sound tails which could be reversed or superposed one on the other to create even larger events. Studie II divides into 5 sections. The studio now offered composers the opportunity to work with additive synthesis (with basic effects) and subtractive synthesis. Subtractive synthesis takes noise (full band width, or slightly coloured) and uses filters to shape timbre. (see Manning, p58)

The first batch of partials consists of frequency bundle 67 - 690, 952, 1310, 1810, 2500 - marked by lines and shading in between on the score. Each partial has the same

amplitude. Five variants of mixtures were used (with constant intervals of 1, 2, 3, 4,or 5 * 25th root of 5).

The first group of the series ranges from 100 hz and uses 1*, 2*, 3*, 4*, 5*
The first group of the piece (group 67) uses 5* (i.e. 1*, 5*, 10*, 15*, 20*)

(Max patch to demonstrate)

December 1954 saw the German premiere of Déserts and it seemed clear that Stockhausen admired Varèse and his work.

Stockhausen's key tape piece of the 50s was *Gesang der Jünglinge* (1955-6): electronic music to Daniel 3 - vs 57-66. [The three men, Shadrach, Meshach and Abednego were thrown in to the furnace after refusing to celebrate false images]. Due to time constraints (remember electronic music took inordinate amounts of time) and the fact that approaches to the Church for an electronic mass had met with blank stares, something which must not have impressed Stockhausen as he was a devout man, Stockhausen began work on Gesang.

Deliberate and very rigorous organisation of material exploring continua of timbre and speech.

Categories of sound elements (stockhausen, maconie)

1.    SK - pulsed sine
2.    IK - pulsed filtered noise
3.    LS - sounds and syllables
4.    R - noises filtered to about 2% wide [f], [s], [sh]
5.    I - single impulses [t], [b], [k], [g]
6.    SV - synthesized vowel sounds
7.    RO - broadband filtered noise
8.    IO - pulsed complexes
9.    IA - single impulses in chords
10.   RA - chords of 2% bandwidth filtered noise
11.   S(A) - sine-tone chords
12.   GA - sung chords

One of the first multi-channel playback pieces. It is interesting to note that the boy sang after listening to prepared tapes.

Also: György Ligeti (1923-2006), Glissandi (1957) sinusoidal sounds and filtered noise leading to Artikulation (1958). Listening score by Rainer Wehinger. There's an interesting story of Ligeti escaping Hungary and staying with Stockhausen for a few weeks. *The Musical Times*, Vol. 130, No. 1759. (Sep., 1989), pp. 532-535.

<u>Meanwhile: An Italian in Cologne.</u>
Music for instrument and tape. The earliest example: The construction of the Cologne studio began in 1951/1952. Bruno Maderna worked with Meyer-Eppler in Bonn (Institute of Phonetics, University of Bonn) and composed *Musica su Due Dimensioni*, (1952) example for flute, percussion and tape which was performed that summer at Darmstadt to an audience that included Pierre Boulez, Gottfried Michael Koenig, Karel Goeyvaerts and Karlheinz Stockhausen.

<u>Italy</u>
Berio had been in the States for the first concert to include electronic music at the Museam of Modern Art (New York) on 28 October 1952 . He returned from the US and met with Maderna in Milan in 1953. In 1955 the Studio di Fonologia Musicale at RAI (Radio Audizioni Italianne) was created (in Milan). Berio and Maderna composed *Ritrato di Cittá*. *Ritratto di Cittá* was a sound portrait of Milan during the course of a day, with a text by Roberto Leydi – a very early example of radiophonics. One of Berio's preoccupations was the voice. His first important piece at the Milan studios was *Thema – Omaggio a Joyce* (1958). Working with Umberto Eco looking through Joyce's Ulysses. The text was recited by Cathy Berberian.

Luigi Nono. Nono is best known in electronic music for his political work, *La Fabbrica Illumanata* (1964, The illuminated Factory) spotlighting the plight of factory workers. (with sounds from a steel plant in Genova). From 1956, he and Maderna began to plan concert series devoted primarily to contemporary music under the title Incontri Musicali. [common threads: composers working out of radio stations, composers also organising concert series – n.b. The Domaine Musicale]

<u>Back to Stockhausen</u>
1959-60: *Kontakte* (electronic and version for piano, percussion and electronics)
1964: *Mikrophonie I* for tam-tam and six players
Stockhausen experimented with the Momente (1962-4) tam-tam, 'exciting' the tam-tam with different objects (mainly from the Stockhausen kitchen) – two teams of players stand either side of the tam-tam. Player 1 'excites' the tam-tam. Player 2 uses the microphone to closely monitor what is going on. Player 3 operates the filter. The work is composed in 33 moments organised by a 'connection scheme'.
1964-7: *Mixtur* for five orchestral groups, 4 ring modulators and sine-wave generators. *See www.stockhausen.org/mixtur.html*
1965: *Mikrophonie II* for choir (6 sop, 6 bass), Hammond organ, 4 ring modulators and tape. The four mics and the outputs of the hammond organ are connected to the ring modulators thus fusing their signals.
1970: *Mantra* for two pianists, short-wave radio receivers, Ring modulators + tone generators, Chinese woodblocks, antique cymbals. "I was sitting next to the driver, and I just let my imagination completely loose. I was humming to myself…I hear this melody - it all came very quickly together: I had the idea of one single musical figure or formula

that would be expanded over a very long period of time, and by that I meant fifty or sixty minutes. And these notes were the centres around which I'd continually present the same formula in a smaller form ….I wrote this melody down on an envelope"

Hymnen 1966-7 (1969)
Hymnen mit soloisten.
Hymnen mit soloisten und orchestra
Focusing upon the idea of nationality by recontextualising national anthems. A return to "sampled" sound.

Hymnen falls into four regions: Each region has a number of centres
Region 1: Internationale and Marseillaise (dedicated to Boulez)
Region 2: German National anthem, African anthems mixed with the opening of the Russian anthem and a subjective centre (it's a piece of music but it suddenly jumps out of performance and into a studio conversation). This is the ego taking over. (Dedicated to Henri Pousseur)
Region 3: Russian anthem, American anthem, Spanish anthem. (Dedicated to Cage)
Region 4: Double centre of Swiss and the "utopian realm of Hymunion in Harmondie under Pluramon". (Dedicated to Berio)

1966: *Telemusik* (electronic music)
Stockhausen was director of WDR from 1962 to 1980. The creative studios were well equipped during this period. The piece comprises 32 moments with durations determined from a fibonacci series between 13 and 144 seconds. A 6 channel tape machine at NHK (Nippon Houso Kyokai / Japanese broadcasting corporation) was used. RING MODULATION. Each moment announced by the sound of a Japanese ceremonial drum or gong: *bokusho* / *taku* beats for shorter sections, *rin* or *keisu* sounds for longer moments with the sound also of the *mokugio* drum from time to time (every sixth section from section 3). Recordings from Bali, Japan, Vietnam, Hungary, Spain, Russia, The Amazon, The Sahara, and Brazil.

Keisu – 11 and 22  - dividing the work into 3 large sections
Rin – 8, 16, 24
Mokugio – 3,9,15,21,27
Bokusho 8 sections starting with 1
Taku 12 sections starting with 2
Section 31 has a chorus of temple bells and stands out from the rest.

**At the Todai-Ji temple in Nara, Japan 1966**


**The Denshi Ongaku Studio for electronic music at the Japanese Radio 1966**

**AMERICA**

The early history of American electronic and computer music sees the rise of large foundations (Guggenheim/Rockefeller), academic institutions (Princeton/Columbia) and the RCA (Radio Corp of America). Later history sees the rise of DIY inventors (Moog and Buchla) working on Voltage control analogue synthesis and a number of other synthesizer manufacturers. American electronic and computer music also divided itself stylistically between those working on the East-coast (NY etc.) and those on the West-coast (California, San Diego)

Columbia University in New York City became interested in electronic music. Vladimir Ussachevsky (1911-1990) wrote his *Wireless Fantasy* in 1960. Ussachevsky was one of the first American electronic music pioneers. Ussachevsky and Otto Leuning (1900-1996) music, *low-speed* (1952) moved their studio from Ussachevsky's living room into University accommodation. Milton Babbitt began work at Princeton. In January 1959 the Columbia – Princeton Electronic Music Center (containing a Mark II RCA synthesizer) was established. (for a picture see Manning)

Louis and Bebe Barron founded a personal studio. Working as early as 1948 with taped sounds they hit fame (but not fortune) in 1956 when they made the film score for Forbidden Planet. They worked with John Cage (1912 -1992) in 1951 where the *Project for Music for Magnetic Tape* was initiated. They worked on the first *Williams Mix* recording 600 sounds. The cutting and splicing for Williams Mix was finished in late 1952.
Williams Mix comprises:
a. City sounds
b. Country sounds
c. Electronic sounds
d. Manually produced sounds including normal music
e. Wind produced sounds including voice
f. Small sounds requiring amplification to be heard.

C indicated control and predictability
V described lack of control or unpredictability
C and V applied to pitch, timbre and loudness.
Therefore B v c v = country uncontrolled pitch, known timbre, uncontrolled loudness.

Cage selected materials using chance procedures (dice, coins etc).
Others working with Cage on ' music for magnetic tape' were Feldman, Brown, Tudor and Wolff. Similar technical processes to that of musique concrète and elektronische musik but aesthetically bound around Cage's ideas of indeterminacy.

The project terminated in 1953. After Cage visited Milan in 1959 he worked consistently with David Tudor and began to use electronics in live performance especially in collaboration with choreographer Merce Cunningham.

<u>Synthesizers</u>

Key dates.
1949 Robert Moog began building Theremins.
1959 saw the establishment of the San Francisco Tape Music Center, under the direction of Ramon Sender and Morton Subotnick.
1962 saw the arrival of Donald Buchla at  the San Francisco Tape Music Center.
Buchla designed a synthesizer for Morton Subotnick and Ramon Sender. Buchla included an idea for a sequencer (stored voltages that automated events: see Manning).
Subotnick and Buchla made an application to the Rockerfeller foundation for $500 and a 16 step sequencer with touch sensitive keyboard was built. Their work together was to produce the series 100. Subotnick received commissions from Nonesuch Records – for *Silver Apples of the Moon* (1967), *The Wild Bull* (1968) and *Touch* (1969). All were completed on the Buchla.

Musical Example: *Silver apples of the moon.* A mechanical landscape: Sequencers, gates, sample-and-hold circuits. Part II focuses more upon repeating gestures using sequences of 8 or 16 notes. The title of the work comes from a poem by Yeats.

<u>Bell Laboratories and the development of Music N languages.</u>

June 1955 Ussachevsky and Luening received $10,000 from the Rockefeller foundation funded through Barnard College to investigate the state of studio facilities at home and abroad. Amongst many interesting new developing studios, Ussachevsky and Luening discovered research taking place at Bell Telephone laboratories, New Jersey into computer analysis and (re)synthesis of sounds. The work at Bell Telephone Laboratories proved to be unique. Key figures at that time included Max Mathews and John Pierce. In 1957 Mathews finished MUSIC 1 (computer program). The first piece produced with MUSIC 1 was a 17 second composition by Newman Guttman called *The Silver Scale* (1957). Mathews described it as "terrible".

With revisions of the software the Music N languages developed. Music III used the instrument idea and the concept of score and orchestra which is still in use today in the well known package, Csound.

Music IV was finished – in 1962.
Jean-Claude Risset was doing graduate work in physics at the Ecole Normale Supérieure in Paris but received money to work at Bell in 1964 as research composer in residence. His research investigated instrument tones and he created an introductory catalogue of computer synthesized sounds - Risset, 1969

John Chowning got hold of a copy of the MUSIC IV cards.
"The sounds we could make with a computer at that time were unbearably dull, not because we couldn't do better but we didn't know a lot. So in 1967, with ears starved for some sound that had the richness of the sounds we hear in nature, I was experimenting with extreme vibrato. I realized that as I increased the rate and depth of a vibrato, I was no longer hearing it as a change in pitch, but rather as a change in timbre. It was a kind of frequency modulation" (MSP example)

1971: Chowning hit on the FM theory for good. But few were interested. "The office of licensing contacted Yamaha, and Yamaha sent an engineer. I played some examples, and in ten minutes he understood." The DX7 was the result.

Steve Reich
More on Reich under Minimalism.
*It's Gonna Rain* 1965
*Come Out* 1966 led to the phase pieces *Violin Phase* and *Piano Phase* 1967

## IRCAM

(see www.ircam.fr for details on the history over and above the following: In 1969 Jean Claude Risset moved back to France and met with Boulez who wanted him to head up the computer department of the newly formed IRCAM. IRCAM opened its doors officially in 1977. There were 5 departments: computer department (JCR), instrumental performance (Vinko Globokar), electronic music department (Berio), pedagogy (Michel Decoust) diagonal department (which intersected all departments, headed by Gerald Bennett).

Boulez, Répons and the 4X.

In Italy in the mid-1960, Giuseppe Di Giugno was teaching physics at the University of Naples. He became interested in electronic music. Di Giugno met Berio at IRCAM and they began work on the 4A (1975). Di Giugno worked with Hal Alles (another engineer) to make the 4B, then the 4C (which was more programmable). Finally in 1980 the 4X came into existence and the first early performance of Boulez' Répons.

Others utilised it in a less significant way: Luciano Berio, Philippe Manoury, Pierre Henry, François Bayle, Denis Lorrain, George Benjamin, Marco Stroppa. Marc Battier and Cort Lippe were IRCAM tutors.

The 4X cost $100,000.

In 1985 Miller Puckette arrived at IRCAM and worked on 4X related software with Philippe Manoury. Manoury's works included *Jupiter* (1987), a work that 'listened' to the realtime flute sounds and scheduled appropriate triggers as the machine 'followed' the score. Puckette needed a realtime scheduler. "I used ideas that I had learned from Max Mathews and so I ended up calling the program MAX". Puckette and David Ziccarelli ended up writing the basis of the well known software MaxMSP.

At first, the Macintosh provided the MIDI and hooked into the 4X. Then the interface became increasingly more significant. When Ziccarelli and Puckette parted company, Ziccarelli formed cycling74.com. (Max/MSP is commercial software) and Puckette continues to teach at the University of California, San Diego. (http://crca.ucsd.edu/~msp/)

However the key work that used computers in live music was Répons by Boulez.

Répons (1981-1984)

Répons was begun in 1980: a reworking of the percussive vs. sustaining instruments of Eclat/multiples with the electronics taking over the role of trills for example by using complicated delay mechanisms. Répons was dedicated to Alfred Schlee (the former director of Universal Edition) but contains a hidden reference to Paul Sacher (1906 – 1999) a well known contributor to the arts.

*        – Soloists number six: piano 1, piano 2 (organ), harp, cimbalom, xylophone(glockenspiel), vibraphone (in this version
*        – a 24 piece ensemble: two flutes, two oboes, two clarinets, bass clarinet, two bassoons, two horns, two trumpets, two trombones, tuba, three violins, two violas, two cellos and double bass.
*        – Computer and six loudspeakers.

Répons is

*        - a dialogue between soloists and ensemble
*        - a dialogue between the soloists themselves
*        - a dialogue between different types of material

Répons is

*        Version 1 - 17 minutes long
*        Version 2 - 35 minutes long
*        Version 3 - 45 minutes long

Répons demands huge quantities of gear. The 4X demanded a 32Tonne truck and a team of operators/technicians.

The space is divided amongst the soloists and the loudspeakers with the ensemble in the middle and the audience in the spaces in between.



Diagram of the sound projection in *Répons*

The 4X and a PDP11/55 do most of the work and are controlled by an assistant. The PDP11 gave instructions to the 4X. (This is all handled within MAX now - and it is rumoured that the electronics for Répons can now be run off Max/MSP).

The soloists are transformed by ring modulation. There are numerous delays and consequently arpeggios are created. There is also a kind of frequency shifting (somewhat like ring-modulation but this allows Boulez to 'map' one input note to many others (in a complex series). In addition each soloist has a tape recorder and pre-recorded tape with which to "play". The player plays the tape and then his instrumental gestures – particularly volume – control what comes out of the tape).

[For more details see Gerzso: Contemporary Music Review Vol.1]

Other Boulez works that utilise the IRCAM software: *Anthemes 2* (1997) and *...explosante fixe...*(1991-93)

Philippe Manoury (1952) is also important. His works include *Jupiter* (flute and electronics), *Pluton* (piano and electronics). *La Partition du ciel et de l'enfer* for ensemble and computer (1989) and *Neptune*, for 3 percussionists and computer (1991). One of his most recent works at IRCAM is *En écho* for voice and computer. Research for this project lead to an opera called *60e Parallèle* (see Naxos)

From the cycling74 questions and answers page

*Where did Max/MSP come from?*

*Max was first developed for the Macintosh in the mid-1980s at IRCAM by Miller Puckette. In 1989, IRCAM started work on a real-time synthesizer card for the NeXT computer produced by Ariel called the IRCAM Signal Processing Workstation (ISPW). Puckette ported Max to the NeXT and ISPW and added a set of objects to do audio on the card. Max combined with the audio was known as Max/FTS and was widely used at IRCAM and about 30 other centers and individual studios around the world. A single card with two processors was about $12,000, not including the computer.*

*In 1996, Miller Puckette, now at the University of California San Diego, began developing a new program, Pd or Pure Data, aimed at the new generation of powerful microprocessors. The goals of Pd are different than Max/FTS, but it shares the ability to do real-time signal processing by connecting Max objects together. Initially developed on the SGI platform, Pd is now being ported to Windows NT. Shortly after Pd was started, David Zicarelli decided to add audio processing for PowerPC computers to the existing Opcode Max environment. Max/MSP is the result. It uses the Pd signal processing infrastructure, and adds features inspired by Max/FTS but not yet implemented in Pd, along with new innovations and user-interface enhancements appropriate for the Opcode Max environment.*

[project] IRCAM 30 years of music and technology, performance and pedagogy, research and production.

An overview of IRCAM composers such as Georges Benjamin, Marco Stroppa (now head of WDR in Germany, after Stockhausen), Tristan Murail, Philippe Manoury, Emmanuel Nunes, Kaija Saariaho, Pierre Boulez, Jonathan Harvey, Magnus Lindberg and others should give you a good idea of not only how instrumental music has changed but, how electronics has helped it change (whilst keeping it - relatively - accessible).

## Synthesizers

Voltage control enabled the development of the keyboard to control oscillators. Now oscillators could control oscillators. Then we see the development of the sequencer (stored voltages access sequentially). Key composers in the UK include the wonderful Daphne Oram (1925-2003) and Delia Derbyshire (1937-2001).

1966 Peter Zinovieff was working in London. Influenced by Moog, Zinovieff and Tristram Cary began to collaborate. (see Chadabe p.150 for an anecdote). They booked the QEH for a date in January 1968. To make ends meet Zinovieff formed EMS Ltd. From a bequest they made the cheap VCS-1, the expansion of which became the VCS-3. Then came the Synthi A and the Synthi 100 http://www.ems-synthi.demon.co.uk/ gives you an idea of current retail value.

The EMS firm employed over 40 people at that time. At their studio composers such as Cary, Harvey and Hans Werner Henze worked for a time. HWH made Glass Music (1970), Prison Song (1971) and Tristan (1973). Also Birtwistle. His works included Four Interludes (1969), Medusa (1970), Signals (1970), Chronometer (1971) Orpheus (1976). Pink Floyd used a VCS3 in Dark Side of the Moon. Brian Eno was also a key user.

Monophony to Polyphony

The 'Four Voice' engineered by Tom Oberheim was one of the best early polyphonic synths. Oberheim had started in early 1960s. In 1976 he designed the OB-1 with more programmability. Dave Smith designed the Prophet 5 in 1978. He too was a hobbyist working in Silicon Valley. By 1974 he had formed Sequential Circuits. The Prophet 5 - 'real synthesizer' had, by 1983 sold more than 8,000 units.

Realtime
At bell labs, Music V was the primary means of music creation (and this involved tonnes of punched cardboard being transported to machines that then produced code that then produced sound and which eventually produced something audible – at which point, the composer repeated the process!). In 1967 however, Max Mathews and F.R. Moore developed GROOVE (Generated Realtime Operations on Voltage-Controlled Equipment).

The development of the computer

1.    first-generation computers based on valve technology (very big and hot)
2.    second-generation computers based on transistor technology and
3.    third-generation computers based on integrated circuits.

Examples
Early microcomputers such as IBM, Commodore, Atari, ZX Spectrum etc.
Apple II based on a 6502 processor.
Atari produced the 400 and 800 series.
In 1979 Intel produced the 16bit 8086 and Motorola produced the 68000.
In 1981 IBM entered the PC market.

Back to synths
In 1975 John Appleton, Sydney Alonso, and Cameron Jones were working at Dartmouth College, New Hampshire. In 1976 the New England Digital Corporation was established to manufacture the system, known as the Synclavier.

There was one rival for the Synclavier: it was called the Fairlight.

Two Australians, Peter Vogel and Kim Ryrie, made a prototype audio processor called the QASAR M8, completed in 1978 leading in turn to a synthesizer known as the Fairlight Computer Music Instrument or CMI in 1979.

MIDI

Synth manufacturers needed to find a way for their machines to communicate with each other. Through a number of meetings at National Association of Music Merchants (NAMM) trade fairs. The four Japanese heavies: Roland, Yamaha, Korg and Kawai, plus Oberheim and Sequential Circuits. The first machines to ship with MIDI 1.0 arrived in 1983. The DX7 arrived in 1983 at <$2,000!

This was synthesis – composers required the power of analogue tape so the race was on to produce the first sampler. In 1981, E-Mu produced the Emulator 1. Even though the Fairlight could sample sounds it was very expensive machine. The Emulator had 8 bit A-D and D-A converters, and a sampling rate of 30kHz. With 120kilobytes (yes 120k) memory that gave you 4 seconds of sound at maximum fidelity!!! The Fairlight CMI (Computer Music Instrument) sold for about $25,000 when it was first introduced in 1980.

1970s, Ikutaro Kakehashi formed Roland. In the 1960s Ikutaro was building organs in the style of Hammond (first developed in the 1930s)

Computers

In 1982, Karl Stienberg was working as a sound engineer at Delta Studio near Hamburg. He met Manfred Rürup. They formed Steinberg in 1983. Because Steinberg was not a professional programmer he put all the information on one page. Music Software has retained much of this 'grand interface' ever since. Cubase was released on the Atari and Macintosh in 1989 and the PC version came out in 1992.

Bear in mind that MIDI is just an instruction (such as 'a piano key has been pressed at middle C') to a synthesizer or sampler.

However, it wasn't long before people could not only edit MIDI on their home computers, but audio. In 1983, Peter Gotcher and Evan Brooks formed Digidesign and began by selling drum chips for Linn, Oberhiem Simmons and Emu. In 1985, when the Macintosh became available, they developed Sound Designer, the first commercial digital audio editor. Digidesign is now owned by Avid and is 'industry standard'.

New instruments
Of those people who design new instruments, some of the best work is being done in Amsterdam at STEIM (http://www.steim.nl). Key figure, Michel Waisvisz. A British composer who had good links with STEIM in the early 90s was Walter Fabek (with his chromasone) and Jonathan Impet (working to produce a meta trumpet). Games manufacturers found themselves inadvertently making musical instruments too: Mattel Toys invented the PowerGlove and the joystick is a device that has great potential.

Concepts
Alvin Lucier's I am sitting in a Room.(1969)
Steve Reich's It's Gonna Rain (1965)
Acousatic Ecology and soundscape composition. The work of Murray Shafer, first in
Montreal then in Vancouver at Simon Fraser University.

In the rock and popular music world.
Wendy (nee Walter) Carlos - Switched on Bach (1968) and the Well Tempered
Synthesizer. Carlos who went on to play the original music to A Clockwork Orange.

Isao Tomita - esp *Snowflakes are dancing* (1974) based upon the piano works of
Debussy.
Emerson , Lake and Palmer - Pictures at an Exhibition (1971)
Beach Boys - *Good Vibrations* (1966) - use of Theremin.
Beatles - simple tape loops and reversed playback of recordings in *I'm only Sleeping* and
*Tomorrow Never Knows* from *Revolver* (1967).
More elaborate tape transformations in Sgt. Pepper's Lonely Hearts Club Band (1967).
Yes - Rick Wakeman on keyboards
Tangerine Dream, Pink Floyd … and many others.


NOW:UK
Jonathan Harvey *Mortuos Plango, Vivos Voco* (1980) composed at IRCAM using cross
synthesis. (see Emmerson for an in depth article).Then *Bhakti* (1982) and finally Ritual
Melodies (1990).
Denis Smalley – early studies with Messiaen and at the GRM in Paris. Works included
Pentes (1974) Gradual (1974), Vortex (1982), Tides (1984), Wind Chimes (1987), Valley
Flow (1992).

Sound diffusion systems included at GMEB in 1973 with Clozier and Barrière, the
Gmebaphone.  Then BEAST with Jonty Harrison. In York – Trevor Wishart began to
develop the composers desktop project with (A. Bently, R, Orton and others).

See http://adrian-moore.staff.shef.ac.uk/teaching/mus355/repository/mp3list.html for
examples of key works by UK based composers (Harvey, Harrison, Smalley)

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Prentice-hall.

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