120 Years

of Electronic Music

Electronic Musical Instruments 1870 - 1990

1870

1900

1930

1940

1950

1960

1980

Introduction

120 Years Of Electronic Music (update v3.0)
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.
Work currently (2004) in progress is a section documenting audio synthesis software from 1950 to 2004
'120 Years Of Electronic Music' is an ongoing project and the site will be updated on a regular basis. Most of the sections have been updated in this revision and a links page and bibliography have been added.
Please send your comments, complaints, suggestions and information to the author: Simon Crab

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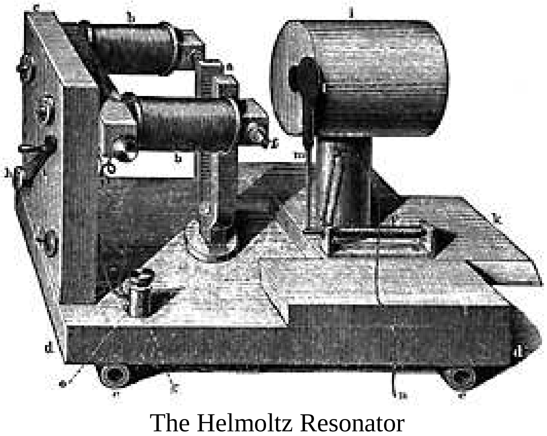
'120 Years Of Electronic Music' A Condensed History



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 'Sphäraphon' (1921) the 'Pianorad' (1926). The Vacuum tube was to remain the primary type of audio synthesis until the invention of the integrated circuit in the 1960'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.

Elisha Gray and "The Musical Telegraph" (1876)

fig. 1: Elisha Gray

Elisha Gray (born in Barnesville, Ohio, on Aug. 2, 1835, died Newtonville, Mass., on Jan. 21, 1901) would have been known to us as the inventor of the telephone if Alexander Graham bell hadn't got to the patent office one hour before him. Instead, he goes down in history as the accidental creator of one of the first electronic musical instruments - a chance by-product of his telephone technology.

Gray accidentally dicovered that he could control sound from a self vibrating electromagnetic circuit and in doing so invented a basic single note oscillator. The 'Musical Telegraph' used steel reeds whose oscillations were created and transmitted , over a telephone line, by electromagnets. Gray also built a simple loudspeaker device in later models consisting of a vibrating diaphragm in a magnetic field to make the oscillator audible.

After many years of litigation, A. G. Bell was legally named the inventor of the telephone and in 1872, Gray founded the Western Electric Manufacturing Company, parent firm of the present Western Electric Company. Two years later he retired to continue independent research and invention and to teach at Oberlin College.

fig. 2 Elisha Gray's Musical Telegraph of 1876

Elisha Gray's first "musical telegraph" or "harmonic telegraph" contained enough single-tone oscillators to play two octaves and later models were equipped with a simple tone wheel control. Gray took the instrument on tour with him in 1874. Alexander Graham Bell also designed an experimental ' Electric Harp' for speach transmission over a telephone line using similar technology to Gray's.

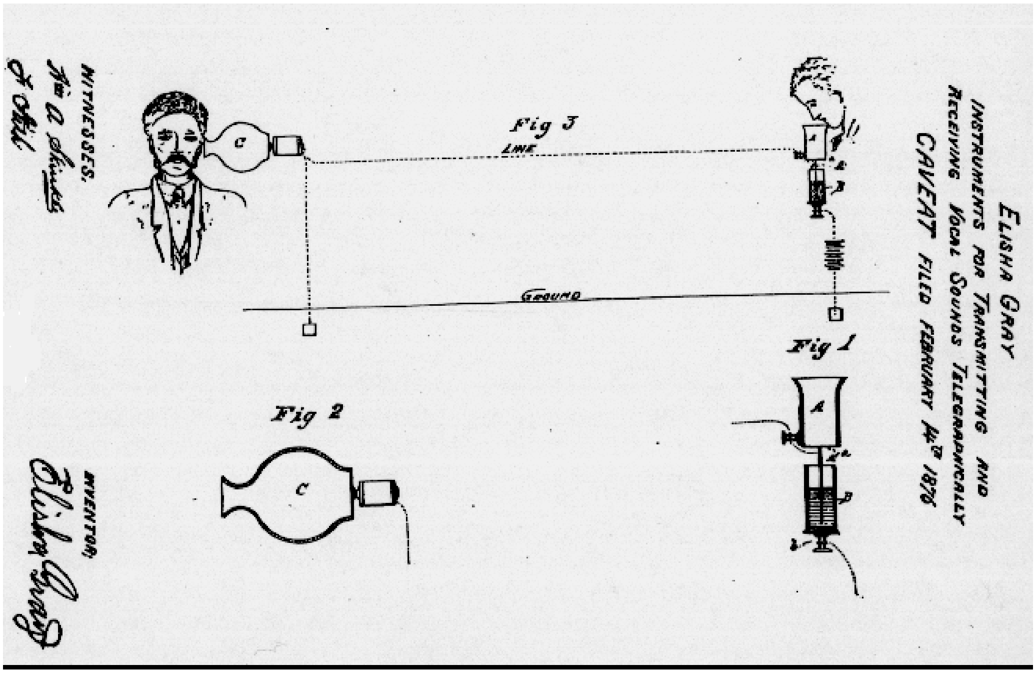


fig. 3 Gray's drawing for the patent of a method for "transmitting vocal sounds telegraphically"

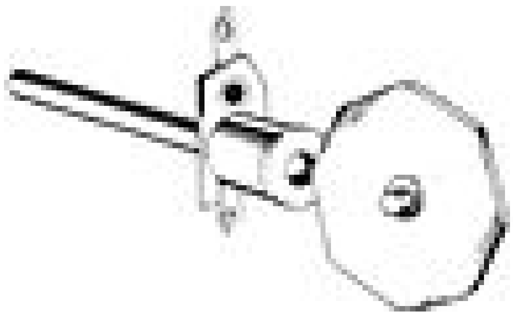
William Du Bois Duddell and the "Singing Arc" (1899)

fig. 4 A carbon arc streetlamp of the type used in Victorian Britain

Before Thomas Alva Edison invented the electric light bulb electric street lighting was in wide use in Europe. A carbon arc lamp provided light by creating a spark between two carbon nodes. The problem with this method of lighting, apart from the dullness of the light and inneficient use of electricity was a constant humming noise from the arc. The British physicist William Duddell was appointed to solve the problem in London in 1899 and during his experiments found that by varying the voltage supplied to the lamps he could create controllable audible frequencies.

By attaching a keyboard to the arc lamps he created one of the first electronic instruments and the first electronic instrument that was audible without using the telephone system as an amplifier/speaker. When Duddell exhibited his invention to the London institution of Electrical Engineers it was noticed that arc lamps on the same circuit in other buildings also played music from Duddell's machine this generated speculation that music deliverd over the lighting network could be created. Duddell didn't capitalise on his discovery and didn't even file a patent for his instrument.

Duddell toured the country with his invention which unfortunately never became more than a novelty. It was later recognised that if an antena was attached to the singing arc and made to 'sing' at radio frequencies rather than audio it could be used a continuous radio wave transmitter. The carbon arc lamp's audio capabilities was also used by Thadeus Cahill during his public demonstrations of his Telharmonium ten years later.



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Thaddeus Cahill's “Dynamophone/Telharmonium” (1897)

fig. 5 Thaddeus Cahill

In 1897 Thaddeus Cahill (born: Mount Zion,Iowa 1867, died New York City 1934) patented (pat no 580,035) what was to become the "Telharmonium" or "Dynamophone" which can be considered the first significant electronic musical instrument . The first fully completed model was presented to the public in 1906 in Holyoke, Mass.

The Telharmonium was essentially a collection of 145 modified dynamos employing a number of specially geared shafts and associated inductors to produce alternating currents of different audio frequencies. These signals were controlled by a multiple set of polyphonic velocity sensitive keyboards (of seven octaves, 36 notes per octave tuneable to frequencies between 40-4000Hz) and associated banks of controls.

The resulting sound was audible via acoustic horns built from piano soundboards in the early models, later models were linked directly to the telephone network or to a series of telephone receivers fitted with special acoustic horns - this was the only way to amplify the sound in this preamplifier era (Cahill's invention had predated the invention of amplifiers by 20 years). The Telharmonium supplied 1 amp of power to each telephone receiver on the network this was much more than the telephone itself but was enough to be able to hear the music without lifting the receiver speaker to the ear however this also masked and disrupted any other signal on the line. The instrument was usually played by two musicians (4 hands) and reproduced "respectable" music of the time: Bach, Chopin, Grieg, Rossinni etc.

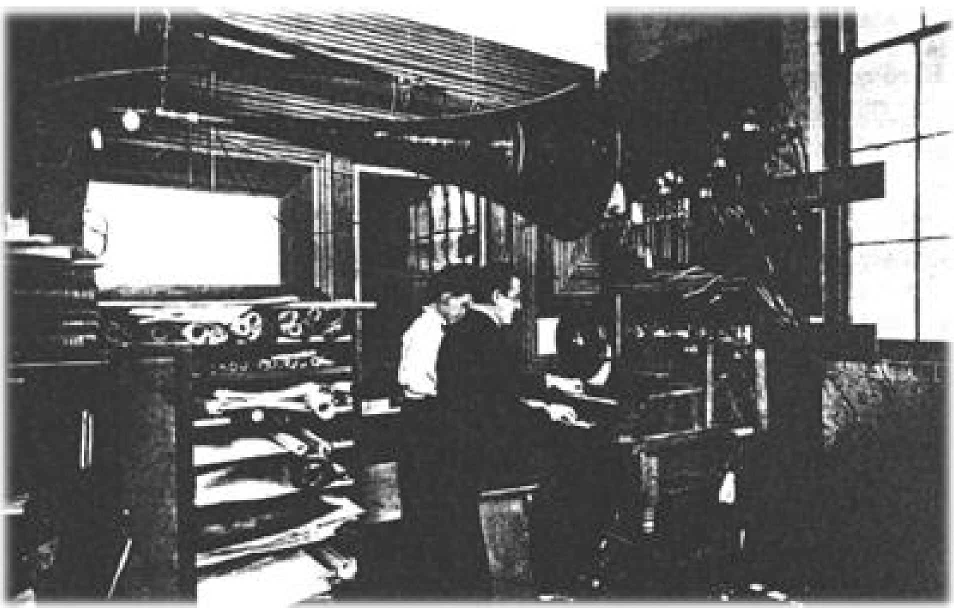

fig. 6 The 60ft long, 200 ton, $200,000 "Telharmonium"

The Telharmonium was an immense structure about 200 tons in weight and 60 feet long assuming the proportions and appearance of a power station generator... the quoted cost was $200,000. The monstrous instrument occupied the entire floor of "Telharmonic Hall" on 39th Street and Broadway New York City for 20 years.

Despite the Telharmonium's excessive proportions the sound it produced was both flexible and novel to a degree unmatched by subsequent designers until the 1950's, and unusually, the instrument was portable - taking up thirty railroad carriages when transported from Holyoke, Mass to NYC. The visionary 36-note-per-octave keyboard designed around Cahill's ideas of just Intonation were far ahead of their time musically but proved unpopular with musicians who had little time to practice on the unusual keyboard this factor eventually added to the demise of the instrument. The sound produced from the Telharmonium at Telharmonic Hall was dogged with technical imperfections on behalf of the performers and by cable transmission errors such as sudden drops in volume when extra voices were added and a 'growling' effect on the bass notes that was said to make the overall experience 'highly irritating'.

Cahill completed the third and final Telharmonium in march 1911, this machine was even bigger and more expensive than its predecessor. The third Telharmonium had a whole set of redesigned and more powerful alternators, stronger magnets to reduce the bass rumbling and volume controls. The instrument was installed at 535 west 56th street New York City.

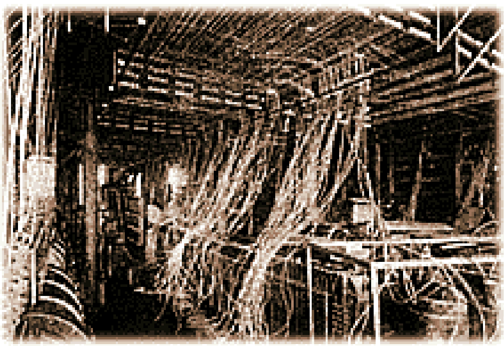

fig. 7 Inside the Telharmonium

Cahill and the 'New England Electric Music Company' funded a plan to transmit 'Telharmony' using the Dynamophone to hotels, restaurants, theatres and private homes via the telephone network. This visionary quest failed when the capital outlay became prohibitive and it was discovered that the machine interfered seriously with local telephone calls. The venture ground to a halt before the first world war. Rumour has it that a New York businessman, infuriated by the constant network interference, broke into the building where the Telharmonium was housed and destroyed it, throwing pieces of machinery into the Hudson river below. The final Telharmonium (the last of 3 built) was operating until 1916 and having survived the Wall Street crash and World War 1 was finally killed off by the advent of popular radio broadcasting and amplification. Despite its final demise, the Telharmonium triggered the birth of electronic music- The Italian Composer and intellectual Ferruccio Busoni inspired by the machine at the height of its popularity was moved to write his "Sketch of a New Aesthetic of Music" (1907) which in turn became the clarion call and inspiration for the new generation of electronic composers such as Edgard Varèse and Luigi Russolo.

No recordings of the Telharmonium/Dynamophone are known to have survived, though Arthur.T. Cahill, brother of Thaddeus, was as recently as 1950 trying to find a home for the prototype instrument, his search proved unsuccessful and the historic machine vanished. The principles underlying the telharmonium are still used in the **Hammond Organ** designed in the early 1930s.

Mark Twain (Clemens) and the Telharmonium

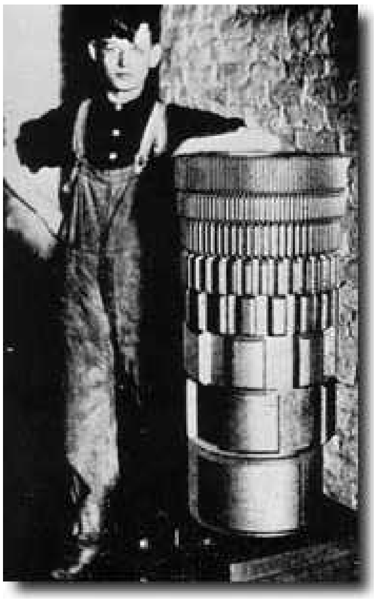

fig. 8 A rotor from the Telharmonium

<< I recall two pleasant social events of that winter: one a little party given at the Clemenses' home on New-Year's Eve, with charades and storytelling and music. It was the music feature of this party that was distinctive; it was supplied by wire through an invention known as the telharmonium which, it was believed, would revolutionise musical entertainment in such places as hotels, and to some extent in private houses. The music came over the regular telephone wire, and was delivered through a series of horns or megaphones -- similar to those used for phonographs -- the playing being done, meanwhile, by skilled performers at the central station. Just why the telharmonium has not made good its promises of popularity I do not know. Clemens was filled with enthusiasm over the idea. He made a speech a little before midnight, in which he told how he had generally been enthusiastic about inventions which had turned out more or less well in about equal proportions. He did not dwell on the failures, but he told how he had been the first to use a typewriter for manuscript work; how he had been one of the earliest users of the fountain- pen; how he had installed the first telephone ever used in a private house, and how the audience now would have a demonstration of the first telharmonium music so employed. It was just about the stroke of midnight when he finished, and a moment later the horns began to play chimes and "Auld Lang Syne" and "America". >>

Mark Twain: A Biography,Albert Bigelow Paine (New York: Harper & Brothers, 1912), 1364-1365

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Choralcello Electric Organ (1888-1908)

fig. 9 A Choralcello photographed in 1917

The Choralcello ("heavenly Voices") was was a hybrid electronic and electro-acoustic instrument. The Choralcello was designed and developed by Melvin Severy with the assistance of his brother in law George B. Sinclair at Arlington Heights, Mass USA. The machine was manufactured by the 'Choralcello Manufacturing Co' in Boston as an expensive home organ for social music recitals. The Choralcello was developed by Severy from 1888 until 1909 when it was presented to the public in Boston, Mass. The company was taken over in 1918 by Farrington. C. Donahue & A. Hoffman (in some reports claimed as its inventor). At least six of the instruments were sold and continued to be used up unitl the 1950's. Two working examples of the instruments are known to have survived in the USA.

The Choralcello was a direct contempoary of the Telharmonium, though not as big, was still a huge instrument using a similar electromagnetic tone wheel sound generation to the Telaharmonium used in the 'organ' section of the instrument as well as a set of electromagnetically operated piano strings. The Choralcello consisted of two keyboards, the upper (piano) keyboard having 64 keys and the lower 88 (piano and 'organ'), controlling (in later models) 88 tone wheels and a set of piano strings that were vibrated by electromagnets and a set of hammers that could play the strings in a normal piano fashion. The keyboards also had a set of organ style stops to control the timbre and fundamentals of the tone that could then be passed through cardboard, hardwood, softwood, glass, steel or "bass-buggy" spring resonators to give the sound a particular tone.

The Choralcello also incorporated a pianola style paper roll mechanism for playing 'pre-recorded' music and a 32 note pedal board system. The entire machine could occupy two basements of a house, the keyboards and 'loudspeakers' being the only visible part of the instrument.

The "Intonarumori" (1913), "Rumorarmonio" (1922) & the "Enharmonic Piano" (1931)

fig. 10 Luigi Russolo, Marinetti and Piatti with the Intonarumori machines (1914)

The instruments and music created by the Futurist painter/musician Luigi Russolo although not electronic played a revolutionary role in the incorporation of noise and environmental sound into modern music and were a primary source of inspiration for many composers including Edgard Varèse, John Cage and Pierre Schaeffer amongst others.

Russolo's attempts to put the Futurists theories on music and art into practice brought about some of the most extraordinary musical experiments in pre-war Europe: the noise intoners or "Intonarumori".

"Ancient life was all silence. In the 19 century, with the invention of the machine, noise was born Today, noise triumphs and reigns supreme over the sensibilities of men"

Luigi Russolo 1913

The "Intonarumori" (1913)

in "*L'arte dei Rumori*" 1913, Russolo describes the passage through history from silence to sound and on to noise-sound and musical noise. he argued that the limited range of the current musical instruments could no longer satisfy modern man's acoustic thirst.

> "let us cross a great modern capital with our ears more alert than our eyes and we will get enjoyment from distinguishing the eddying of water, air and gas in metal pipes, the grumbling noises that breathe and pulse with indisputable animility, the palpitation of waves, the coming and going of pistons, the howl of mechanical saws, the jolting of the tram on its rails, the cracking of whips, the flapping of curtains and flags.
> We enjoy creating mental orchestrations of crashing down of metal shop blinds, slamming doors, the hubbub and shuffle of crowds, the variety of din from the stations, railways, iron foundries, spinning mills, printing works, electric power stations and underground railways"

The or 'Intonarumori' or noise machines were a family of acoustic sound generators designed by Russolo to create the palette of sound described in the 'Art Of Noises'. The individual machines were comically basic in appearance: solid boxes of varying sizes and heights each fitted with a huge metal speaker. Russolo and his assistant Piatti worked away perfecting them ready for their first full scale concert in 1914.

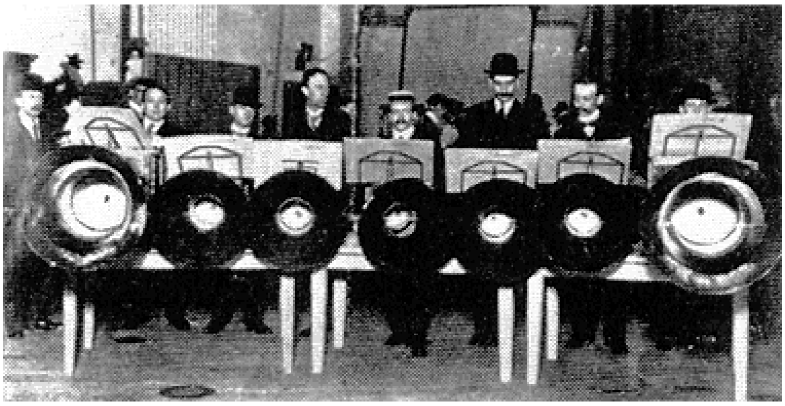

fig. 11 The first public concert of the 'Intonarumori' in 1914

> "It was necessary for practical reasons that the noise Intoners were to be as simple as possible....and this we succeeded in doing. It is enough to say that a single stretched diaphragm placed in the right position gives, when tension is varied a scale of more than ten notes, complete with all the passages of semitones, quarter-tones and even the tiniest fractions of tones.
> The preparation of the material for these diaphragms is carried out with special chemical baths and varies according to the timbre required. By varying the way in which the diaphragm is moved further types of timbres of noise can be obtained while retaining the possibility of varying the tone"
>
> *Luigi Russolo, 1914*

Marinetti, the Italian Futurist poet and helmsman described the experience of demonstrating the noise intoners to the incredulous public as like "showing the first steam engine to a herd of cows"

fig. 12 The Intonarumori with orchestra, 1914

In 1914 Russolo and Marinetti gave 12 performances of the "Intonarumori" at the London Coliseum, the performances were, apparently, warmly applauded and Marinetti claimed that 30,000 people had witnessed the music of the future.

The heroic days of the noise machines ended after the first world war. Russolo sustained serious head injuries during the war and after a long convalescence left Italy and moved to Paris where he carried out subsequent elaboration's on the Noise Machines. His concerts during the 1920's in the city still caused fierce controversy but also impressed several outstanding composers such as Milhaud, Ravel, Honegger and the future prophet of the avant garde Edgard Varèse.

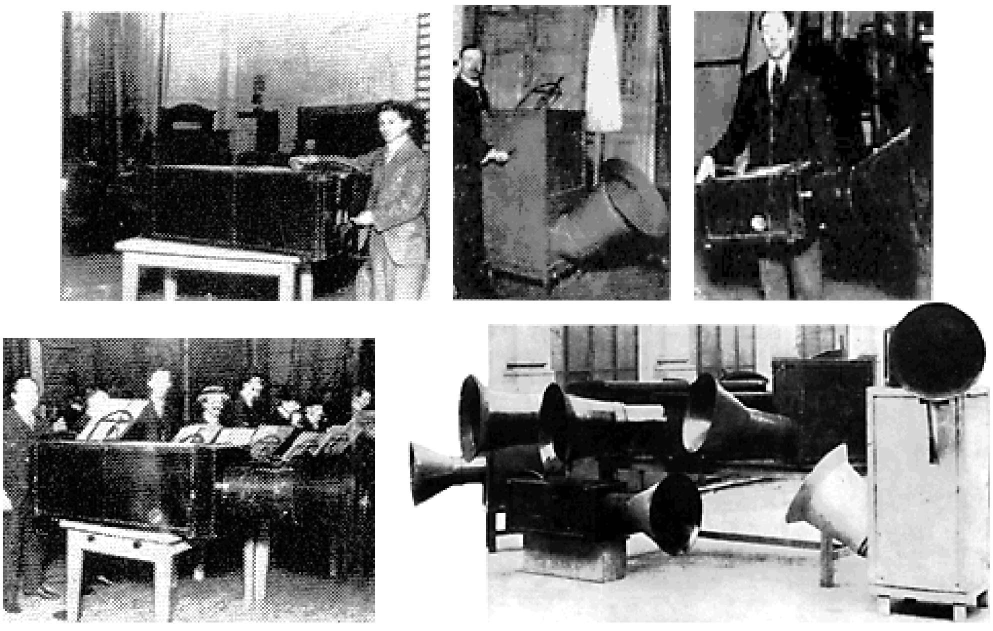

fig. 13 Various Intonarumori circa 1914. From a poster for the concert at the London Colliseum

The Rumorarmonio (1922)

Later versions of the Noise machines developed by Russolo in Paris included "Rumorarmonio" or "Noise Harmonium" or the "Russolo-Phone" which combined several noise machines with a rudimentary keyboard. This was presented to the Parisian public in 1929 by Varèse who planned to put the instruments in to mass production. Unfortunately the plans came to nothing and Russolo somewhat discouraged turned more and more to his painting and philosophy.

fig. 14 Russolo seated in front of two "Rumorarmonio"

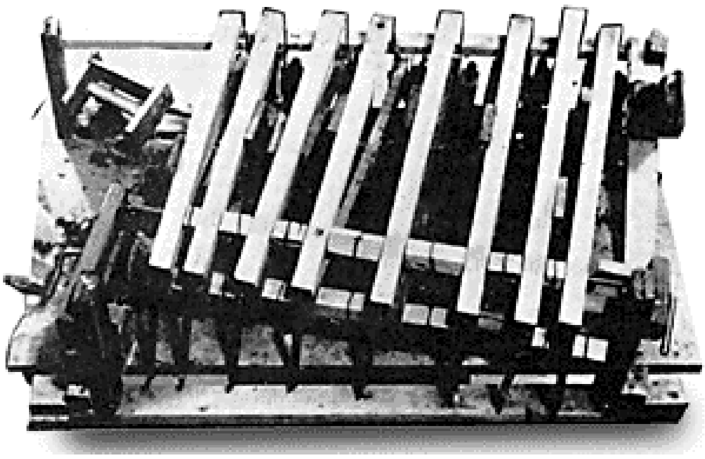

fig. 15 'The Enharmonic Piano

The Enharmonic Piano was Russolo's last experimental instrument built during his time in Paris. The instrument consisted of a series of piano strings that were tuned to sympathetically vibrate when played.

The Audion Piano (1915)

fig. 17 Lee De Forest

Lee De Forest (*Born: August 26, 1873, Council Bluffs, Iowa. Died June 30, 1961*) , The self styled "Father Of Radio" (the title of his 1950 autobiography) inventor and holder of over 300 patents, invented the triode electronic valve or 'Audion valve' in 1906- a much more sensitive development of John A. Fleming's diode valve. The immediate application of De Forest's triode valve was in the emerging radio technology of which De Forest was a tenacious promoter, De Forest also discovered that the valve was also capable of creating audio frequencies using the heterodyning/beat frequency technique: combining two high frequency signals to create a composite lower frequency within audible range.

fig. 16 Lee De Forest's Triode Valve of 1906

De Forest Created the 'Audion Piano', the first vacuum tube instrument in 1915. The Audion Piano was a simple keyboard instrument but was the first to use a beat-frequency (heterodyning) oscillator system and body capacitance to control pitch and timbre (the heterodyning effect was later exploited by the Leon Teramen with his Theremin series of instruments and Maurice Martenot's Ondes-Martenot amongst others). The Audio Piano used a single triode valve per octave which were controlled by a set of keys allowing one note to be played per octave. The output of the instrument was sent to a set of speakers that could be placed around a room giving the sound a dimensional effect. De Forest planned a later version of the instrument that would have separate valves per key allowing full polyphony- it is not known if this instrument was ever constructed.

De Forest described the Audio Piano as capable of producing:

"Sounds resembling a violin, Cello, Woodwind, muted brass and other sounds resembling nothing ever heard from an orchestra or by the human ear up to that time - of the sort now often heard in nerve racking maniacal cacophonies of a lunatic swingband. Such tones led me to dub my new instrument the 'Squawk-a-phone'."

(Lee De Forest Autobiography "The Father Of Radio" 1915. P331-332)

"The Pitch of the notes is very easily regulated by changing the capacity or the inductance in the circuits, which can be easily effected by a sliding contact or simply by turning the knob of a condenser. In fact, the pitch of the notes can be changed by merely putting the finger on certain parts of the circuit. In this way very weird and beautiful effects can easily be obtained."

De Forest, the tireless promoter, demonstrated his electronic instrument around the New York area at public events alongside fund raising spectacles of his radio technology. These events were often criticised and ridiculed by his peers and led to a famous trial where De Forest was accused of misleading the public for his own ends:

> *"De Forest has said in many newspapers and over his signature that it would be possible to transmit human voice across the Atlantic before many years. Based on these absurd and deliberately misleading statements, the misguided public ... has been persuaded to purchase stock in his company. "*

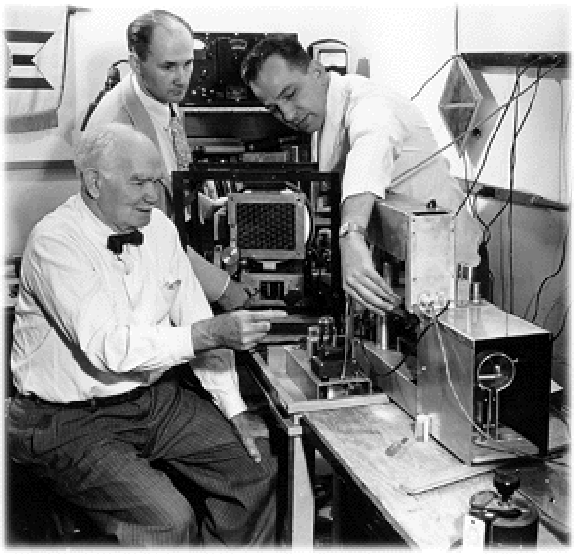

fig. 18 Lee De Forest in 1948

De Forest also collaborated with a sceptical Thadeus Cahill in broadcasting early concerts of the Telharmonium using his radio transmitters (1907). Cahill's insistence on using the telephone wire network to broadcast his electronic music was a major factor in the demise of the Telharmonium.

Vacuum tube technology was to dominate electronic instrument design until the invention of transistors in the 1960s. The Triode amplifier also freed electronic instruments from having to use the telephone system as a means of amplifying the signal.

The Optophonic Piano (1916)

fig. 19 The Optophonic Piano of Vladimir Baranoff Rossiné

The Optophonic Piano was an electronic optical instrument created by the Russian Futurist painter Vladimir Baranoff Rossiné *(Born in 1888 at Kherson ,Ukraine - Russia, died Paris, France 1944)*. Rossiné started working on his instrument c1916. The Optophonic Piano was used at exhibitions of his own paintings and revolutionary artistic events in the new Soviet Union, Rossiné later gave two concerts with his instrument (with his wife Pauline Boukour), at the Meyerhold and Bolchoi theatres in 1924. Vladimir Rossiné left the Soviet Union in 1925, emigrated to Paris where he continued to hold exhibitions of paintings and concerts of his instrument.

The Optophonic Piano generated sounds and projected revolving patterns onto a wall or cieling by directing a bright light through a series revolving painted glass disks (painted by Rossiné), filters, mirrors and lenses. The keyboard controlled the combination of the various filters and disks. The variations in opacity of the painted disk and filters were picked up by a photo-electric cell controling the pitch of a single oscillator. The instrument produced a continuous varying tone which, accompanied by the rotating kaleidascopic projections was used by Vladimir Rossiné at exhibitions and public events.

"Imagine that every key of an organ's keyboard immobilises in a specific position, or moves a determined element, more or less rapidly, in a group of transparent filters which a beam of white light pierces, and this will give you an idea of the instrument Baranoff-Rossiné invented. There are various kinds of luminous filters: simply coloured ones optical elements such as prisms, lenses or mirrors; filters containing graphic elements and, finally, filters with coloured shapes and defined outlines. If on the top of this, you can modify the projector's position, the screen frame, the symmetry or asymmetry of the compositions and their movements and intensity; then, you will be able to reconstitute this optical piano that will play an infinite number of musical compositions. The key word here is interpret, because, for the time being, the aim is not to find a unique rendering of an existing musical composition for which the author did not foresee a version expressed by light. In music, as in any other artistic interpretation, one has to take into account elements such as the talent and sensitivity of the musician in order to fully understand the author's mind-frame. The day when a composer will compose music using notes that remain to be determined in terms of music and light, the interpreter's liberty will be curtailed, and that day, the artistic unity we were talking about will probably be closer to perfection..."

Extract of an original text by Baranoff Rossiné (1916)

fig. 20 A painted disk of the Optophonic Piano

Lev Sergeivitch Termen & "The Theremin" (1917)

also: The "Rhythmicon", The "Terpistone", The "ThereminCello", The "keyboard Theremin" and the Story of Leon Termen.

fig. 21 Lev Sergeivitch Termen playing the "Theremin"

The principles of beat frequency or heterodyning oscillators were discovered by chance during the first decades of the 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). the musical potential of the effect was noted by several engineers and designers including Maurice Martenot, Nikolay Obukhov, Armand Givelet and Leon (or Lev) Sergeivitch Termen the Russian Cellist and electronic engineer.

One problem with utilising the heterodyning effect for musical purposes was that as the body came near the vacuum tubes the capacitance of the body caused variations in frequency. Leon Termen realised that rather than being a problem, body capacitance could be used as a control mechanism for an instrument and finally freeing the performer from the keyboard and fixed intonation.

fig. 22 Leon Theremin playing the 1920 production model of the Theremin

Termen's first machine, built in the USSR in 1917 was christened the "Theremin" (after himself) or the "Aetherophone" (sound from the 'ether') and was the first instrument to exploit the heterodyning principle. The original Theremin used a foot pedal to control the volume and a switch mechanism to alter the pitch. This prototype evolved into a production model Theremin in 1920, this was a unique design, resembling a gramophone cabinet on 4 legs with a protruding metal antennae and a metal loop. The instrument was played by moving the hands around the metal loop for volume and around the antennae for pitch. The output was a monophonic continuous tone modulated by the performer. The timbre of the instrument was fixed and resembled a violin string sound. The sound was produced directly by the heterodyning combination of two radio-frequency oscillators: one operating at a fixed frequency of 170,000 Hz, the other with a variable frequency between 168,000 and 170,000 Hz. the frequency of the second oscillator being determined by the proximity of the musician's hand to the pitch antenna. The difference of the fixed and variable radio frequencies results in an audible beat frequency between 0 and 2,000 Hz. The audible sound came from the oscillators, later models adding an amplifier and large triangular loudspeaker. This Theremin model was first shown to the public at the Moscow Industrial Fair in 1920 and was witnessed by Lenin who requested lessons on the instrument. Lenin later commissioned 600 models of the Theremin to be built and toured around the Soviet Union.

Termen left the Soviet Union in 1927 for the United States where he was granted a patent for the Theremin in 1928. The Theremin was marketed and distributed in the USA by RCA during the 1930's and continues, in a transistorised form, to be manufactured by Robert Moog’s *'Big Briar'* company.

The heterodyning vacuum tube oscillator became the standard method of producing electronic sound until the advent of the transistor in the 1960's and was widely used by electronic musical instrument designs of the period. The Theremin became known in the USA as a home instrument and featured in many film soundtracks of the 1940-50's, it also appeared in several pop records of the 1960's (the Beach Boys "good Vibrations" being the most well known example) but never overcame it's novelty appeal and was used for effect rather than a 'serious instrument', most recordings employ the Theremin as a substitute string instrument rather than exploiting the microtonal and pitch characteristics of the instrument. Leon Sergeivitch Termen went on to develop variations on the original Theremin which included the "Terpistone", The "Rhythmicon", the "keyboard Theremin" and the "Electronic Cello".

The "Rhythmicon" (1930)

The first electronic rhythm generator.

The "Terpistone" (1930)

The Terpistone was an adaptation by Leon Termen of the Theremin for use by dancers. The control antenna being made in the form of a huge metal sheet hidden under the floor. Movements of the dancers in the area above the sheet caused variations in pitch of the Terpistone's oscillators due to the capacitance of the dancers bodies. This instrument was used for several 'exotic' dance, music and light shows throughout the 1930's.

The "Keyboard Theremin"(1930)

A Theremin with the capacitance controls replaced by a standard keyboard.

The "Theremin Cello" (1932)

A fingerboard operated Cello like variation of the Theremin that enabled continuous glissando and tone control.

The story of Leon Sergeivitch Termen (1896 – 1993)

fig. 23 Lev Sergeivitch Termen playing the Theremin at Stamford University 1991

The story of Lev Sergeivitch Termen is like some nightmarish John Le Carre novel. Prof. Theremin was born in the Russian city of St Petersberg in 1896, he would become one of the most important pioneers in the development of electronic music through his instrument the Thereminvox (commonly referred to as the Theremin). Prof. Theremin first invented a prototype Thereminvox in 1920, he worked upon his invention for the next few years, whilst also relocating from Russia to New York. A US patent was granted to Theremin for the invention of the Thereminvox in 1928.

Theremin set up a studio there catering to high society patrons from whom he would extract the moneys he used to continue his experiments. His New York studio apparently was kitted out with a variety of devices, that in the late twenties must have seemed like pure science fiction: a variety of electronic audio devices; electronic lighting shows; an electronic dance platform; even a prototype colour television system.
In 1938 Theremin was kidnapped in the New York apartment he shared with his American wife (the black ballet dancer, Iavana Williams) by the NKVD (forerunners of the KGB). He was transported back to Russia, and accused of propagating anti-Soviet propaganda by Stalin. Meanwhile reports of his execution were widely circulated in the West. In fact Theremin was not executed, but interned in Magadan, a notoriously brutal Siberian labour camp. Theremin was put to work on top secret projects by the Soviet authorities, culminating in his invention of the first "bug," a sophisticated electronic eavesdropping device. Theremin supervised the bugging of both the American embassy, and Stalin's private apartment. For this groundbreaking work he was awarded the Stalin Prize (first Class), Russia very highest honour.

fig. 24 Lucie Bigelow Rosen

After his rehabilitation Theremin took up a teaching position at the Moscow conservatory of music. However he was ejected for continuing his researches in the field of electronic music. Post war Soviet ideology decreed that modern music was pernicious. Theremin was reportedly told that electricity should be reserved for the execution of traitors. After this episode Theremin took up a technical position, and worked upon non-music related electronics . Ironically his invention the Thereminvox, was becoming vastly influential in America, a development of which he was completely unaware.
Before his death in 1993 Prof. Theremin made one final visit to America lecturing, and demonstrating his Thereminvox. Indeed the instrument is still being used today, and has an avid following of Theremin-o-philes.

The Electrophon, Sphäraphon, Partiturophon and the Kaleidophon
(1921-1930)

The Electrophon

The Sphäraphon range of electronic instruments was developed by the musician Jörg Mager specifically for microtonal music in Berlin from 1921 to 1928. The initial instrument, the Electrophon, built with the assistance of the electronics company Lorenz, was a heterodyning tone generator based instrument. The Electrophon was controlled by a handle that the player moved across a marked semi-circular dial creating a continuous glissando effect. The Electrophon had no manual keyboard control.

Kurbelsphäraphon

The Kurbelsphäraphon was an improved Electrophon with a added filters to improve the timbre and to avoid continuous glissando the KurbelSphäraphon had two switchable tuning handles used in conjunction with double foot pedal to control the volume. The KurbelSphäraphon was completed in 1923 and presented at the Donaueschingen Festival in 1926 where it was mostly ignored. The composer Georgy Rimsky-Korsakov (Grandson of the Russian composer) composed some quarter-tone experimental pieces for the instrument.

The Klaviatursphäraphon or Sphaerophon

Supported by the city of Darmstadt (the Heinrich Hertz Institut für Schwingungsforschung and the Reichsrundfunk radio station) and with the assistance of Oskar Vierling, Mager continued his work on his instruments creating the Klaviatursphäraphon in 1928, replacing the handles of the Kurbelsphäraphon with two short keyed monophonic keyboards - the shorter keys allowing the player to play both keyboards simultaneously thereby producing a duophonic tone. It was also possible to tune the keyboard to microtonal tuning. Additional tone colour was added by mechanical resonators and specially formed speakers.

The Partiturophon

The "Partiturophon" was a four (in later models, five) keyboard and five voice version of the Klaviatursphäraphon produced in 1930. This instrument allowed the player to play four (or five) voices at once, one voice per keyboard:

fig. 25 Jörg Mager at the 'Partiturophon'

> "Mager produced today and organ with many registers on which four voice playing is possible. So far there is only one difficulty; that is, that each voice must have its own keyboard, thus the four voice movement must be played on three manuals and the pedal. For this reason the manuals must be close to each other and the keys short, so that one can easily play on several manuals with one hand. For this reason the keys are somewhat narrower than those on a regular organ or piano keyboard. Apart from these difficulties, which require a special adjustment to the playing of the new instrument, it is surprising in its infinite multiplicity of sound possibilities, through dynamic wealth of shading and through the possibilities of expression in the tones"

Frederick Prieberg

The Kaleidophon

The Kaleidophon was completed in 1939 and although its history is undocumented is described as "an electronic monophonic instrument with "kaleidoscopic tone mixtures" the instrument was built influenced by the tonal ideas of Arnold Schoenberg and Ferruccio Busoni.
Mager’s instruments were extensively used mainly in theatrical productions in Germany though none are known to have survived the second world war. in 1929 Mager was given the use of a small castle in Darmstadt where he founded the Studiengesellschaft für Elektro Akustische Musik.

The Pianorad (1926)

fig. 26 The Pianorad, showing oscillators and speaker horn

The Staccatone (1923)

The Staccatone was designed by the radio technology journalist Hugo Gernsback and was his first attempt at building a polyphonic electronic instrument. The Staccatone used a number of LC oscillators to produce a note with a sharp attack and decay.

The Pianorad (1926)

The Pianorad was a development of the Staccatone again designed by Gernsback and built by Clyde Finch at the Radio News Laboratories in New York. the Pianorad had 25 single LC oscillator for every key for its two octave keyboard giving the instrument full polyphony, the oscillators produced virtually pure sine tones:

> "The musical notes produced by the vacuum tubes in this manner have practically no overtones. For this reason the music produced on the Pianorad is of an exquisite pureness of tone not realised in any other musical instrument. The quality is better than that of a flute and much purer. the sound however does not resemble that of any known musical instrument. The notes are quite sharp and distinct, and the Pianorad can be readily distinguished by its music from any other musical instrument in existence."

Each one of the twenty five oscillators had its own independent speaker, mounted in a large loudspeaker horn on top of the keyboard and the whole ensemble was housed in a housing resembling a harmonium. A larger 88 non keyboard version was planned but not put into production. The Pianorad was first demonstrated on June 12, 1926 at the radio station WRNY in New York City performed by Ralph Christman. The Pianorad continued to be used at the radio station for some time, accompanying piano and violin concerts.

The Dynaphone (1927-28)

The French electrical engineer René Bertrand, who had been experimenting with electronic instruments as early as 1914, was a long time friend and collaborator with Edgard Varèse and with Varèses support Bertrand developed the "Dynaphone" (not to be confused with Cahill's Dynamophone/Telharmonium). The Dynaphone was a portable, monophonic non-keyboard, dial operated vacuum tube oscillator instrument. The instrument was semi-circular in shape with a diameter of 30 cm played on top of a table. The Dynaphone belonged to a family of dial-operated non keyboard electronic instruments developed around the 1930's such as Mager's 'Spharaphon'.

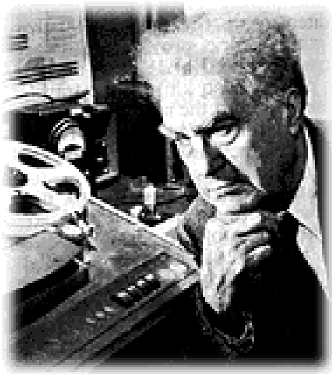

fig. 27 Edgarde Varèse

The right hand controlled the pitch using a circular dial on a calibrated disc (cardboard cut-out templates of music could be inserted). The total rotation of the dial was equal to seven octaves but only the five highest or lowest could be selected at any one time by the means of a switch, giving an overlap of three octaves common to both ranges. Vibrato effects could be added by moving the right hand to and fro slightly and the machine also included a push button for articulating the sound. The left hand controlled the volume and timbre - described as similar to a cello, low flute, saxophone or french horn. A later development of the Dynaphone (known as the " Radio-electric-organ" used a five octave keyboard on which the note played could be doubled at the fifth and octave.
The first public demonstration of the instrument in 1928 was a performance of Ernest Fromaigeat's 'Variations Caractéristiques' for six Dynophones and later in 'Roses de Metal' a ballet by the Swiss composer Arthur Honegger.

In 1932 Varèse applied to the Guggenheim memorial fund for a grant towards continuing the development of the Dynaphone:

> "...The Dynaphone (invented 1927-28) is a musical instrument of electrical oscillations similar to the Theremin, Givelet and Martenot electrical instruments. But its principal and operation are entirely different, the resemblance being only superficial. The technical results i look for are as follows:
>
> - To obtain pure fundamentals
>   By means of loading the fundamentals with certain series of harmonics to obtain timbres which will produce new sounds.
> - To speculate on the new sounds that the combination of two or more interfering Dynaphones would create if combined as one instrument.
> - To increase the range of the instrument to reach the highest frequencies which no other instrument can give, together with adequate intensity.
>
> The practical result of our work will be a new instrument which will be adequate to the creative needs of musician and musicologist....."

Despite Varèse's assertions, the Dynaphone was not distinctly different from its close competitors and the Guggenheim Foundation did not sponsor Bertrands work despite several further attempts by Varèse.

The Cellulophone (1927)

Invented by the French engineer Pierre Toulon aided by Krugg Bass, the Cellulophone ("Cellule Photo-électrique") was demonstrated as a prototype in France, 1927. The Cellulophone was an electro-optical tone generator based instrument resembling an electronic organ. The machine had two eight octave keyboards and a foot pedal board. The sound was generated by rotating discs in which a ring of equidistant slits were cut (54 slits for the lowest note), different shaped masks were used for different timbres. The disks masked a light beam that flashed through the slits and on to a photoelectric cell, the speed of the rotating disk determining the frequency of the output signal, provided by a vacuum tube oscillator.

One disk was used for all the notes of each octave therefore notes whose frequencies could not be generated by an integral number were out of tune, this system however gave the unique and unusual possibility of having a different timbres for each octave.

The Cellulophone was one of a generation of instruments in the 1920-30's using a photo-electric sound system, other examples being the "Licht-ton Orgel" , the "Photona" and the "Radio Organ of a Trillion Tones". The increased sophistication and reliability of post war electronic circuitry marked the decline of light based synthesis after the 1940's except for a few pioneers such as Daphne Oram who used a similar sytem not only to synthesise sounds but to sequence sounds.

Pierre Toulon proposed in the 1930's a related technique of speech synthesis using fragments of optical film mounted on a rotating drum.

The Tri-Ergon (1919)

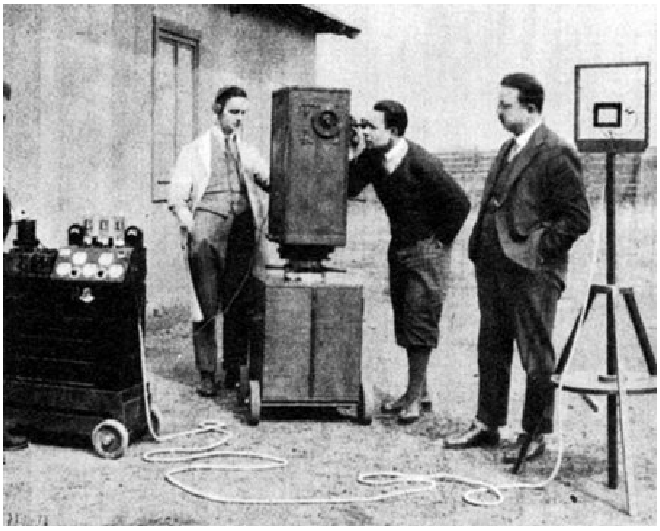

fig. 28 The name Tri-Ergon refers to its three inventors: Vogt, Massolle and Engl

Three German inventors, Josef Engl, Hans Vogt, and Josef Engl patented the "Tri Ergon" process. In 1922, Tri-Ergon announced the development of a glow lamp light modulator for variable density recording of sound. The Tri Ergon Process uses a technology known as variable density, which differed from a later process known as variable area. The Tri Ergon process had a pattented flywheel mechanism on a sprocket which prevented variations in film speed. This flywheel helped prevent distortion of the audio. Tri Ergon relied on the use of a photo-electric cell to transduce mechanical sound vibrations into electrical waveforms and then convert the electrical waveforms into light waves. These light waves could then be optically recorded onto the edge of the film through a photographic process. Another photo-electric cell could then be used to transduce the waveform on the film into an electrical waveform during projection. This waveform could then be amplified and played to the audience in the Theater. The Fox Film Corporation acquired the rights to the Tri Ergon technology in 1927.

In 1926, Theodore W. Case and E. I. Sponable demonstrated their sound-on-film developments to representatives of the Fox Film Corporation, and to William Fox himself. The Fox-Case Corp. was organized to exploit the system, which was given the name Movietone. The Fox Film corporation started making Movietone News newsreels. One of the first newsreels was Charles A. Lindbergh's fabled takeoff for Paris. The years 1928 and 1929 were marked by rapid expansion in facilities and personnel, successful showings and stepped-up schedules of newsreel releases. In March of '29, the making of silent pictures by Fox was discontinued.

Walter Ruttmann «Weekend»

"…At great technical expense, Walter Ruttmann collects sound recordings of a weekend in Berlin: from finishing work on Saturday to starting the next week on Monday morning. Lasting a good eleven minutes, the piece alternates between narration and sound pattern. With his ear for the narrative as well as the visual, Ruttmann works on a kind of audio-art. His formulations can also designate structure on the basis of musical points of departure such as pitch and rhythm (see the reproduction of his notation for a speech sequence). But the characteristic style of «Weekend» is thoroughly narrative-related. Tone coloring, rhythm, and pitch merely customize the storytelling."

Golo Föllmer

"…1930 saw the first attempts to produce radio plays with the Tri-Ergon-Technology (Walter Ruttmann's collage «Weekend» and Friedrich Bischoff's «Hörsymphonie»: «Hallo! Hier Welle Erdball». The bureaucrats, however, condemmned this technology for being influenced by Bolshevist ideas. Thus the attempt was a failure, the patents sold abroad and radio art had to wait for many more years to be able to use the Tri-Ergon technology."

Hermann Naber

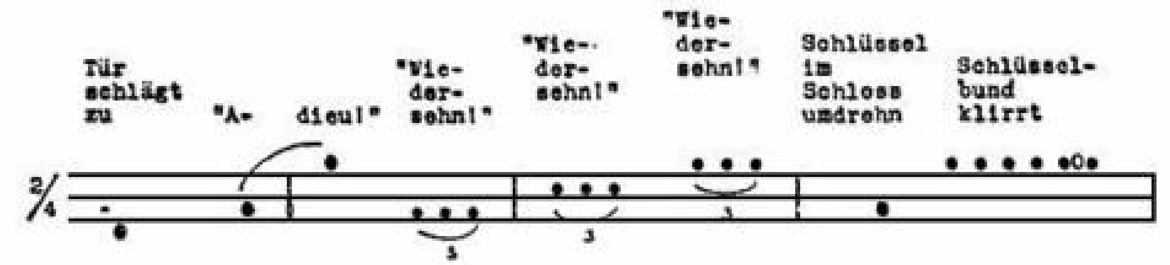

fig. 29 Score for «Weekend»

The “Clavier à Lampes” (1927) The “Orgue des Ondes” (1929), The “Givelet” (1930)

The 'Clavier à Lampes'

Armand Givelet, an engineer and physicist at the radio laboratory at the Eiffel Tower in collaboration with the organ builder Eduard Eloi Coupleaux produced their first instrument the “Clavier à Lampes” in 1927. The “Clavier à Lampes” was a monophonic vacuum tube oscillator instrument.
In 1928 Givelet demonstrated his technique of 'silent recording' or direct injection. This was a solution to the problem of recording music with microphones for radio broadcast, the microphones of the day being of very low quality, Givelet's solution was to connect his electronic instruments directly into the radio transmitter or sound recorder.

fig. 30 Armand Givelet and his "Wave Organ" (1933)

The 'Orgue des Ondes" (1929)

Givelet and Coupleaux's second instrument was the 'Orgue des Ondes' or 'Wave Organ' in 1929 . The wave Organ was designed as a cheap replacement for pipe organs used to play the popular music of the day and as a way of getting around the problem of recording and transmitting radio broadcast music using microphones - microphones at this time were still crude and unsuitable for recording music, the "Wave Organ" could be plugged straight into an amplifier or radio transmitter, bypassing microphones completely.
Givelet's instrument was based on the same technology, vacuum lamp oscillators, as the Theremin and Ondes-Martenot but the "Wave Organ" had an oscillator for each key therefore the instrument was polyphonic, a distinct advantage over its rivals despite the amount of room needed to house the huge machine. The organ had over 700 vacuum oscillator tubes to give it a pitch range of 70 notes and ten different timbres - for each different timbre a different set of tubes was used. The Organ may have used as many as 1,000 tubes in total for oscillators and amplifiers. The sound of the organ was said to be particullarly rich due to small variations in the tuning between each note creating a chorus like effect - infact, the organ was capable of an early type of additive (addition of sine or simple waveforms) and subtractive (filtering comlex waveforms) synthesis due to its number of oscillators and distortion of the sine waves produced by the LC oscillators.
The "Wave Organ" eventually succumbed to the popularity and portability of the American built Hammond Organ.

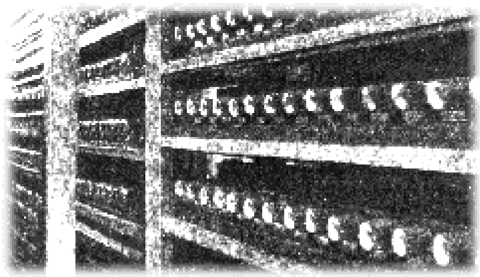

fig. 31 The multiple oscillators of the "Orgue-des-ondes"

The Piano Radio-Électrique (1929)

The Piano Radio-Électrique was a small electric organ type instrument equipped with the player piano mechanism of the Orgue-des-ondes controlling a set of oscillators mounted in a separate cabinet, it could be accompanied on the piano played manually or using a second electropneumatic system controlled by the player piano.

The Coupleaux -Givelet Organ' or 'Givelet' (1930)

fig. 32 The keyboards of the 'Givelet'

Givelet and Coupleaux's last know instrument was the 'Coupleaux -Givelet Organ' or 'Givelet'. The Givelet was a unique instrument that combined vacuum tube oscillators with a sound control system using a punched paper roll in a way similar to a player piano to define the sound synthesis. Pitch, volume, attack, envelope, tremolo and timbre could be controlled by cutting and splicing paper rolls and like the "Wave Organ", the Givelet was polyphonic. The technique of using punched paper "programs" was not exploited until fifteen years later in the 1950's with the RCA Synthesiser.

Givelets and Coupleaux's instrument was designed to be a commercial and cheap replacement for pipe organs and utilise the ability for 'silent recording'. The Givelets were installed in churches around France and at a broadcasting radio station in Paris. The Givelet eventually lost out commercially to the American Hammond Organ

The Ondes-Martenot (1928)

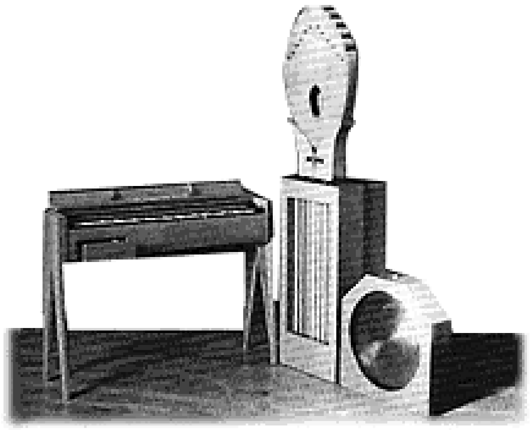

fig. 33 A concert version of the Ondes-Martenot

Maurice Martenot a Cellist and radio Telegraphist, met the Russian designer of the Theremin, Leon Termen in 1923, this meeting lead him to design an instrument based on Termens ideas, the first model, the "Ondes-Martenot" was patented on the 2nd of April 1928 under the name *"Perfectionnements aux instruments de musique électriques"* (improvements to electronic music instruments). His aim was to produce a versatile electronic instrument that was immediately familiar to orchestral musicians. The first versions bore little resemblance to the later production models: consisting of two table mounted units controlled by a performer who manipulated a string attached to a finger ring (using the bodies capacitance to control the sound characteristics in a manner very similar to the Theremin) this device was later incorporated as a fingerboard strip above the keyboard. Later versions used a standard keyboard.

fig. 34 The Ondes Martenot (1940)

The Ondes-Martenot became the first successful electronic instrument and the only one of its generation that is still used by orchestras today, Martenot himself became, 20 years after its invention, a professor at the Paris Conservatoire teaching lessons in the Ondes-Martenot.
The Ondes-Martenot's success was the Theremins loss, although both used the vacuum tube oscillator as a sound source and were both monophonic, where the Theremin had a sliding scale and no fixed preset notes the Ondes-Martenot had a keyboard and a strip control for glissando and vibrato and an appearance that was familiar to any keyboard player.

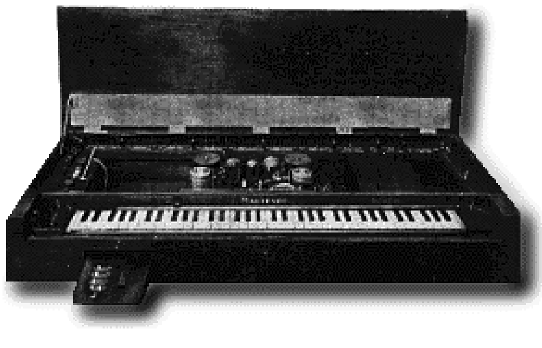

fig. 35 an early version of the Ondes-Martenot

The instrument also had a bank of expression keys that allowed the player to change the timbre and character of the sounds. A later (1938) version of the instrument featured microtonal tuning as specified by the Hindu poet Rabindranath Tagore and the musician Alain Danielou. The Ondes-Martenot was quickly accepted and eventually had a wide repetoire, works were written for the instrument by composers such as Edgard Varèse, Olivier Messian (The "Turangalîla Symphonie" and "Trois Petites Liturgies de la Presence Divine" amongst others),Darius Milhaud , Arthur Honegger, Maurice Jarre, Jolivet and Koechlin.

The Sonorous Cross -"La Croix Sonore" (1929-1934)

The "Sonorous Cross /La Croix Sonore" was one of several Theremin type instruments developed in Europe after Leon Termens departure to the USA in 1927, others included the "*Elektronische Zaubergeige*" and the "*Elektronde*". The Sonorous Cross was designed and built in Paris by Michel Billaudot and Pierre Duvalier for the the Russian émigré composer Nikolay Obukhov in 1929. The instrument was the result of several years experimenting with beat frequency/heterodyning oscillators. As with the Theremin the Sonorous Cross was based on body capacitance controlling heterodyning vacuum tube oscillators but in Obukhov's instrument the circuitry and oscillators were built into a metal sphere of 44cm diameter and the antenae of the Theremin was replaced by a large brass crucifix of a height of 175cm with a central star.

The Sonorous Cross was played in the same way as the Theremin - using the bodies capacitance to control the oscillators frequency, in this case moving the hands out from the central star on the crucifix altered the pitch and volume of the instrument. The ritualistic gestures made while playing this most unusual looking of instruments complemented the occult and mystical nature of Obukhov's music and life.

Nikolay Obukhov composed numerous pieces using his instrument as well as several using the Ondes-Martenot, culminating in his major work;"Le Livre De Vie" which exploited the glissando effects the Sonorous Cross could produce. Obukhov continued to develop the instrument and produced an improved version, completed in 1934. Obukhov also designed two other instruments, the "Crystal" apiano type instruments where the hammers hit a row of crystal spheres and the "Éther" an electronically powered instruments where a large paddle wheel created various humming sounds. A version of the Sonorous Cross is now at the musée de L'Opéra, Paris.

The "Hellertion"(1929) & the "Heliophon"(1936)

The Hellertion (1929)

The Hellertion was a monophonic vacuum tube instrument developed collaboratively by Peter Lertes, an electrical engineer in Leipzig and Bruno Helberger a well known pianist of his time. Several variants of the instrument were constructed with the assistance of Schneider-Opel in Frankfurt, Germany the last of which was known as the Heliophon.

The Hellertion was one of the first electronic instruments to use a fingerboard/continuous controller instead of a keyboard manual. The fingerboard was a flat metal resistance strip covered in leather which when pressed completed a circuit. Depending on where the strip is pressed, a different resistance in the circuit is created altering the voltage sent to the oscillator and thereby producing different pitches. The force of the pressure controlled the volume of the output signal. The fingerboard was marked to help the performer find the correct pitch on the strip and had a range of approximately five octaves. The original instrument had just one fingerboard strip which was gradually increased to four and then on the later models, six aligned in parallel horizontally at the height of a piano keyboard. The four and six strip models allowed four and six voice polyphony when the strip could be played simultaneously with fingers and thumbs. The Hellertion was occasionally used in concerts as a piano addition, the melody being played with one hand on the Hellertion and the accompaniment being played with the other hand on the piano. A version of the Hellertion was produced in 1931 microtonally tuned to 10 divisions of an octave.

The Helliophon (1936)

A development of the Hellertion by Bruno Hellberger. The first version of the Heliophon was completed in Berlin, 1936 but destroyed during WW2, Hellberger continued the development after the war and built a second model in 1947 in Vienna, Austria and continued the development of the Heliophon until his death in Vienna in 1951 (subsequent development was taken over by Woflgang Wehrmann).

The sound of heliophon was produced, as with the Hellertion, by heterodyning vacuum tube oscillators but with the Heliophon the sound was controlled by two 58 note pressure sensitive keyboard manuals instead of a series of fingerboard strips. Each keyboard had the ability to be split into three different pitches and timbres simultaneously, the output volume being controlled by footpedals with a knee lever to add vibrato. each keyboard had a Hellertion style fingerboard to add glissando and timbre variations.

The Heliophon was employed by Hellberger throughout the 1940's and 50's for theatrical and musical productions, the instrument was said not only to be capable of producing realistic imitations of orchestral instruments but able to imitate the human vocal sounds.

1930

The Trautonium, Mixtur-Trautonium, Radio Trautonium and Concert-Trautonium (1930)

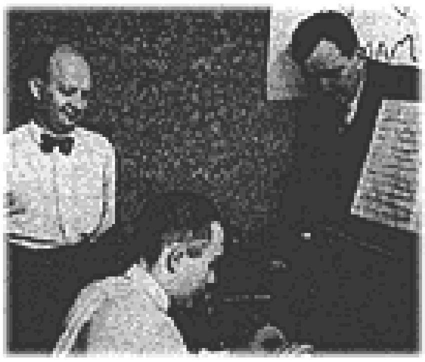

fig. 36 The first Trautonium (left to right: Paul Hindemith, Oskar Sala, Dr Friedrich Trautwein, 1929)

The Trautonium (1930)

The Trautonium was developed by the electrical engineer Dr Freidrich Adolf Trautwein *(b Würzburg 1888, Germany; d Düsseldorf 1956)* and first exhibited in Germany in 1930. The domestic version of the Trautonium was manufactured and marketed by Telefunken between 1932 and 1935. A number of composers wrote works for the instrument including Paul Hindemith who learnt to play the Trautonium and produced a 'Concertina for Trautonium and Orchestra' as well as Höffer, Genzmer, Julius Weismann and most notably Oskar Sala who became a virtuoso on the machine and eventually took over the development of the Trautonium producing his own variations- the 'Mixtur-Trautonium', The 'Concert-Trautonium' and the 'Radio - Trautonium'. Oskar Sala has continued to work with the Trautonium to the present day. Trautwein also produced an 'Amplified Harpsichord'(1936) and 'Electronic Bells'(1947), after the second world war Trautwein worked in Paris on aviation research and then set up a school for recording engineers in Düsseldorf (1950), Trautwein produced his last instrument the 'Elektronische Monochord' in 1952.

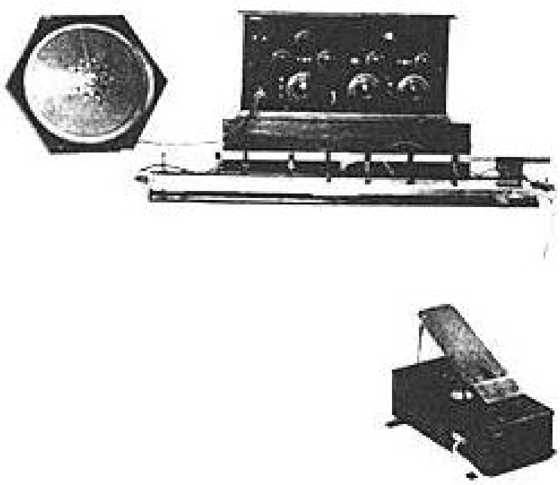

fig. 37 A very early model of the Trautonium

The Original Trautonium had a fingerboard consisting of a resistance wire stretched over a metal rail marked with a chromatic scale and coupled to a neon tube oscillator. The performer on pressing the wire touches the rail and completes the circuit and the oscillator is amplified via a loudspeaker. The position of the finger on the wire determines the resistance controlling the frequency and therefore controls the pitch of the oscillator. The Trautonium had a three octave range that could be transposed by means of a switch. An additional series of circuits can be added to control the timbre of the note by amplifying the harmonics of the fundamental note, non harmonic partials can also be added by selective filtering. This unique form of subtractive synthesis produced a tone that was distinctive and unusual when compared to the usual heterodyning valve instruments of the 1920-30's. The foot pedal of the machine controlled the overall volume.

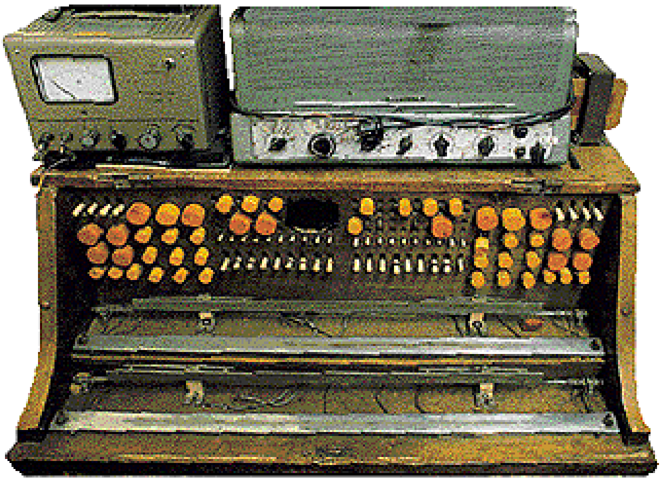

fig. 38 Dr. Friedrich Trautwein's "Trautonium" showing the fingerboard wires and the metal rails.

A later developments of the Trautonium by the Trautonium virtuoso and composer Oskar Sala was the Mixturtrautonium. The Mixturtrautonium used the same technology as the original Trautonium but in later models (1960's) used semi-conductors instead of triode lamps to give a more precise subharmonic frequency range. The first version, the 'Concert Trautonium' - using Thoraton electric tubes from AEG, was ready in 1936 for Harald Genzmer's " Conzert für Trautonium und Orchester". After the war Sala established a workshop for film music production in Berlin where he recorded music for Hitchcock's "the birds" and continues to the present day to compose and record music.

fig. 40 Oskar Sala and the "Mixtur-Trautonium"

The essential design principles of the Trautonium were retained in the development of the semi-conductor version of the Mixturtrautonium; sound production on the basis of subharmonic mixture, and the method of playing with two string manuals. The latter are made of wire-covered catgut strings which act as variable resistors. according to the position at which they are pressed againts the contact rail beneath them, they control the frequencies of the electronic sound generators. when the finger glides over the string a continuous glissando results over the entire tonal region which has just been tuned up.

Micro-tonal intervals could be produced on the Mixturtrautonium. To ensure accurate contact with the notes leather covered sprung and moveable metal tongues are added to each string. In a c-tuning they are located above the nots c,d,g and a in each octave. Unlike with a vibrating string, the gradation of the electrical string manual is linear and not exponential so that all octave have the same finger range.

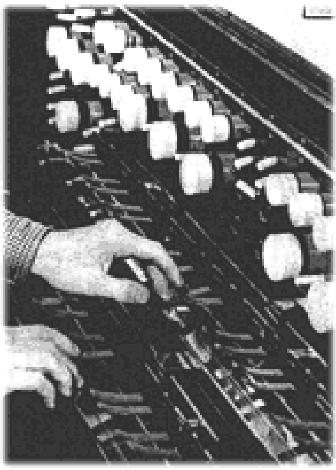

fig. 39 The Mixturtrautonium showing the resistance wires with leather thongs.

"....A clear advantage of the semi-conductor Trautonium is the absolute precision in sub harmonic frequency division. Each string controls the frequency of a top oscillator. this operates parallel four dividers who's signals in their interrelationship results in a mixture. each divider can be switched to one of a maximum of 24 values (20 in the case of the tube version) Three settings can be pre-selected which correspond to the sideways switch positions of the trautonium pedal. additionally to the frequency of the top oscillator a simoultaneaously working frequency ("neighbouring tone") in a freely determinable interval can be produced, which alternatively is available for one of the dividers. In this way it is possible, for instance to make a major characteristic from the minor chord pattern of the sub harmonic series. The square wave-shaped basic signal of a divider initially enters a transformer which turns it into a saw tooth signal. Together with noise proportions which can be admixed, the latter is passed to a format filter which can impress on this raw material the vowel sounds u,o,a,e,i or gliding transitions. Each of the four mixture dividers has its own filter."

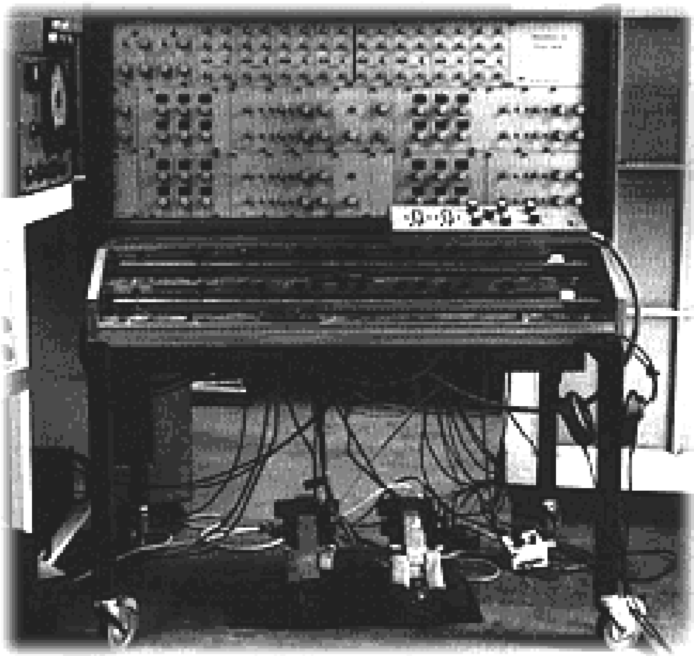

fig. 41 The Concertrautonium

"…The next processing step is taken by the channel amplifiers with the four sound components being adjusted to each other in volume. what is known as the "percussion unit" produces an envelope with adjustable values for "attack" and "decay" by means of which via a channel amplifier percussive sound developments can be produced. the mixture formed from the four channels goes to the master amplifier whose intensity during performance is influenced by the pedal pressure as well as the liquid resistor beneath the manual."

Nikolaus Heyduck "Das musikinstrument 1/90"

The Ondium Péchadre (1930)

The Ondium Péchadre was developed in France by H.C.R.Péchadre in 1930. The instrument was a monophonic heterodyning vacuum tube oscillator based instrument. The instruments was light and portable and built in a heart shaped box, in performance the base of the instrument rested on the players knees and the instrument was supported against a table. The six octave range of the instrument was controlled by moving a pointer around a circular calibrated dial while the left hand controlled the volume of the sound with a velocity sensitive push button device. The attack of the sound wave could be altered to give a more staccato effect or softened to give a more string like sound, the timbre of the sound could also be altered.

The Rhythmicon or "Polyrhythmophone" (1930)

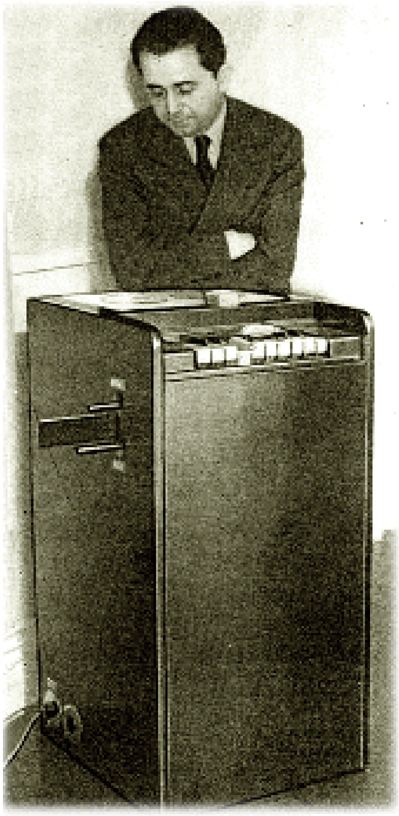

fig. 42 Cowell and Termen's "Rhythmicon" in 1932

In 1916 the American Avant-Garde composer Henry Cowell was working with ideas of controlling cross rythms and tonal sequences with a keyboard, he wrote several quartet type pieces that used combinations of rythms and overtones that were not possible to play apart from using some kind of mechanical control- "unperformable by any known human agency and I thought of them as purely fanciful".(Henry Cowell) In 1930 Cowell introduced his idea to Leon Termen, the inventor of the Theremin, and commisioned him to build him a machine capable of transforming harmonic data into rhythmic data and vice versa.

"My part in its invention was to invent the idea that such a rhythmic instrument was a necessity to further rhythmic development, which has reached a limit more or less, in performance by hand, an needed the application of mechanical aid. The which the instrument was to accomplish and what rhythms it should do and the pitch it should have and the relation between the pitch and rhythms are my ideas. I also conceived that the principle of broken up light playing on a photo-electric cell would be the best means of making it practical. With this idea I went to Theremin who did the rest - he invented the method by which the light would be cut, did the electrical calculations and built the instrument.

Henry Cowell

"The rhythmic control possible in playing and imparting exactitudes in cross rhythms are bewildering to contemplate and the potentialities of the instrument should be multifarious... Mr. Cowell used his rythmicon to accompany a set of violin movements which he had written for the occasion.... The accompaniment was a strange complexity of rhythmical interweavings and cross currents of a cunning and precision as never before fell on the ears of man and the sound pattern was as uncanny as the motion... The write believes that the pure genius of Henry Cowell has put forward a principle which will strongly influence the face of all future music."

Homer Henly, May 20, 1932

The eventual machine was christened the "Rythmicon" or "Polyrhythmophone" and was the first electronic rhythm machine. The Rhythmicon was a keyboard instrument based on the Theremin, using the same type of sound generation - hetrodyning vacuum tube oscillators. The 17 key polyphonic keyboard produced a single note repeated in periodic rhythm for as long as it was held down, the rhythmic content being generated from rotating disks interupting light beams that triggered photo-electric cells. The 17th key of the keyboard added an extra beat in the middle of each bar. The transposable keyboard was tuned to an unusual pitch based on the rythmic speed of the sequences and the basic pitch and tempo could be adjusted by means of levers.

Cowell wrote two works for the Rythmicon "Rythmicana" and "Music for Violin and Rythmicon" (a computer simulation of this work was reproduced in 1972). Cowell lost interest in the machine, transfering his interest to ethnic music and the machine was mothballed. After Cowell, the machines were used for psychological research and one example (non working) of the machine survives at the Smithsonian Institute.

The Rhythmicon was rediscoverd twenty-five years after its creation by the producer Joe Meek (creator of the innovative hit single 'Telstar', 1961) apparently discovered abandoned in a New York pawnbrokers. Meek brought it back to his home studio in London where it was used on several recordings.

This Rhythmicon was used to provide music and sound effects for various movies in the Fifties and Sixties, including: 'The Rains of Ranchipur'; 'Battle Beneath the Earth'; Powell and Pressburgers' 'They're a Weird Mob'; 'Dr Strangelove', and the sixties animated TV series 'Torchy, The Battery Boy'.

The Rhythmicon was also rumoured to have been used on several sixties and seventies records, including: 'Atom Heart Mother' by Pink Floyd; 'The Crazy World of Arthur Brown' by Arthur Brown, and 'Robot' by the Tornadoes. Tangerine Dream also used some sequences from the Rhythmicon on their album 'Rubicon'.

fig. 43 The Rhythmicon

The 'Theremin Cello' (1930)

The Theremin Cello was another adaptation of Leon Termen's, originally a cellist himself, Theremin instrument. The instrument was manufactured by Termens Teletouch company in New York City, USA, c1930.
Instead of the Cello's strings, the Theremin-Cello has a flexible black plastic film fingerboard which produces a tone for as long as the finger is depressed, the pitch is defined by the position on the fingerboard and the volume is controlled by a lever. The timbre of the sound is controlled by two rotary knobs built onto the Cello's body.
The instrument was used throughout the 1930's by a number of musicians most notably Leopold Stowkowski who commissioned Termen to design and build a bass Theremin Cello which was later abandoned due to the side effects caused by subharmonic frequencies on the orchestra's string section.

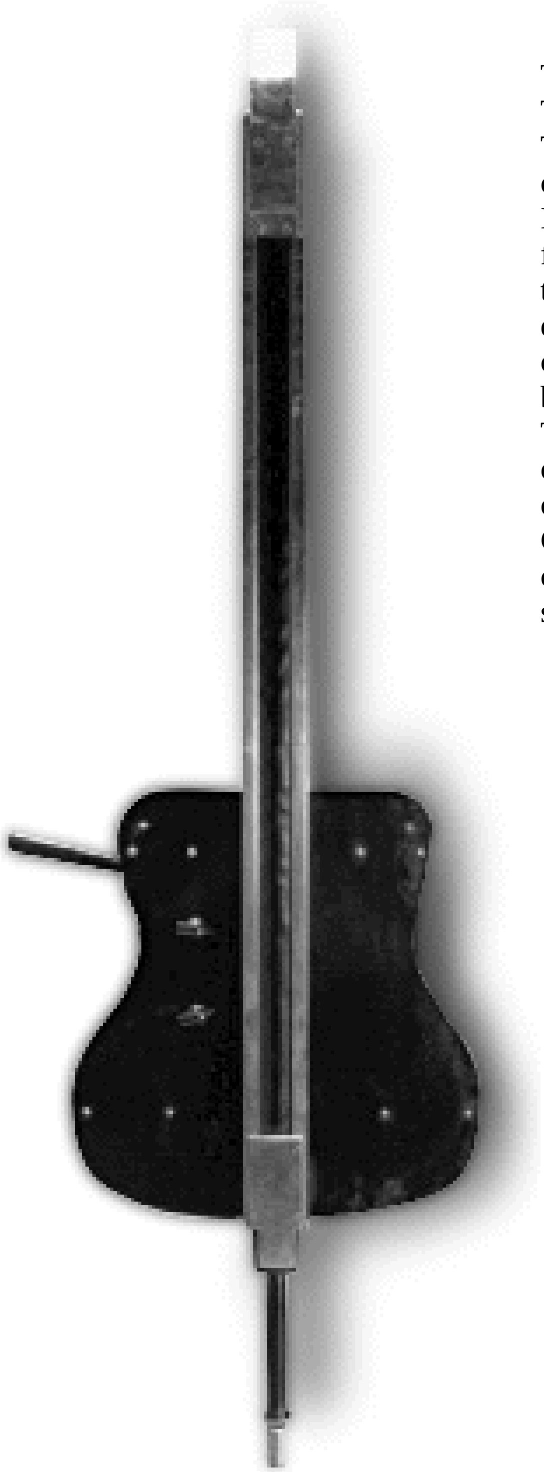

fig. 45 Front view of the Theremin Cello

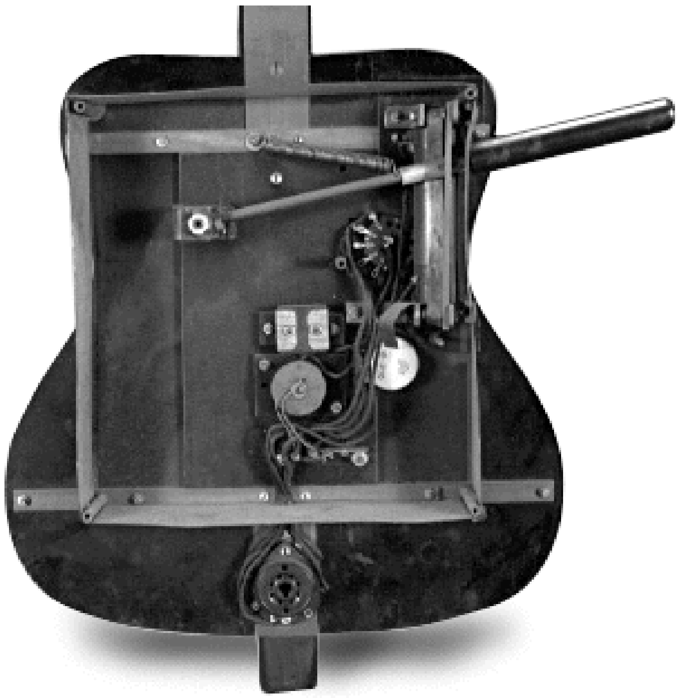

fig. 44 Rear view of the Theremin Cello shows the volume control and tone generator.
(images courtesy:America's Shrine to Music Museum)

The Westinghouse Organ (1930)

The Westinghouse Organ seems to have been a semi-polyphonic multi vacuum tubed electronic organ designed by R.C.Hitchock for Westinghouse Electric Manufacturing Company in the USA. The organs debut was at Pittsburgh's KDKA radio station in 1930.

The "Sonar" (1930)

The "Sonar" was a monophonic heterodyning vacuum tube instrument developed by N.Anan'yev in the USSR from 1930. The instrument had a fingerboard/continuous controller to vary the pitch of the oscilator. The Sonar was said to have been able to reproduce simple speech phrases such as "mama", "papa" as well as conventional instrumental sounds.

The Saraga-Generator(1931)

The Saraga-Generator was developed by Wolja Saraga at the Heinrich-Hertz Institut Für Schwingungsforschung in Berlin, Germany around 1931. The Saraga Generator was an unusual photoelectrically controlled vacuum tube instrument. The instrument consisted of a photoelectric cell mounted on the white painted inside surface of a box with a small slit cut on one face. low voltage neon lamp was placed at some distance from the box and the performers movements interrupting the light beam caused variations in pitch.Envelope and timbre were affected by manipulating a hand held switch device, the overall volume being controlled by a foot pedal. The instrument had a tonal range of four octaves.

The "Radio Organ of a Trillion Tones" (1931)

also:"The Polytone Organ" (1934) & "The Singing Keyboard" (1936)

The "Radio Organ of a Trillion Tones" (1931)

The "Radio Organ of a Trillion Tones" was created and developed by A. Lesti and F. Sammis in the USA during 1931.The Radio Organ used a similar technique as the Cellulophone and variants - rotating photo-electric disks interrupting a light beam at different frequencies produced varied pitches an timbres from a vacuum tube oscillator; the principle was improved in the "Polytone".

The Polytone Organ (1934)

A. Lesti and F. Sammis's development of the Radio Organ of a Trillion Tones was christened the 'The Polytone Organ', this instrument was a three keyboard manual organ using the same sound production system as the 'Radio Organ' - rotating photo-electrical tone-wheel sound generation. The instrument was completed in 1934 and was one of the first multi-timbral instruments.

The Singing Keyboard (1936)

F. Sammis invented the "singing Keyboard" in 1936, a precursor of modern samplers, the instrument played electro-optical recordings of audio waves stored on strips of 35mm film which were triggered and pitched when the player pressed a key. More recent instruments such as the Mellotron and Chamberlin use a similar technology of triggered and pitched magnetic tape recordings.

The Variophone (1932)

Developed in the Soviet Union in 1932 by Yevgeny Alexandrovitch Sholpo, the Variophone used an optical synthesis method where sound waves are drawn onto transparent 35mm film generating sounds controlled by photo-electric cells. Sholpo had been experimenting with 'drawn sound' since the 1920's and created several sound works by photographing drawings to create soundtracks. At the same time in the USSR several other artists were experimenting with similar ideas such as Arseny Avraamov who produced film soundtracks created by photographing series of drawings - "Plan Velikikh Rabot" (Plan of great works) and "Kem Bit" (who to be) in 1930.
This technique was later developed by the Moscow Experimental Studio and by Daphne Oram in England.

The Emiriton (1932)

The Emiriton was an example of a series of finger-board electronic instruments developed in the Soviet Union in the 1930's, inspired perhaps by Leon Termen's avoidance of a standard keyboard with his Theremins. Other instruments included V.A.Gurov's (a former colleague of Leon Termen) "Neo-Violena"(1927) the"Sonar"(1930) and the "Ekvodin"(1931).

Designed by A. Ivanov and A.Rimsky-Korsakov, The Emiriton was a originally a fingerboard instrument allowing the use of glissando effects, with later models incorporating a standard keyboard. The Emiriton produced sound from neon-tube oscillators.
Leon Termen, an ex Cellist, developed a fingerboard "Theremin-Cello" in the USA in the early 1930s

The Emicon (1932)

'The Emicon' (Model S) was developed in the USA by Nicholas Langer and Hahnagyi. The Emicon was a monophonic vacuum tube oscillator instrument controlled with a standard keyboard. The Emicon was said to be able to produce tones similar to a cello, saxophone, oboe, trumpet, mandolin, guitar and bagpipe. The Emicon was manufactured and marketed by Emicon, Inc., Deep River, Connecticut, CA from 1932. A later portable traveling model was built with an amplifier built into a separate case.

fig. 46 Charles D. Stein shows a model how to play the Emicon at the Texas Centennial Exposition in Dallas, June 1936 (image courtesy:America's Shrine to Music Museum)

<< The Emicon is a musical instrument with a keyboard similar to that of a piano, but shorter. It is played by pressing the keys manually, one at a time, a sustained tone resulting. The Emicon presents an almost limitless field for musical expression, because the character of tone and the volume are controlled by the performer. It will offer the musician a fascinating and ever receding horizon of musical possibilities

The tone values are those of the Emicon, though being a new instrument, it is natural that the many varieties of tone should be described in terms of those instruments with which the public is familiar. Hence a clear idea of what is heard when the Emicon is played, may be donveyed by statting that the performer may, at will, produce tones which resemble any one of the several stringed, wood-wind, and brass instruments commonly used in orchestras, violin, cello, sax, oboe, trumpet, etc. as well as mandolin, guitar and even the Scottish bagpipe. The musician has a wide field for experimentation of the intermediary tone-value, because the change from one tone vlaue to another is made without a break. Hence the importance of judging the tone values of the Emicon on their merits, and not as imitations of other instruments. For one who has little or no knowledge of recent achievements in the science of electronics, the Emicon holds much dramtic interest, for the tone is produced without any visible movement of any part of the instrument. The source of the tone is a small tube, about the size of a man's thumb, of a glowing disharge type, without filamnet and non heating. The oscillations of this tube are inaudible except when coupled electrically to an amplifier. The Emicon contains a tone compensated electro dynamic speaker. the frequencies and tone color response of amplifier and speaker is subject to control from the console by means of a smooth linear tone control, (tone value knob). The amplifier and power pack utilize standard radio tubes. In the rear of each key is a resistor of the proper value to produce the pitch of that note. When the key is depressed, contact is made with the main circuit through that resistor and the result is a tone. The various tone characteristics or colr are deteermined by a tone control device which filters out over-tones. This makes possible a wide range, from the relatively simple violin charcter, to the more complicated tones of other instruments with varying overtones or harmonics.
Two or more Emicons played in combinations make possible charming ensemble music.
The Emicon is a musical asset of great value not only for its conventional tone values but for the original musical effects possible. >>

Notes prepared by Charles D. Stein
(from the archive of the America's Shrine to Music Museum, The University of South Dakota.)

Two examples of the Emicon survive at the America's Shrine to Music Museum

The Rangertone Organ (1932)

The Rangertone Organ was developed by the electronics engineer and pioneer of audio recording Richard Ranger (*b Richard Howland Ranger 1899, Indianapolis, Indiana, d 1961*) in the USA during the 1930's. The instrument was marketed by Ranger from his own company 'Rangertone Incorporated' on Verona Ave. in Newark, NJ. Very few of the instruments were sold, one of which was installed at the Recital hall of Skinner Hall of Music, Vassar College. After the failure to sell the instrument Ranger went on to develop a series of high fidelity phonograph devices that never went into production.

During WW2 Ranger spent time investigating German electronic equipment for the US Army it was here that he picked up and removed for his own use the German AEG Magnetophone tape recorder. Ranger returned to the U.S. and in 1947 announced his new Rangertone Tape recorder, based on the Magnetophone, which finally gave the Rangertone Inc the financial success it needed until squeezed out of the domestic market by larger companies such as Ampex.By the early 1960's, Rangertone had eliminated its general-pupose sound recorders from the catalog, concentrating instead on specialized equipment for motion picture production. At some point, the company purchased the rights to manufacture a system using 35 mm tape with sprocket holes, and this product is still in production.

The Rangertone Organ was one of the early tone wheel organs, similar to the Hammond, the Rangertone had its pitch stability controlled by tuning forks, therefore it was possible to change the temperament by changing the tuning of the forks.

Timbre was controlled by push-buttons to the right of the keyboard, and/or by switching between six different amplifier/speaker combinations, which had different tremolo and tonal qualities.The original version was a huge machine, with more than 150 valves. A portable single-keyboard model was built for concert performance.

(Biographicall details by: Dr. David L. Morton, Jr. Research Historian IEEE Center for the History of Electrical Engineering)

The "Syntronic Organ" (1934) & The "Photona" (1935)

Syntronic Organ was an electro-optical tone generator based instrument engineered by Ivan Eremeef and L. Stokowski and was able to produce "one-hour of continuous variation" created by an optically generated tone using films of tone-wheels.Ivan Eremeef later created the "Photona" a 12 electro-optical tone generator based system, developed at WCAU radio, Philadelphia, USA.

The Hammond Organ (1935)

The original Hammond Organ was Designed and built by the ex-watchmaker Laurens Hammond in April 1935. Hammond set up his 'Hammond Organ Company' in Evanston, Illinois to produce electronic organs for the 'leisure market' and in doing so created one of the most popular and enduring electronic instruments ever built. The Hammond Organ model B3 (1950)

Hammonds machine was designed using technology that relates directly to Cahill's 'Telharmonium' of 1900, but, on a much smaller scale. The Hammond organ generated sounds in the same way as the Telaharmonium, the tone weel-The tone generator assembly consisted of an AC synchronous motor connected to a geartrain which drove a series of tone wheels, each of which rotated adjacent to a magnet and coil assembly. The number of bumps on each wheel in combination with the rotational speed determined the pitch produced by a particular tone wheel assembly. The pitches approximate even-tempered tuning.

The Hammond had a unique drawbar system of additive timbre synthesis (again a development of the Telharmonium) and stable intonation - a perennial problem with electronic instruments of the time. A note on the organ consisted of the fundamental and a number of harmonics, or multiples of that frequency. In the Hammond organ, the fundamental and up to eight harmonics were available and were controlled by means of drawbars and preset keys or buttons.
A Hammond console organ included two 61-key manuals; the lower, or Great, and upper, or Swell, and a pedal board consisting of 25 keys. The concert models had a 32-key pedalboard. Hammond also patented an electromechanical reverb device using the helical tortion of a coiled spring, widely copied in later electronic instruments.
As well as being a succesful home entertainment instrument, The Hammond Organ became popular with Jazz, Blues and Rock musicians up until the late 1960's and was also used by 'serious' musicians such as Karheinz Stockhausen in "Mikrophonie II".

fig. 47 Hammond L122, L133, L143

The Sonothèque (1936)

The sonothèque created by L. Lavalée was a "coded performance electronic instrument using photo-electric translation of engraved grooves".

The Kraft durch Freude Grösstonorgel (1936)

The "Grösstonorgel" was a vacuum tube oscilator based organ, notable for having been witnessed by Adolf Hitler at the 1936 Olympic games. The "Grosstonorgel" was designed by Oskar Vierling, Winston.E.Kock and the staff of the Heinrich-Hertz-Institut in Berlin. Vierling was an important member of the institute which was responsible for most of the intensive activity in electronic music and musical instruments in Germany in the 1930's.

fig. 48 The Electronic Orchestra of the Heinrich Hertz Institut

The Electronic Orchestra of the Heinrich Hertz Institut at the Berlin Radio Show in 1932. Daily lectures were given by Prof. Dr. Gustav Leithauser and his assistant Wolja Saraga (Saraga Generator). Up to six performances took place per day during the 10-day show.

The instruments of the orchestra comprised:

- **2 Theremins** (Leon Termen) played by Martin Taubmann and Tscharikoff
- **1 Trautonium** (Dr. F. Trautwein) played by Oskar Sala
- **1 Hellertion** (Helberger and Dr. Lertes) played by Helberger
- **1 Neo-Bechstein Grand Piano** (Prof Nernst and Bechstein/Siemens) played by Narath and Padua
- **1 Electric Grand Piano** (Oskar Vierling) played by Frl Wolfsthal
- **1 Electric Violin** (Oskar Vierling) played by Frau Sugowolski
- **1 Electric Cello** (Oskar Vierling) played by Dr Reinhold

Vierling's previous work had been designing electro-acoustic instruments such as an electric Cello and Violin, the electro-acoustic Elektrochord and assisted in the development of the Neo-Bechstein-Flügel. Oskar Vierling also assisted Jörg Mager in the construction of the Klaviatursphäraphon at Darmstadt. Other designers who studied at the Heinrich-Hertz-Institut included Harald Bode, designer of the Warbo Formant Organ and the Melochord. The institutes director Karl W.Wagner was himself responsible for half of the electronic instruments built in Germany during the 1930's and developed a voice synthesiser that influenced the work in the USA on the Voder and Vocoders in the 1940's.

The "Licht-Ton Orgel" (Light-Tone organ) (1936)

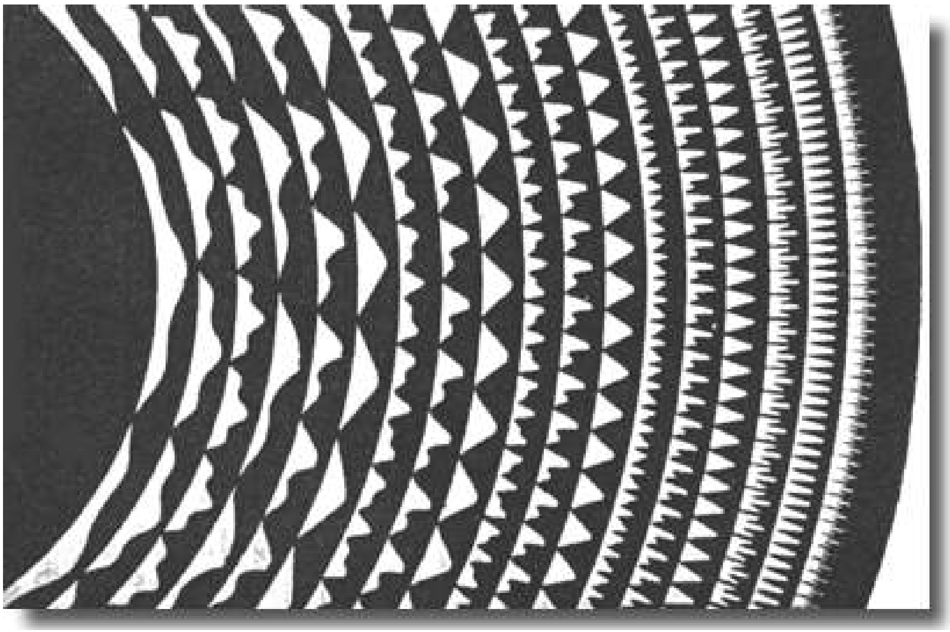

fig. 49 A detail of the Light Tone Organ's glass disk.

The Welte Light-Tone, designed by E. Welte in Germany, 1936, was an electronic instrument using electro-optically controlled tone generators. A glass disk was printed with 18 different waveforms giving 3 different timbres for all the octave registers of each single note. The glass tone wheel rotated over a series of photoelectric cells, filtering a light beam that contolled the sound timbre and pitch.

The "Warbo Formant Orgel" (1937)
The "Melodium: (1938)
The "Melochord" (1947-49)
Bode Sound Co (1963)

The Warbo Formant Orgel (1937)

The Warbo Formant Orgel was the first instrument designed by the designer and pioneer of electronic instruments, Harald Bode (born Hamburg 19 Oct 1909) while at the Heinrich-Herst Institut für Schwingungsforschung at the Technische Hochschule in Berlin. The Warbo Formant Orgel was designed and built in collaboration with C. Warnke and eventually went into commercial production by AG, Dachau. As with many other instruments designed by Bode the 'Warbo Formant Orgel' pioneered aspects of electronics that became standard in later instruments. The Warbo Formant Orgel was a partially polyphonic four-voice keyboard instrument with 2 filters and key assigned dynamic envelope wave shaping, features that were later used on the postwar 'Melochord'.

The "Melodium" (1938)

Bode's second instrument, previewed in 1938 was a monophonic touch sensitive keyboard instrument, the 'Melodium', developed with the assistance of Oskar Vierling, inventor of the 'Grosstonorgel'. The instrument also incorporated a pedal for vibrato and a tuning/transposition knob.

The "Melochord" (1947-49)

Harald Bode built the electronic Melochord 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.
The Melochord was used extensively in the early days of the electronic studio at Bonn University by Dr Werner Meyer-Eppler and was later installed at North West German Radio studios in Köln (alongside a Monochord and a simple oscillator and filter system) where it was used by the Elektronische Musik group throughout the 1950's. Artists who used the Melochord and Monochord at the studio included Herbert Eimert, Robert Beyer, Karel Goeyvarts, György Ligeti, Henri Posseur, Karlheinz Stockhausen and others.
Despite the instruments technical drawbacks, the Melochord was destined to play a historic role in the future of electronic music, Meyer-Eppler's visionary and influential work "Klangmodelle" and lectures at Darmstadt New Music School were all based on the Melochord and in 1961 Harald Bode,

recognizing the significance of transistor based technology over valve based synthesis, wrote a paper that was to revolutionise electronic musical instruments. Bode's ideas of modular and miniature self contained transistor based machines was taken up and developed in the early 1960's by Robert Moog, Donald Buchla and others.

Herbert Eimert and Robert Beyer "Klangstuduie 1". Recorded at the WDR Studio in 1951 using the Melochord, single oscillators and tape manipulation.

Audio File. György Ligeti "Glissandi".Recorded at the WDR Studio in 1957 using the Melochord, oscillators and tape manipulation.

The Bode Sound Co.

fig. 50 The Bode model 7702 Vocoder

From 1950 onwards Harald Bode designed several conventional electronic instruments for Apparatewerk Bayern Germany and Estey Organ Co, USA , beginning with the **'Polychord'** (1950), The **'Bode Organ'** (1951) - this being the basis for the Polychord III, the **'Cembaphon'**(1951) - an amplified harpsichord with electrostatic pickups, The **'Tuttivox'** (1953) and the concert **'Clavioline'** (1953). In 1954 Bode emigrated to the USA where he developed a new model of the **Wurlitzer Electric Piano**.

From 1964, when he worked at the micro circuitry dept of Bell Aerospace laboratories, until his retirement in 1974, Bode pursued privately his own research. Bode developed a modular signal processor incorporating a ring modular and elements of voltage control. In 1963 he developed a frequency shifter and ring modulator under licence to R.A.Moog Co. Bode has more recently developed various sound processing devices such as a Vocoder and an 'infinite phaser' marketed by his own company Bode Sound Co.

During the 1970's Harald Bode composed electronic scores for television commercials and film as well as for live concerts.

The Hammond Novachord (1939)

fig. 51 The Hammond Model Novachord (1939)

The Hammond Novachord was manufactured by the Hammond Organ Co in the USA from 1939 to 1942, designed by Laurens Hammond and C. N. Williams. A total of 1096 models were built.

The Novachord was a polyphonic electronic organ and was Hammonds first electronic tube based instrument. The Novachord was a much more complex instrument than the 'Solovox', Hammond's other electronic instrument, the Novachord used 169 vacuum tubes to control and generate sound and a had a seventy two note keyboard with a simple pressure sensitive system that allowed control over the attack and timbre of the note. The sound was produced by a series of 12 oscillators that gave a six octave range using a frequency division technique- the Novachord was one of the first electronic instruments to use this technique which was later became standard in electronic keyboard instruments.
The front panel of the instrument had a series of 14 switchable rotary knobs to set the timbre, volume, resonance, bass/treble, vibrato (six modulation oscillators were used) and 'brightness' of the sound. A set of 3 foot operated pedals controlled sustain, and volume the third pedal allowing control of the sustain by either foot. The final signal was passed to a preamplifier and then to a set of internal speakers. The Novachord was able to produce a range of sounds imitating orchestral instruments such as the piano, harpsichord, stringed and woodwind instruments as well as a range of it's own new sounds.

In May 1939 'The Novachord Orchestra' of Ferde Grofé performed daily at the Ford stand at the New York World Fair with four Novachords and a Hammond Organ and in Adrian Cracraft's 'All Electronic Orchestra', the Novachord also featured in several film scores (Hans Eisler's "Kammersinfonie" 1940) but seems to have fallen from favour due to the instability of it's multiple tube oscillators and playing technique. The Novachord was discontinued in 1942. A Hammond employee comments:

> "The Novachord made beautiful music if played well, but it was not well adapted either to either an organists style or a pianists style. Thus it required development of a specific style, which not many musicians were prepared to do. it also had technical problems, requiring frequency adjustments to keep it operating chiefly because the frequency dividers and electronic components before the war were not nearly as good as those available in later years. The Hammond Organ Company could have revived it after the war, and could have made it better in light of available technology at the time, but sales had been disappointing ad so it was not considered a good commercial product."

1 9 4 0

Homer Dudley's Speech Synthesisers,
"The Vocoder" (1940) & "Voder"(1939)

fig. 52 Homer Dudley's "Voder" of 1939

"Parallel Bandpass Vocoder"
(1939) Homer.W. Dudley: speech analysis and resynthesis.

"The Voder speech synthesizer"
(1940) Homer.W. Dudley: a voice model played by a human operator.

The Vocoder (Voice Operated reCorDER) developed by Homer Dudley, a research physicist at Bell Laboratories, New Jersey USA, was a composite device consisting of an analyser and an artificial voice. The analyser detected energy levels of succesive sound samples measured over the entire audio frequency spectrum via a series of narrow band filters. The results of which could be viewed graphically as functions of frequency against time.

The synthesiser reversed the process by scanning the data from the analyser and supplying the results to a feedback network of analytical filters energised by a noise generator to produce audible sounds.

A sound sample from Dudley's 1939 Voder, with introduction (170k au file)

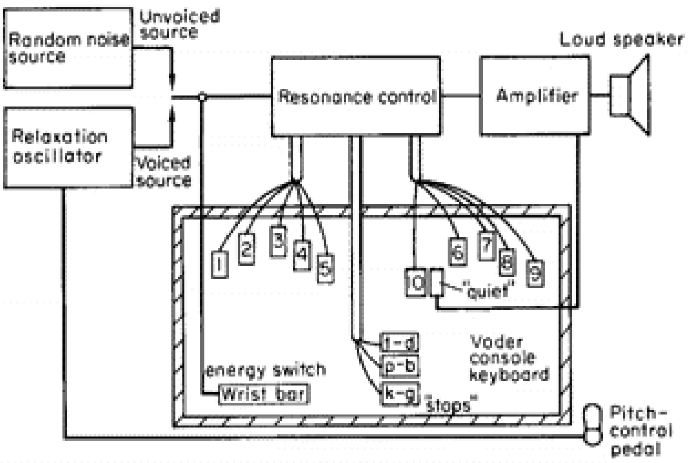

Fig. 53 Diagram of the "Voder"

The fidelity of the machine was limited, the machine was intended as a research machine for compression schemes to transmit voice over copper phone lines. Werner Meyer-Eppler, then the director of Phonetics at Bonn University, recognised the relevance of the machines to electronic music after Dudley visited the University in 1948, and used the vocoder as a basis for his future writings which in turn became the inspiration for the German "Electronische Musik" movement.

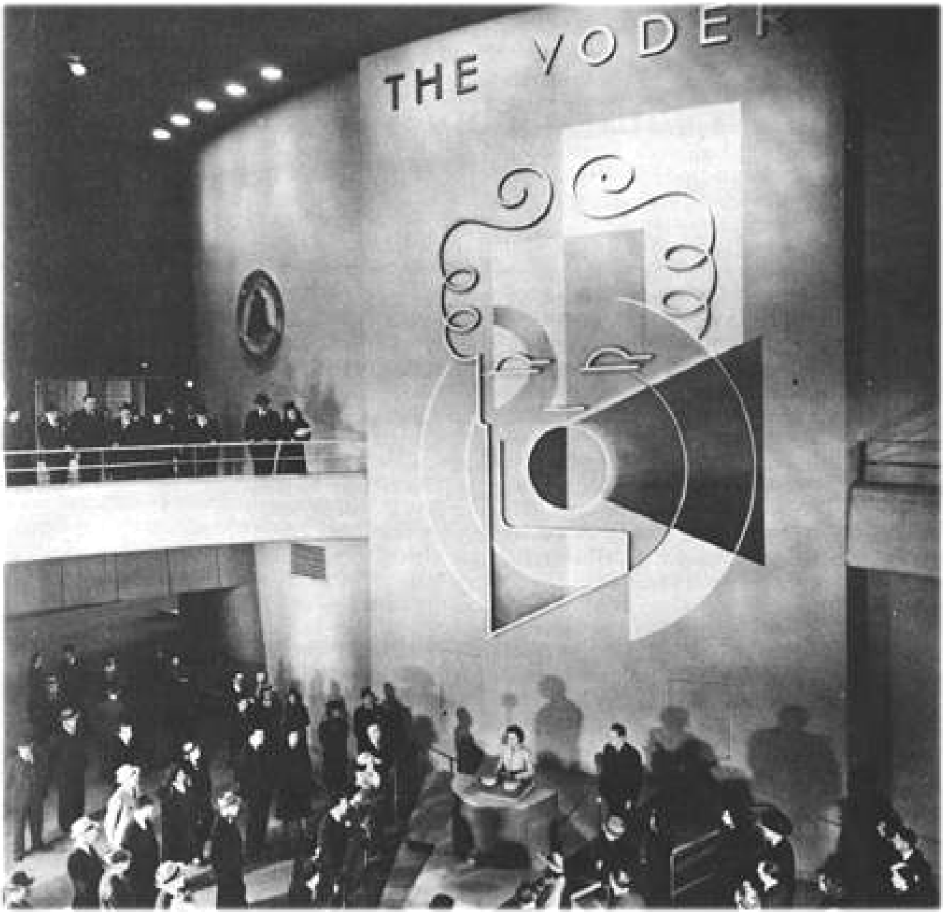

fig. 54 The Voder at the 1939 World's Fair

"At the 1939 World's Fair a machine called a Voder was shown . A girl stroked its keys and it emitted recognsable speech. No human vocal cords entered into the procedure at any point; the keys simply combined some electronically produced vibrations and passed these on to a loud-speaker."

As We May Think" by Vannevar Bush, 1945

The Univox (1940)

Developed by the British 'Univox Company' the Univox was an instrument using a vacuum-tube sawtooth generator modulated by a diode waveform shaper circuit. The pitch range was extended to five octaves using a frequency division technique which also allowed the playing of multiple octaves of the same note from one key. The Univox keyboard had a unique a double contact system under the key allowed basic control over the note shape - striking the key harder caused a thyratron impulse generator make a shorter decay, creating a staccato effect, striking the key softly gave a long decay of up to two seconds. A vibrato oscillator was also provided to modulate the output and also to retrigger the thyratron tube to create 'mandolin' type repeated notes.

The Univox had a front panel of fifteen switches to further control the timbre of the instrument, three vibrato controls, a thryratron modulation control and an overall knee operated volume control. The Univox had a an external amplifier and ten inch speaker unit.
The Univox was noted for the realism in producing string and reed tones such as clarinet and saxaphone.

The Multimonica (1940)

fig. 55 The Hohner Multimonica

The Multimonica 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 Multimonica was marketed in Europe from 1940.

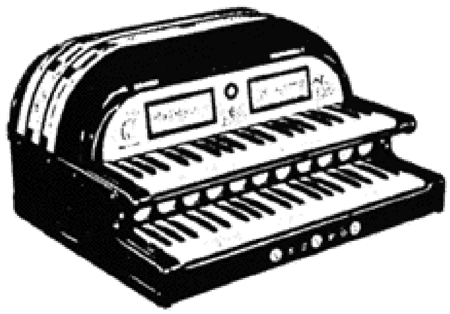

fig. 56 The Hohner Multimonica (drawing)

The Ondioline (1938-40)

Georges Jenny developed the first Ondioline in 1938 whilst undergoing treatment in a tuberculosis sanatorium and continued to re-design and build the instrument at his Paris company "Les Ondes Georges Jenny" (later known as "La Musique Electronique") until his death in 1976. The instruments were individually built by Jenny himself or supplied in kit form, eventually over a thousand instruments were sold in the USA alone. In an attempt to keep production costs low (Ondiolines originally sold for a mere $400) poor quality components were often used, and after a few years, the instrument became unplayable if it was not maintained.

The Ondioline, a monophonic vacuum tube isntrument, 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.

The Ondioline became a popular instrument in Europe, used widely in film and theatre music as well as in light music and cabaret. The Ondioline was marketed in Germany as the "Pianoline" and in The Netherlands as the "Orcheline" and made a notable appearance during the Brussels World Fair (1958) when it was played on top of the Atomium building.

A microtonal version of the instrument was built for the composer Jean-Etienne Marie during the sixties consisting of a four octave keyboard which could be tuned to a variety of microtonal systems.

The Hammond Solovox (1940)

fig. 57 The Model J Hammond Solovox
(Photograph courtesy of Eric Barbour, Svetlana Electron Devices)

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. The Solovox was connected to the electronic sound generation box and speaker housing by three thick cables. The sound was derived from a single LC oscillator which had a frequency range of one octave. The signal from the oscillator was then passed through a series of 5 frequency dividers to create a further two octaves. The Solovox (J+K models) used two vibrating metal reeds modulate the oscillator frequency to create a vibrato effect, in later models this was replaced by a second oscillator acting as a vibrato oscillator.
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.

fig. 58 The sound unit, amplifier and speakers of the Solovox
(Photograph courtesy of Eric Barbour, Svetlana Electron Devices)

The "Electronic Sackbut"(1945) and The "Sonde" (1948)

fig. 59 Hugh Le Caine in his garden

Hugh Le Caine the Canadian composer,physicist and inventor was the producer of innovative instruments and technologies including many custom built electronic instruments and pioneering work with multi-track tape recorders, he was also at the forefront of the development of electronic music studios and an early advocate of "user-friendly" approaches to new technologies.

Unlike better-known contemporaries such as Robert Moog, LeCaine never saw his major inventions developed directly into complete commercial products, most were one off devices which although were never commercial successes had great influence on the world of electronic music. Among his many creations were the "Electronic Sackbut" and the "Sonde".

The "Electronic Sackbut" (1945-1973)

The instrument was a touch sensitive keyboard voltage-controlled synthesizer with pitch,waveform, and formant controllers.

fig. 60 Hugh Le Caine at the Sackbut

Le Caine built the Electronic Sackbut between 1945 (at the University of Toronto) and 1948. It is now recognized to have been the first voltage-controlled synthesizer.

In 1945, when the first Sackbut was built inside a desk, Le Caine visualized an instrument in which the operator would control three aspects of sound through operations on the keyboard in three co-ordinates of space: vertical pressure was to correspond to volume; lateral pressure to pitch change; and pressure away from the performer to timbre.

The control devices were force sensitive. They would alter the sound in response to changes in pressure, something the operator could feel without carefully watching the controls. The timbre controls, however, were soon considerably expanded and could no longer be operated by a single device.

Two innovative techniques stand out in the design of the Sackbut: the use of adjustable wave forms as timbres and the development of voltage control. It is in this regard that the Sackbut is recognized to be the forerunner of the synthesizers of the 1970's.

The 1948 Prototype

fig. 61 The original 1948 Sackbut

The prototype of the Electronic Sackbut, completed in 1948, is now in the collection of the National Museum of Science and Technology. As seen here, it was built on a minimal stand using three legs and three cross pieces. Le Caine did not feel it was an appropriate use of his time to improve the appearance of the instrument by removing the staples and scraps of cloth from the boards that made up the stand.

This photograph was taken in 1954 soon after Le Caine began to work full time designing electronic music instruments at the National Research Council.

The right hand controls the keyboard, playing one note at a time, and applying both vertical pressure to affect volume and horizontal pressure to affect gradual change in pitch. The left hand controls several aspects of the timbre of the sound.

fig. 63 Le Caine with the Sackbut Prototype

fig. 62 The wooden top of the 1948 Sackbut; note the pencilled indications written on the instrument's top

Playing the Sackbut

The control of timbre on the Sackbut was accomplished by the left hand, each finger operating a separate pressure-sensitive control.

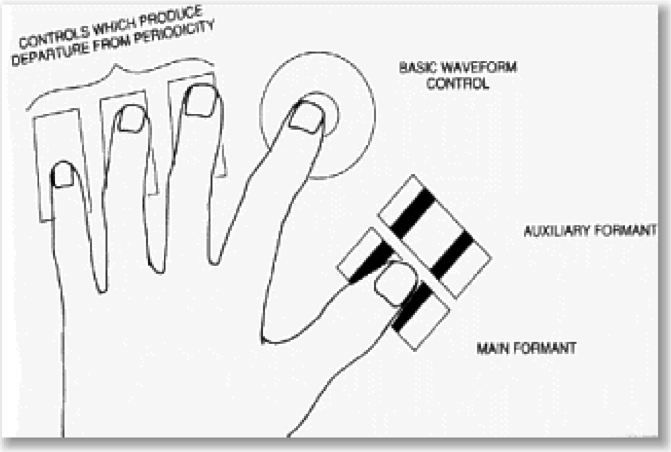

fig. 64 Sackbut controls (1)

The device to continuously alter the wave form was operated by the index finger of the left hand. A moveable pad, shown by dotted lines, made connections at any point within the larger grid of possibilities.

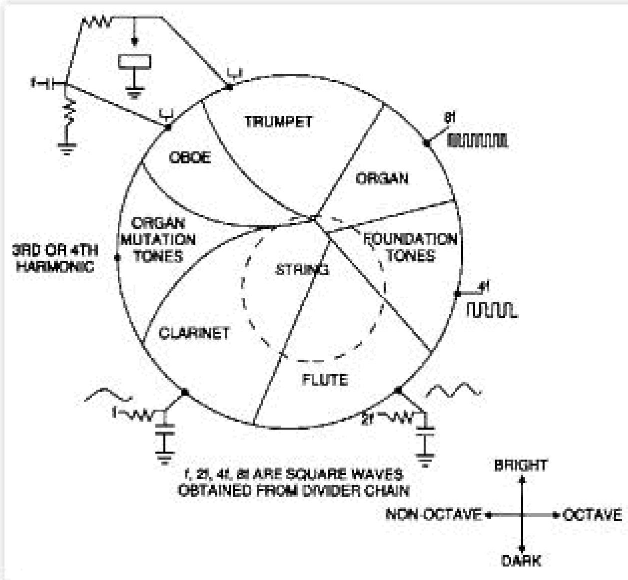

fig. 65 Sackbut controls (2)

The Sackbut Synthesizer

fig. 66 The commercial prototype of the Sackbut Synthesizer

In 1969, Le Caine began to redesign the 1948 Sackbut using modern techniques. By 1971 this working prototype was completed, and there was an attempt to manufacture the instrument commercially as a voltage-controlled electronic keyboard instrument.

The final Sackbut used integrated circuits for the level controls and had an extra octave position, bringing the range of the instrument to seven octaves, its envelope control could be played in reverse without extra adjustments. Plans were made for an instrument with three oscillators but this was never built.

Inside the 1971 Sackbut

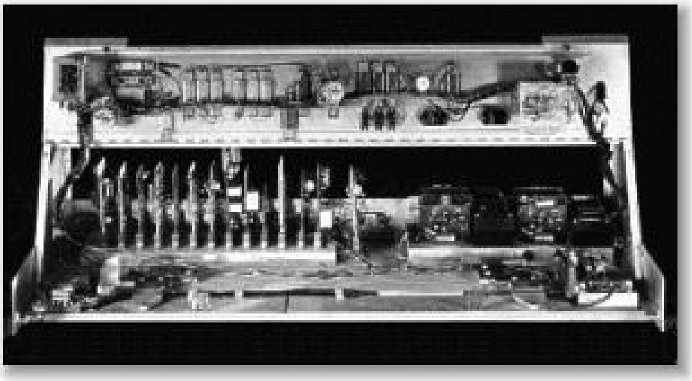

fig. 67 Inside the 1971 Sackbut

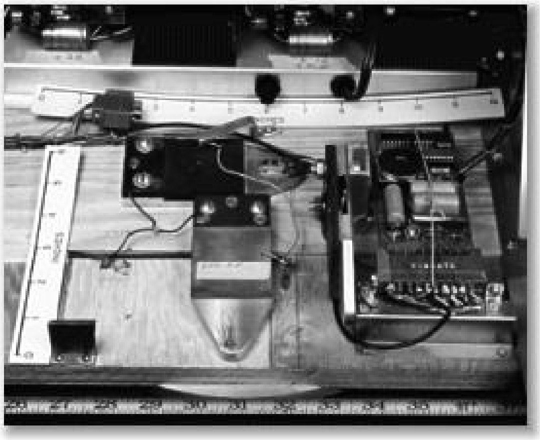

fig. 68 The pressure sensitive devices on the 1971 Sackbut were considerably refined over those of 1948

Le Caine also designed pressure sensitive devices to control aspects of timbre (to control the degree of frequency modulation with low register noise, and the addition of high register formant frequencies). There was also a device for continually and quickly adjusting the wave shape.

The "Sonde"

A one off, custom built for the University of Toronto, Ottowa. The Sonde had 30 fixed frequency oscillators arranged in a 10X20 matrix used to create 200 sine waves whose frequencies were spaced at 5hz intervals: from 5-1khz. Each frequency was routed to a key of a touch sensitive polyphonic keyboard.

Hanert Electric Orchestra (1944-1945)

The Hanert Synthesiser or 'Electric Orchestra' was designed and built by John Hanert c1945 for the Hammond Organ Company and was described as an 'Apparatus for Automatic Production of Music'. The Synthesiser was an instrument for composition and synthesis of electronic music similar to the later RCA Synthesiser and other coded performance machines. Instead of using punch paper tape like the RCA Synthesiser the Hanert Synthesiser had a moving mechanical scanning head that moved over a sixty foot long table covered in eleven inch by twelve inch paper cards. The paper cards held the characteristics of the sound (pitch,duration,timbre and volume) stored in the form of graphite marks that were 'read' by direct electrical contact of the scanning head.

The sound generating part of the instrument occupied a whole room and consisted of a bank of vacuum tube oscillators, a random frequency generator (to produce 'white noise' characteristics for percussive sounds) and wave shaping circuits. Speeding up and slowing down of the music(accelerando/decelerando) could be controlled by altering the speed and direction of the scanning head.

Hanert's unique system allowed a great deal of flexibility in composition and synthesis, marks could be added to the cards simply by using a graphite pencil and the cards could be arranged in any order allowing variations and multiple combinations in the composition. Hanert commented:

> "The composer ultimately usually has but slight control over the instrumentation employed by the orchestra and it is only after tedious and time consuming steps have been taken and the orchestra has ultimately rendered the composition the composer can actually audition his composition......its is seldom that a recording represents the closeness to perfection which is anticipated by the composer and the cunductor.......
> In the method and apparatus of this invention the composer, arranger or conductor has at his command means for controlling the quality of each note, its intensity, envelope and the degree of accent, duration and tempo without necessarily affecting any other note or tone of the composition. he has under his control, within the limitations imposed by the apparatus as a whole, facilities for producing, under his sole control, any of a substantially infinite variety of renditions of a composition."

The Clavioline (1947) & Combichord (1953)

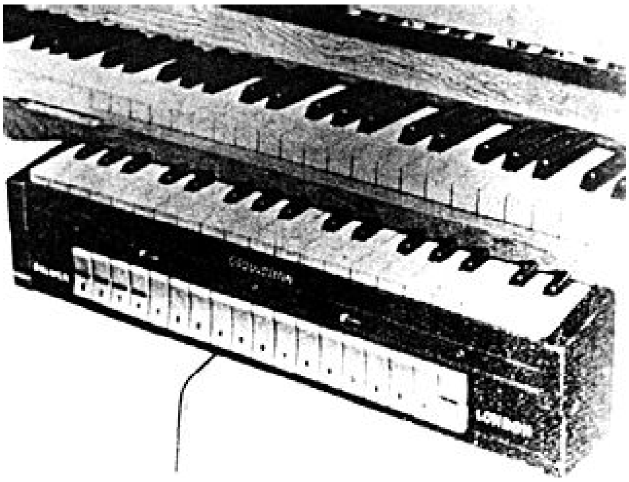

fig. 69 The Selmer version of the Clavioline attached to a piano keyboard

The Clavioline

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. Martin produced a duophonic model of the Clavioline in 1949 shaped like a small grand piano and featuring a 2 note polyphonic system, the duophonic model never went into production. The Clavioline made brass and string sounds which were considered very natural at the time and was widely used in the 1950's and 60's by pop musicians such as the Beatles and the Tornadoes (on'Telstar') and by the jazz musician Sun Ra.

The Clavioline was licensed to various to various global manufacturers such as Selmer (UK) and Gibson (USA). An expanded concert version was produced in 1953 by René Seybold and Harald Bode, marketed by the Jörgensen Electronic Company of Düsseldorf, Germany. In the 1940's Claviolines were also built into large dance-hall organs by the Belgian company Decap and Mortimer/Van Der Bosch.

The Combichord

The Combichord was a combination of a Clavioline and a Tuttivox, designed by Harald Bode in the 1950's.

The Monochord (1948)

fig. 70 The Electronic Music studio of North West German Radio, Köln (1952)

The Monochord was commissioned from Dr Freidrich Trautwein, the inventor of the Trautonium, by the Electronic Music studio of North West German Radio studios, Köln to upgrade its synthesis module which consisted at the time of one sine wave generator and filter system.

The Monochord was basically a modified concert Trautonium, a monophonic variable pitch interval keyboard controlling a valve based tone generator. The keyboard was pressure sensitive and allowed dynamic variations of the envelope shape. A foot pedal controlled the overall volume output from the machine.

The Free Music Machine (1948)

Aka "The Electric Eye Tone Tool Cross-Grainger for Playing Graingers Free Music"

fig. 71 Percy Grainger

The 'Free Music Machine' was created by musician and singer Burnett Cross and the Australian composer Percy Grainger. Grainger a virtuoso Pianist and pupil of Busoni, had been developing his idea of "free music" since 1900: based on eighth tones and complete rhythmic freedom and unconventionally notated on graph paper. Grainger had experimented using collections of Theremins and changing speeds of recorded sounds on phonograph disks and eventually developed his own instruments. Graingers experiments with random music composition predated those of John Cage by 30 years with "Random Round" written in the 1920's.
Graingers first experiments used a Pianola "player piano" controlling three Solovoxes by means of strings atached to the Pianola's keys, this combintaion was abandoned as it was not possible to create a continuous glissando effect from the Pianola. Grainger started work on a more elaborate but eccentric machine in collaboration with Burnett Cross and his wife, Ella Grainger.
The Free Music Machine was a machine that controlled the pitch, volume and timbre of eight oscillators.Two large rollers fed four sets of paper rolls over a set of mechanical arms that rolled over the cut contours of the paper and controlled the various aspects of the oscillators.

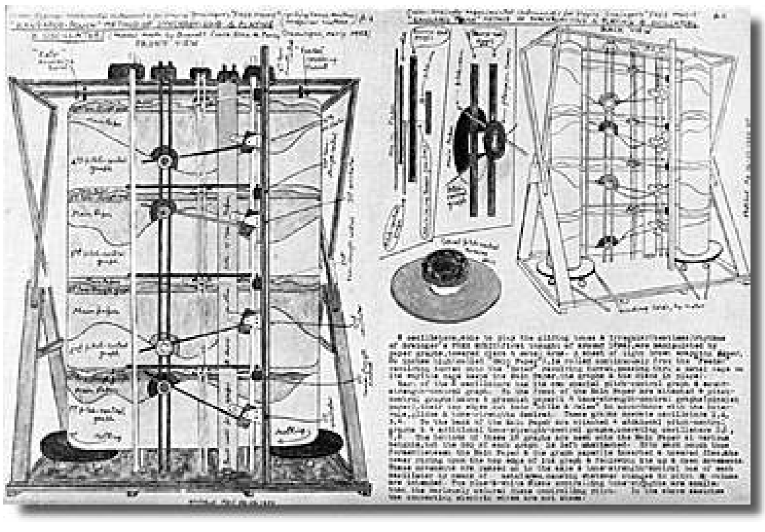

fig. 72 The Kangaroo Poutch Free Music Machine (Grainger's diagram)

Graingers notes decribing the above diagram, April 1952:

" 8 oscillators, able to play the gliding tones and irregular (beatless) rythms of Graingers FREE MUSIC (first thought of around 1892), are manipulated by paper graphs, towered discs and metal arms.A sheet of light brown wrapping paper 80 inches high (called "main paper"), is rolled continually from the "Feeder" revolving turret into the "Eater" revolving turret, passing through a metal cage on its way (the cage keeps the Main Paper, the graphs and ths discs in place).

Each of the 8 oscillators has its own special pitch control graph and sound strength control graph. To the front of the main paper are attached 4 pitch-control graphs (mauve and greenish paper) and 4 tone-strength control graphs (pinkish paper), their top edges cut into "hills and dales" in accordance with the intervals & tone strength desired. These graphs operate oscillators 1,2,3,4. To the back of the Main Paper are attached 4 additional pitch control graphs & 4 additional tone strength control graphs, operating oscillators 5,6,7,8 The bottoms of these 16 graphs are sewn onto the main paper at various heights but the top of each graph is left unattached. Into each pouch thus formed (between the main paper and thegraph paper) is inserted a towered metal disc, the tower riding the upon the top edge of the graph & following its up and down movements. These movements are passed on to the axle and tone strength control box of each oscillator by means of metal arms, causing whatever changes in pitch and volume are intended. The blue-and-white discs controlling tone strengths are smaller than the variously coloured discs controlling pitch. In the above sketches the connecting electric wires are not shown."

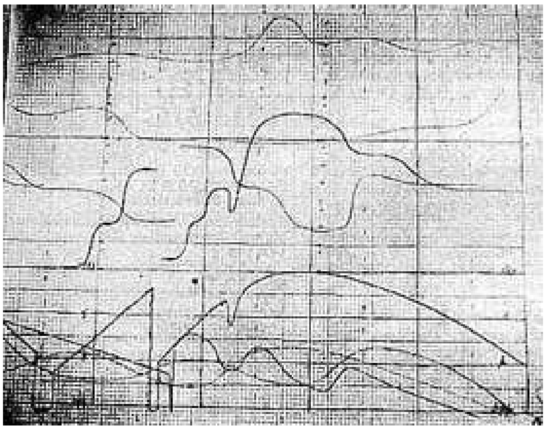

fig. 73 A typical score by Grainger for a quartet of Theremins.

Grainger specified the requirements of his Free Music Machine to be:

- To play any pitch of any size, half, quarter or eighth tones, within the range of 7 voices.
- To be able to pass from pitch to pitch by way of a controlled guide as well as by leap
- Complex irregular rhythms must be able to be performed past the scope of human execution. Dynamics were to be precisely controlled.

The machine had to be to be run and maintained by the composer.

Grainger was a continual experimenter picking up skills where necessary, amongst some of the eccentric instruments he produced were:

- The first sliding pipes for playing gliding tones.
- The electrical reproducing Duo Art grand piano 1932, for beatless music and irregular barring.
- The portable folding harmonium.
- The Burnett Cross movie-film gliding soundtrack, (abandoned as it did not allow Grainger to deal directly with the sounds themselves).
- The Smith's Organ Flute Pipe, set up with hanging mops, rolling pins.

- A range of experiments with reeds in boxes used as tone tools played with vacuum cleaners (1944-6)
- The sewing machine and hand drill (to act as an oscillator for playing variable tones) October 1951.
- The "Kangaroo Pouch", Grainger's own efficient framework design with the skatewheel mountings suggested by his collaborator, Burnett Cross and four vacuum-tube oscillators built by Branch, an electronics student, from the local White Plains High School.
- The Butterfly Piano conversion tuned in 6th tones, (1952)
- The electric eye tone tool Cross-Grainger 1957-59, the last remaining component.

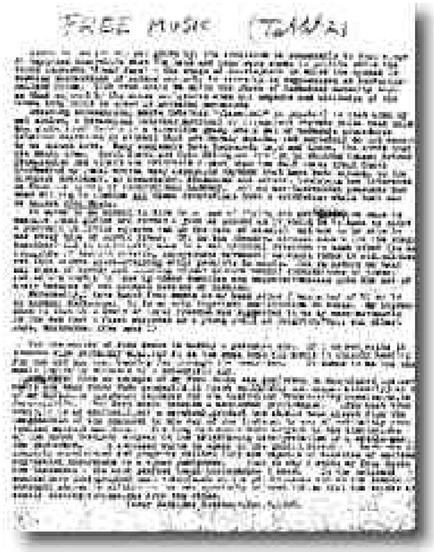
FREE MUSIC

fig. 74 Percy Grainger's description of Free Music. December 6th, 1938

FREE MUSIC (Tablet 2)

Music is an art not yet grown up; its condition is comparable to that stage of Egyptian bas-reliefs when the head and legs were shown in profile while the torso appeared "front face" - the stage of development in which the myriad irregular suggestions of nature can only be taken up in regularised or conventionalised forms. With Free Music we enter the phase of technical maturity such as that enjoyed by the Greek sculptors when all aspects and attitudes of the human body could be shown in arrested movement.

Existing conventional music (whether "classical" or popular) is tied down by set scales, a tyrannical (whether metrical or irregular) rhythmic pulse that holds the whole tonal fabric in a vice-like grasp and a set of harmonic procedures (whether key-bound or atonal) that are merely habits, and certainly do not deserve to be called laws. Many composers have loosened, here and there, the cords that tie music down. Cyril Scott and Duke Ellington indulge in sliding tones; Arthur and others use intervals closer than the half tone; Cyril Scott (following my lead) writes very irregular rhythms that have been echoed, on the European continent, by Stravinsky, and others; Schoenberg has liberated us from the tyranny of conventional harmony. But no non-Australian composer has been willing to combine all these innovations into a consistent whole that can be called Free Music.
It seems to me absurd to live in an age of flying and yet not to be able to execute tonal glides and curves - just as absurd as it would be to have to paint a portrait in little squares (as in the case of mosaic) and not to be able to use every type of curved lines. If, in the theatre, several actors (on the stage together) had to continually move in a set theatrical relation to each other (to be incapable of individualistic, independent movement) we would think it ridiculous, yet this absurd goose-stepping still persists in music. Out in nature we hear all kinds of lovely and touching "free" (non-harmonic) combinations of tones, yet we are unable to take up these beauties and expressivenesses into the art of music because of our archaic notions of harmony.

Personally I have heard free music in my head since I was a boy of 11 or 12 in Auburn, Melbourne. It is my only important contribution to music. My impression is that this world of tonal freedom was suggested to me by wave movements in the sun that I first observed as a young child at Brighton, Vic., and Albert Park, Melbourne. (See case I)

Yet the matter of Free Music is hardly a personal one. If I do not write it someone else certainly will, for it is the goal that all music is clearly heading for now and has been heading for through the centuries. It seems to me the only music logically suitable to a scientific age.
The first time an example of my Free Music was performed on man-played instruments was when Percy Code conducted it (most skilfully and sympathetically) at one of my Melbourne broadcast lectures for the Australian Broadcasting Commission, in January, 1935. But Free Music demands a non-human performance. Like most true music, it is an emotional, not a cerebral, product and should pass direct from the imagination of the composer to the ear of the listener by way of delicately controlled musical machines. Too long has music been subject to the limitations of the human hand, and subject to the interfering interpretation of a middle-man: the performer. A composer wants to speak to his public direct. Machines (if properly constructed and properly written for) are capable of niceties of emotional expression impossible to a human performer. That is why I write my Free Music for theramins - the most perfect tonal instruments I know. In the original scores (here photographed) each voice (both on the pitch-staves and on the sound- strength staves) is written in its own specially coloured ink, so that the voices are easily distinguishable, one from the other.

Percy Aldridge Grainger, Dec.6, 1938

The "Electronium" and "Electronium Pi" (1950)

The Electronium

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.

Electronium Pi

Electronium Pi was a keyboard controlled electronic instrument with 20 stop-tabs for divide-down synthesis. The Electronium Pi had a three octave range, transposable up or down within six octaves, controlling a single vacuum tube oscillator.The Electronium Pi was used in music concerts as an add-on for piano players and was much used throughout the 1950's in germany for both light and serious music. The Electronium Pi was used by several german Avant-Garde composers, Karlheinz Stockhausen used various Electronium models on "Telemusik" and "solo"(1952-6) and later on "Kurzwellen" (1968), These pieces being performed by his own group with the pianist Harald Bojé playing a modified standard Electronium.

Dr Kent's Electronic Music Box (1951)

The Electronic Music Box was a synthesis and composition device designed and built as a personal project by Dr Earle L.Kent while employed at the C.G.Conn Ltd Company, Ekhart, Indiana, USA, to design electric organ circuits. The Music Box was an analogue 'beat frequency' vacuum tube based synthesiser controlled by a punched paper strip device as used previously in the 1930's by instruments such as Givelet and Coupleaux's 'Givelet' and later on the RCA mkII and Siemens Synthesiser amongst others. The punch paper strip was a system similar to a 'pianola' paper reader and allowed the composer to produce musical sequences that were beyond the manual dexterity of the performer:

> "The goals established for the music Box involved wider flexibility of performance than is possible in any conventional musical instrument. It was felt that it should not be confined to the usual limitations of manual keying. It should be capable of grater speed and wider combinations than are possible by manual or pedal dexterity, and it should not be limited to the equally tempered scales as are most keyed instruments. It was recognised that virtually any speed or combination could be obtained by keying with a perforated paper roll with the loss of some of the vital control usually exercised by a musician while making music and also with the loss of its conventional acceptance as a musical instrument. However, it was felt that a musician usually "records" his manual manipulation rather precisely in his brain before a concert by repetitive rehearsal and that the losses by recording this operation on paper would be exceeded by the gains"
>
> *Dr. Earle L. Kent*

Although based on the established 'beat frequency'/heterodyning principle, Kent's instrument employed a more complex system of frequency changers to create a more interesting range of timbre and control over the shape of the note. The Music Box was designed to allow control off the 'slurring' of the note, formant filtering control and control of volume and depth and rate of tremolo. The Electronic Music Box was influential on the development of electronic musical intruments. Dr Kent was visited by Harry Olson who later adapted features of his RCA synthesiser to incorporate functions of the Music Box, but the Conn company chose not to exploit the commercial possibilities of the instrument.

"An Electronic Music Box"

A complete copy of the paper presented by Dr Earle L.Kent to the Institute of Radio Engineers (I.R.E) at the Seventh Annual National Electronics Conference and Exhibition, Chicago, Illinois. October 22, 1951.

Paper presented by Dr Earle L. Kent to the Institute of Radio Engineers (I.R.E) at the Seventh Annual National Electronics Conference and Exhibition, Chicago, Illinois. October 22, 1951. Sponsored by the Professional Group on Audio.

TRANSACTIONS OF THE IRE-PGA

AN ELECTRONIC MUSIC BOX

Earle L.Kent
C.C. Conn Ltd.
Elkhart, Indiana

Introduction

Considerable progress has been made in circuits and techniques for the production of music electronically. Many of these ideas have been combined in a novel device for producing music. It is called an Electronic Music Box for lack of a better name and because the tones it produces are keyed automatically. Only musical results have been considered in the development of this device. Its commercial possibilities , and the possible reaction of musicians to it, have had no influence on its design. the project was a personal spare time activity.

The goals established for the music Box involved wider flexibility of performance than is possible in any conventional musical instrument. It was felt that it should not be confined to the usual limitations of manual keying. It should be capable of grater speed and wider combinations than are possible by manual or pedal dexterity, and it should not be limited to the equally tempered scales as are most keyed instruments. It was recognised that virtually any speed or combination could be obtained by keying with a perforated paper roll with the loss of some of the vital control usually exercised by a musician while making music and also with the loss of its conventional acceptance as a musical instrument. However, it was felt that a musician usually "records" his manual manipulation rather precisely in his brain before a concert by repetitive rehearsal and that the losses by recording this operation on paper would be exceeded by the gains.

Other goals for the device included wide flexibility and easy control of the other musical attributes. Wide control was desired for the timbre of the tones, including both harmonic content and formant of the tones. the attack and release, or start and stop, of the tones should be variable over wide ranges as well as the pitch and vibrato or tremolo. The instrument should be able to slur or "play between keys" as most stringed instruments can and the tones should have spacial qualities that are not achieved by when the tones come from one source such as one loudspeaker. Means for realizing these goals and other desirable features are exemplified in the electronic music box.

Tone Source

A tone generator that is capable of the desired versatility while being keyed by a perforated roll of paper is the heart of the device. It was felt that a tone source such as indicated by [*Figure 1*] met the requirements better than any other known type of generator. Each voice produced by the music box requires an individual channel as shown. This method of tone production utilizes a frequency changer (1) which makes it possible to create a tone with a predetermined harmonic content at a fixed frequency and to change the fundamental frequency of this wave, to produce the wanted tone pitch, without changing the harmonic content. This method has further features because it is possible to key a DC voltage to change the pitch and because it is easy to introduce a desirable tremolo effect. The fixed oscillator indicated in the Block Diagram [*Figure 1*] should operate at some frequency above the audio range, say 30 kc. The production of the 30 kc complex tone can be by synthesis or any other method that may be considered adequate for the particular application. The 30 kc complex tone is then changed in frequency to whatever pitch is desired by the frequency changer, The changer requires a narrow pulse for its operation, The pulse frequency must be variable so its frequency is equal to that of the fixed oscillator plus or minus the audio frequency that is to be produced, For example, if a 440 cps tone is to be produced, the pulse frequency would be either 30,440 cps or 29,550 cps.

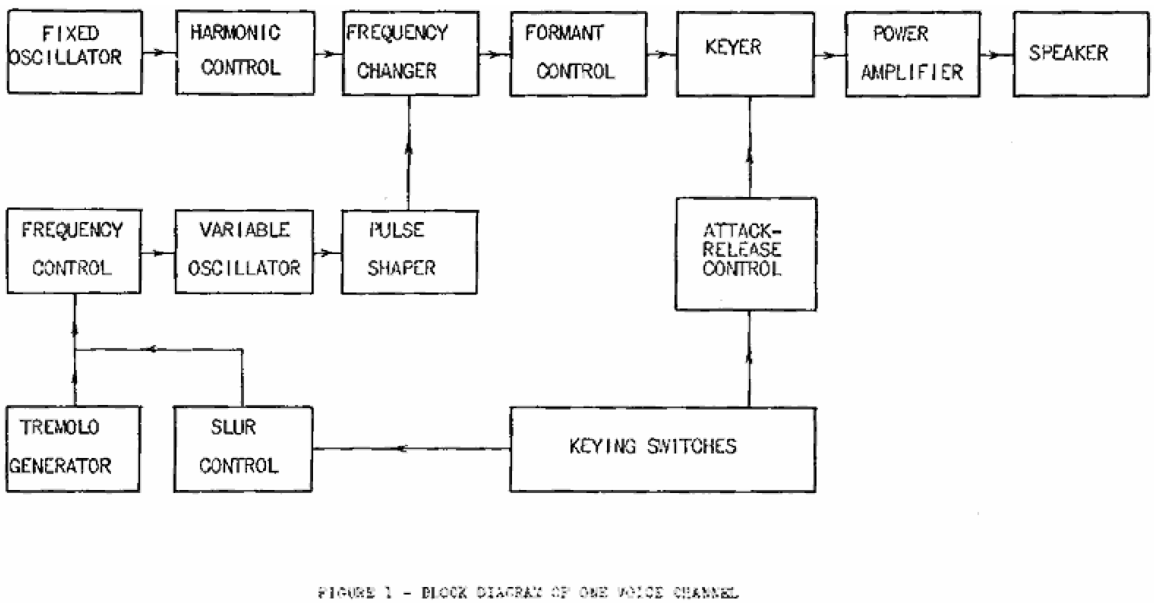

fig. 75 "Figure 1"

Frequency Control

The pulse frequency can be controlled by varying reactance or resistance directly in the pulse generating circuit, It is controlled in this instance indirectly by varying the dc voltage on the grid or a reactance tube in the variable oscillator circuit, The voltage for this control can be established by any convenient means. Variable resistance may be used as voltage dividers to make the tuning of each note to any desired pitch convenient.

Slur Control

An RC circuit introduced between the source of the tuning control voltage and the reactance tube grid provides a variable delay in tuning changes that enables the instrument to slur at a suitable rate from one pitch to another.

Tremolo Generator

A low frequency oscillator whose speed can be controlled provides an ac signal that provides tremolo or vibrato effects when introduced to the tuning circuit, This is a frequency modulation effect and a pleasing tremolo results, The speed and magnitude of the vibrato are controlled by the "operator" of the instrument.

Formant Control

After the tone leaves the frequency changer it can be modified by suitable filters for formant control if desired. The use of resonant circuits here produces effects that are comparable to those produced in conventional musical instruments.

Keying

The output of the formant control stage is turned on and off by a keying stage that again uses a dc voltage for control, The attack and release envelopes of the tone are controlled by varying the time constants of RC circuits. The key switch may be controlled by a conventional organ-type keyboard or any other arrangement that may be desired.

Volume Control

The dynamics of the voice channel are controlled by conventional volume control techniques, The intensity of the tone produced by the loudspeaker can cover any required range of volume.

The Demonstration Circuit

A functional model constructed to demonstrate the possibilities of the music box makes use of a circuit that is not intended to represent the ultimate in design. Some of the more obvious features such as formant control are omitted and a very simple harmonic control is provided, The circuit is shown in Figure 2.

The fixed frequency tone is generated at 30 kc by a push-pull oscillator that produces a relatively pure wave and two pulse waves 180 degrees out of phase with each other, By means of mixer tubes these three ingredients are mixed in proper proportions to produce the complex tone wanted, This 30 kc tone is introduced to a control grid of the pentagrid mixer tube that functions as a frequency changer.
The variable frequency pulse wave is derived from the cathode circuit of a variable oscillator whose frequency is controlled by a variable reactance tube, The dc voltage applied to the grid of this tube establishes the frequency. A capacitor is provided to maintain whatever voltage is established by the key switch after the switch is opened, This is particularly useful if the channel is keyed from an organ-type keyboard because it makes it possible to have the pitch maintained during a sustained tone release after the key is allowed to return to its normal "up" position, This capacitor in junction with a variable resistor constitutes the slur control, The pitch changes between notes may be rapid or gradual.
A variable potentiometer is provided for each pitch the channel is to produce, They may be tuned to equally tempered scale, just scale, or

any other scale. If it is necessary to quickly change from one scale to another, this may be done by using auxiliary controls that can be switched in with a gang switch.

The tremolo signal is introduced in the tuning potentiometer circuit so as to affect the high notes more than the low tones.

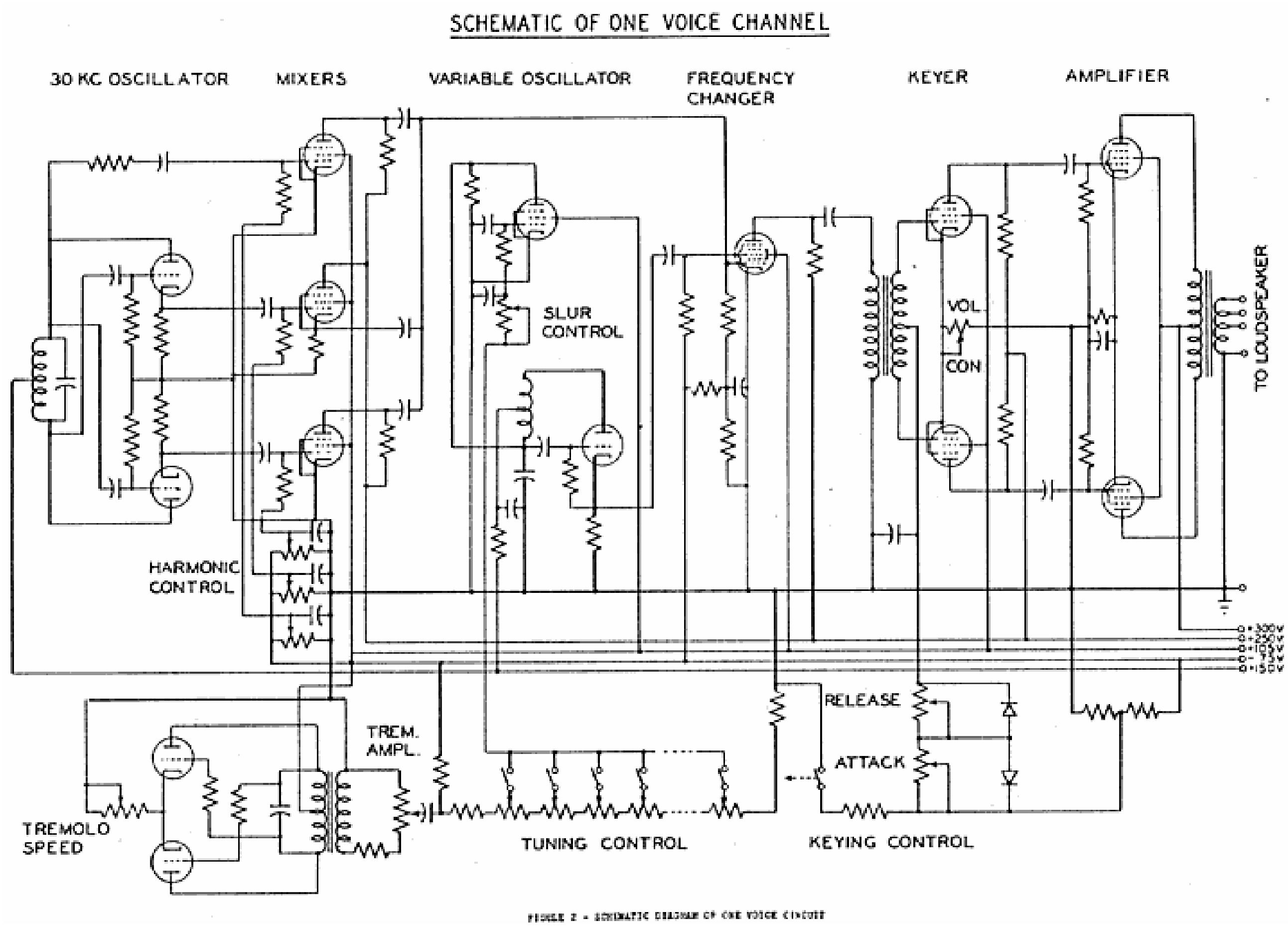

fig. 76 "Figure 2"

A balanced amplifier is used in the keying stage to turn the tones on and off, This stage is biased to cut-off when the keying switch is open, When it is closed, the bias is reduced to allow the stage to conduct the signal to the power amplifier, In order to key this stage with a single throw switch, which is especially desirable when keying with a perforated paper roll, and yet be able to have independent control of the attack and release characteristics, requires that the controls be shunted with rectifiers. Closure of the key switch causes the voltage across the capacitor in the keying circuit to become less negative and current is said to flow into it, This current flows through the ATTACK control and through the rectifier shunting the RELEASE control, Opening the key switch causes the reversed of the current as the grid voltage returns to its original negative value and the current flows through the RELEASE control and the rectifier shunting the ATTACK control. These controls make staccato and legato effects possible and they allow struck, or plucked, string effects.

The keying is done by a perforated roll of wrapping paper, The paper speed is adjustable by changing the speed of the roll driving motor in order to control the tempo or speed of the music.
The tone timbre, attack, release, tremolo speed, tremolo anplitude, slur, and dynamics are controlled by knobs on each voice channel, These controls are not particularly convenient to operate in the form and location shown but were so made for ease of construction.

The model demonstrates the practicabillty of such a device and indicates the possibility of a composer or an arranger producing music without many of the usual limitations of musical instruments and musicians. It opens new possibilities in musical fantasy comparable to what has been done with animated cartoons in motion pictures.

The tuning stability is about the same as that of a violin. A knob is provided to tune the instrmunent silently using the 60 cycle power line frequency as standard. The individual notes do not need to be tuned each time the instrument is used but screwdriver adjustments are provided to tune individual notes to the equally tempered scale, the just scale, or any other musical scale.

The electronic music box is not expected to replace any existing musical instruments but it may prove to be useful in research and education in music and it may be used to supplement conventicnal instruments in radio, recording, motion pictures, and concert work.

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1. Earle L. Kent, "*A Method for changing the frequency of a complex Wave*"
Proceedings National Electronics Conference, vol. 2, pp, 329-338; 1946,

The "Clavivox" (1950) & The "Electronium-Scott" (1950-70)

fig. 77 Raymond Scott's 'Clavivox'

The Clavivox (1950)

The Clavivox was invented by the composer and engineer Raymond Scott circa 1950. Scott (born Harry Warnow September 10, 1908, Brooklyn, NY) was the leader of the Raymond Scott Quintet, working originally for the CBS radio house band in the 1930s. Beginning in the early 1940s, his music made for eccentric but brilliant scores for cartoons for Warner Bros such as 'Looney Tunes' and 'Merrie Melodies'. Scott incorporated elements of Jazz, Swing, pop music and avant-garde modern music into his compositions using a highly personal and unusual form of notation and editing. To the exasperation of his musicians, Scott would record all the band sessions on lacquer discs and later, using a cut and paste technique, edit blocks of music together into complex and almost unplayable compositions.

fig. 78 The Raymond Scott Quintet c1938 (actually a sextet)

In the 1946 Scott founded Manhattan Research Inc., a commercial electronic music studio designed and built by Raymond Scott, featuring Scott's own electronic devices and other electronic instruments of the period. The studio had many unique sound processors and generators including 'infinitely variable envelope shapers', 'infinitaly variable ring modulators', 'chromatic electronic drum generators' and 'variable wave shape generators'. Scott built his first electronic musical instrument in 1946 called "The Orchestra Machine" and in 1948 he built an instrument dubbed "The Karloff" this machine was designed to create sound effects for advertisments and films and was said to be able to immitate sounds such as voice sounds, the sizzle of frying steak and jungle drums.

In the 1950's Scott started to develop a commercial keyboard instrument: the Clavivox (completed circa 1950 The Clavivox was patented in 1956. US Patent number is 2,871,745.). The Clavivox was a vacuum tube oscillator instrument controlled by a three octave keyboard (with a subassembly circuit designed by a young Bob Moog). The instrument was designed to simulate the continuous gliding tone of the Theremin but be playable with a keyboard.

By 1959 the Clavivox had evolved into a more complex proto-synthesiser outgrowing it's Theremin roots (Bob moog) :

> "This was not a theremin anymore -- Raymond quickly realized there were more elegant ways of controlling an electronic circuit. There are several different ways of changing the waveform that are characteristic of, but not identical to analog synthesizer. A lot of the sound producing circuitry of the Clavivox resembles very closely the first analog synthesizer my company made in the mid-'60s. Some of the sounds are not the same sounds that you can get with an analog synthesizer, but they're close."
> The machine was fitted with three 'key' controls on the left of the keyboard that controlled the attack of the note or cut of the note completely, these keys could be played with the left hand to give the enevelope characteristics of the note. Other controls on the Clavivox's front panel were for fine and coarse tuning and vibrato speed and depth.
>
> The original Clavivox was intended for mass production but the complexity and fragility of the instrument made this venture impractical. However later more stable versions were marketed by Dr. Thomas Rhea for Raymond Scott, who later worked for Robert Moog.

The Electronium-Scott (1950-1970)

fig. 79 The 'Electronium-Scott'

From the 1940's through to the 1960's Scott built a number of electronic one off instruments and began experimenting with analogue pitch sequencing devices. One of the prototype instruments built during the fifties was a huge machine standing six feet high and covering 30 feet of scott's studio wall. The pitch sequencer was built using hundreds of telephone exchange type switch relays and the sounds were generated from a bank of 16 oscillators, a modified Hammond organ, an Ondes Martenot and two Clavivoxes. The noise produced by the clicking switches had to be dampened by a thick layer of audio insulation. Scott used the machine to compose several early electronic music pieces in the 1960's including three volumes of synthesised lullabies "Soothing Sounds for Baby" (1963) stylistically predating minimalist music's (Phillip Glass, Steve Reich) use of repetition and sequences by 20 years.

Scott's final and most ambitious machine christened the ' Electronium' (not to be confused with the Hohner Electronium and Electronium-Pi) was the culmination of his work using pitch and rhythm sequencers (the design used a number of Moog-designed components, who had also contributed to the Clavivox) . Scott described the machine as an "instantaneous composition-performance machine, The Electronium is not a synthesizer -- there is no keyboard [it was manipulated with knobs and switches] -- and it cannot be used for the performance of existing music. The instrument is designed solely for the simultaneous and instantaneous composition-performance of musical works"

In 1972, Scott became the head of electronic music research and development for Motown Records. After his retirement, Scott used MIDI technology to continue composing until 1987, when he suffered a debilitating stroke that left him unable to speak or work. Raymond Scott died in 1994.

The RCA Synthesiser

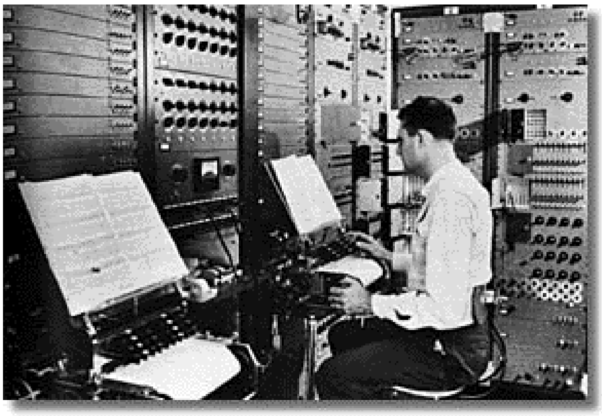


fig. 81 The RCA MKII synthesiser at the Columbia-Princeton Eectronic Music Centre 1956

The RCA Synthesiser was invented by the electronic engineers Harry Olsen and Hebert Belar, employed at RCA's Princeton Laboratories, as a way of electronically generating popular music. Although it never fulfilled its inventors expectations it's novel features were an inspiration for a number of electronic composers during the 1950's.

fig. 80 Harry F Olson in 1956

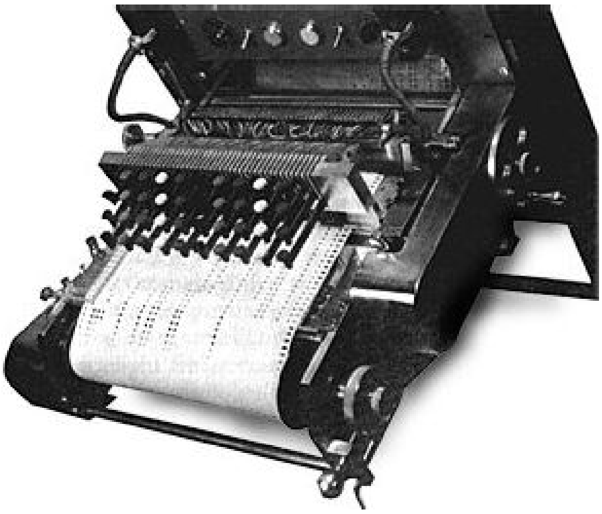


fig. 82 The punch-paper keyboard input of the RCA MKII

The publication of "A Mathematical Theory Of Music" (1949) inspired Belar and Olsen to create a machine to generate music based on a system of random probability. The theory being that random variations of already created popular songs could be used to create new marketeable songs.This flawed theory never came to fruition partly due to the lack of sufficient processing power available at the time and partly to the mistaken concept that the basis of composition could be gleaned from mathematical analysis of a muscial piece.

The sound source was again the Vacuum Tube Oscillator (12 of them in the mkI and 24 in the mkII) but with a unique progammable sound contoller in the form of a punch-paper roll which allowed the composer to predefine a complex set of sound parameters. This allowed the mixing of generated sounds and shaping the sound with dividers, filters, envelope filters, modulators and resonators.

The final audio was monitored on two speakers and recorded to an internal laquer disk cutter, giving six concentric grooves-a total of 3 minutes per groove - which could then in turn be mixed together onto another laquer disk (this archaic system was not updated to the more flexible tape recorder until 1959). By re using and bouncing the disk recordings a totall of 216 sound track could be used.

Sound File A Laquer disc recording fgrom the RCA Synthesiser.

In 1957 a grant from the Rockefeller Foundation, Columbia University was able to rent the RCA Syntheiser MkII and set up the Columbia-Princeton Electronic Music Centre. This organisation became one of the most important centres of elctronic music during the 1950s. New electronic Composers such as Otto Luening, Vladimir Ussachevsky , Milton Babbit and others were now able to experiment with programming complex serial-type compositions on the MKII RCA, which previously were too tricky for a composer to handle manually.

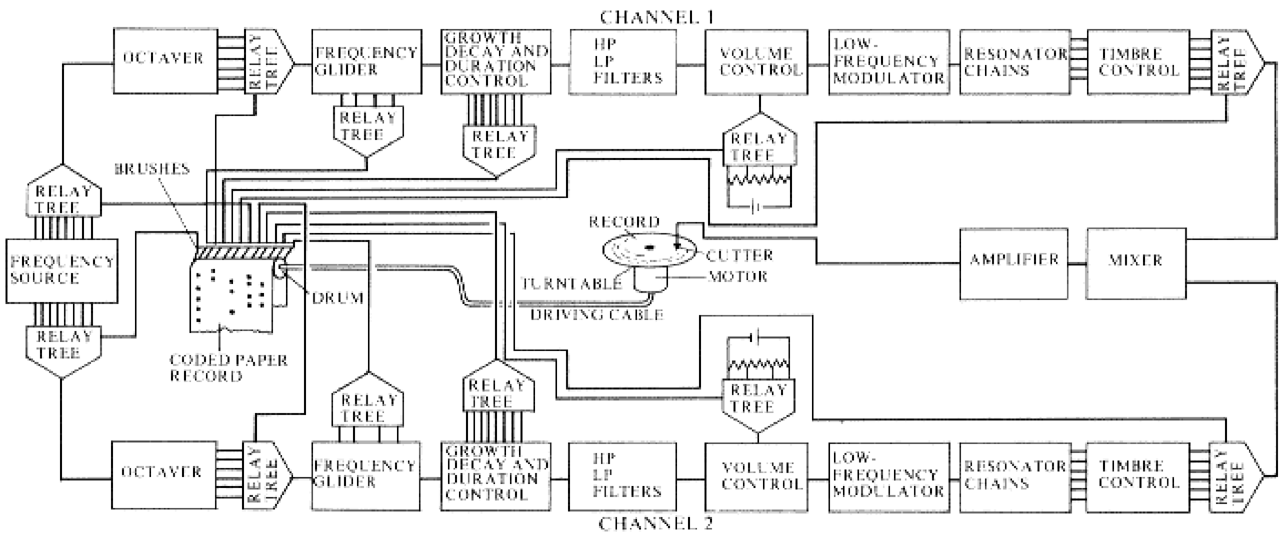


fig. 83 A diagram of the RCA MkII showing hard disk recording and paper roll programmer.

Images of the RCA Synthesiser

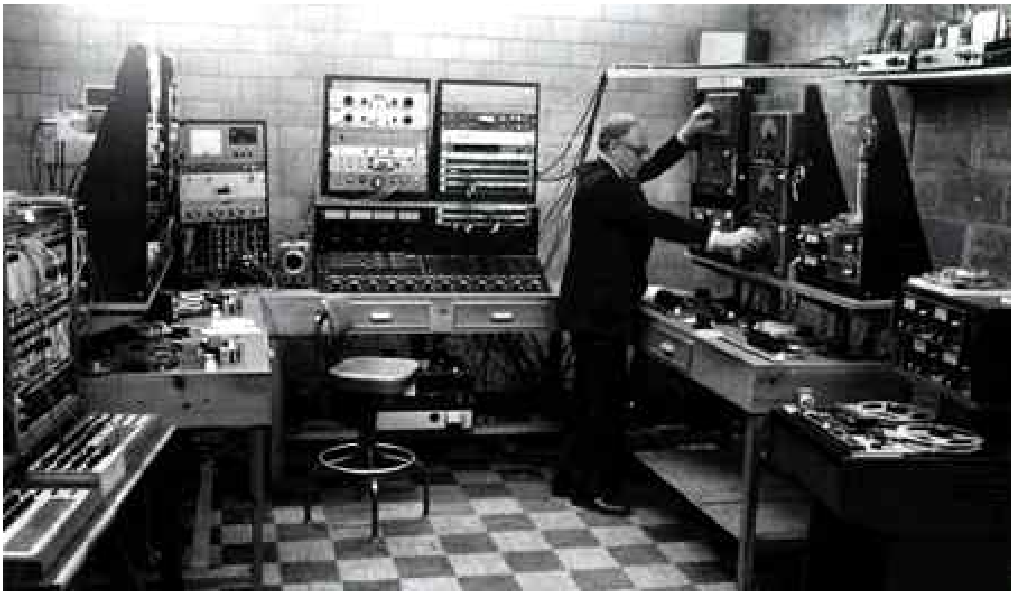


fig. 84 The Electronic Music Centre at Columbia-Princeton University, 1956

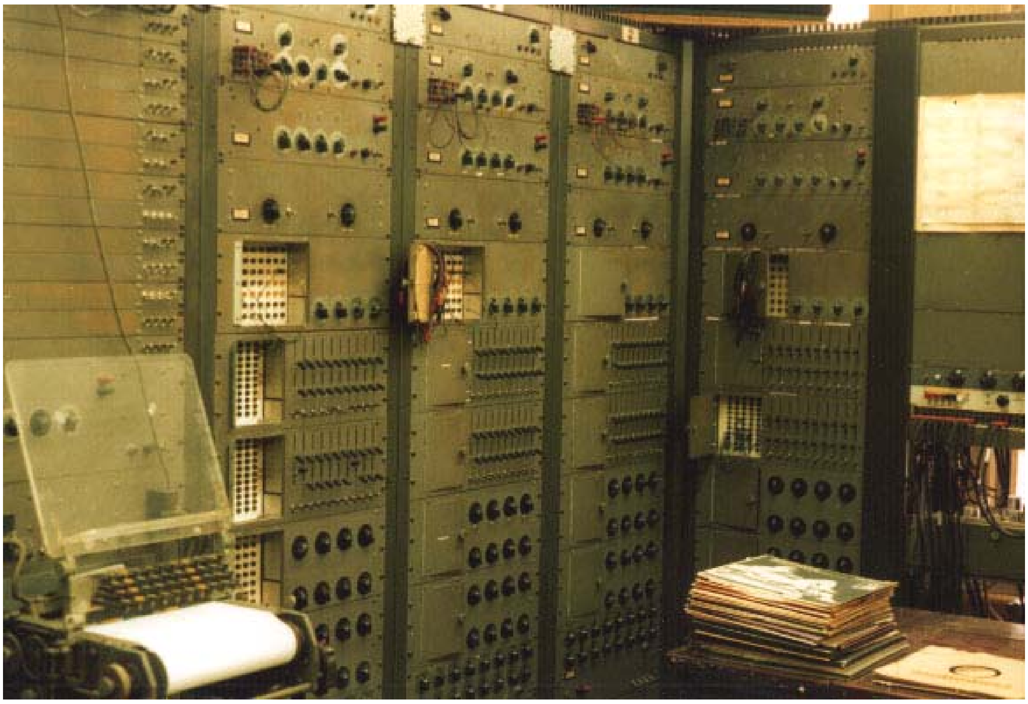


fig. 85 An RCA MkII Synthesiser at the Colombia-Princeton Electronic Music Centre, 1956

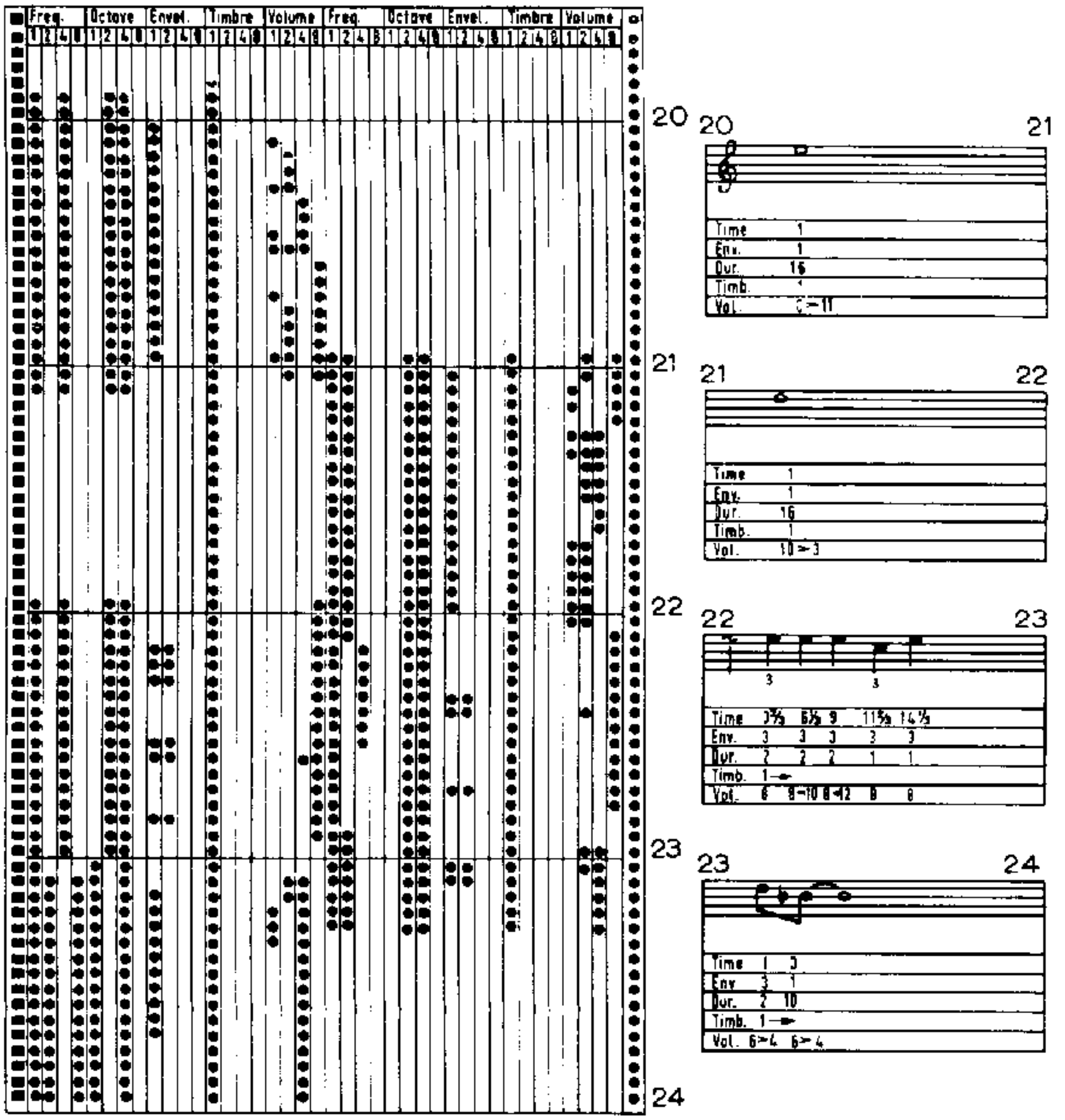


Fig 65 Punched information for RCA Music Synthesizer. Setting-up procedure described on right

fig. 86 A Diagram of the punch-paper roll input of the RCA MKII

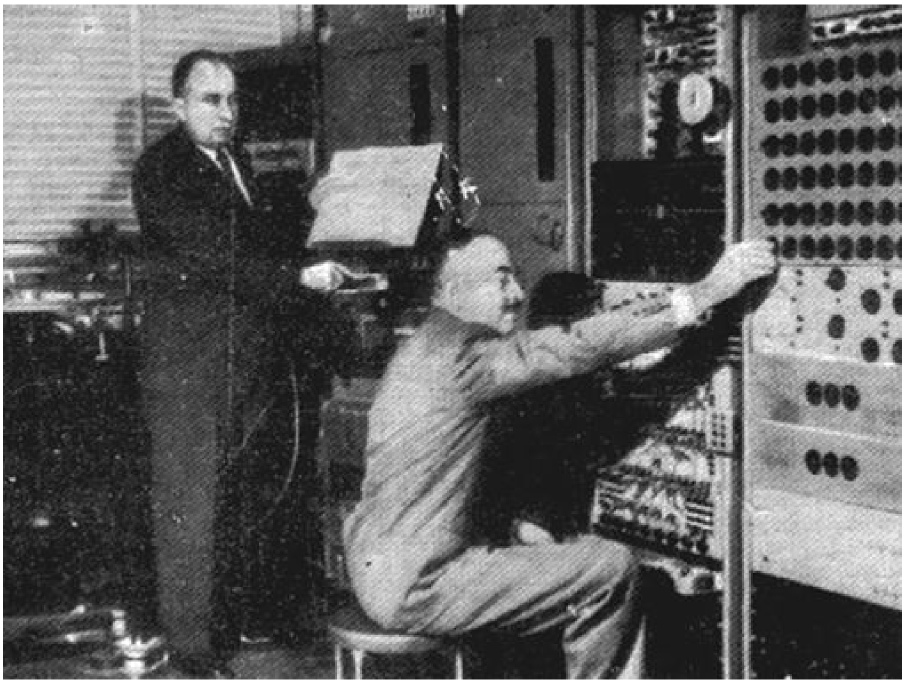


fig. 87 An RCA MkII Synthesiser at the Colombia-Princeton Electronic Music Centre, 1956

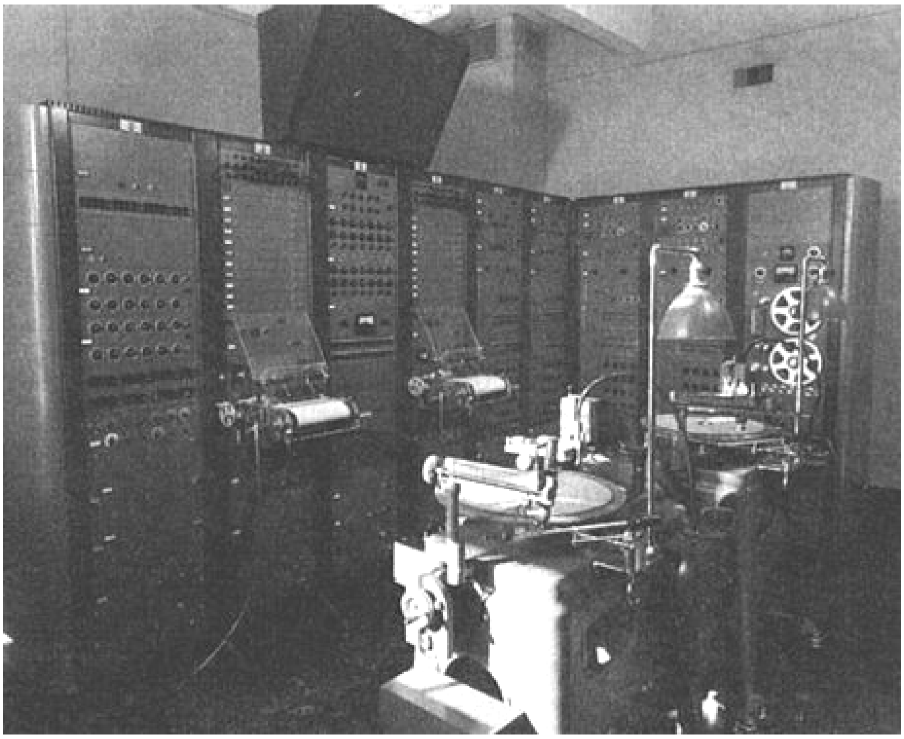


fig. 88 The RCA mkII showing the laquer disk cutters

The Composer-Tron (1953)

Developed during the early 1950's by Osmond Kendall for the Canadian Marconi Company, the Composer-Tron was an analogue synthesis and composition instrument that utilised an innovative and unique control system.

The Composer-Tron had a cathode ray tube input device that could 'read' patterns or shapes hand drawn on it's surface with a grease pencil. The drawn shape could be defined as the timbre of the note or as the envelope shape of the sound, rhythmical sequences could be written by marking a cue sheet type strip of film.

The purpose of the Composer-Tron, like that of the 'Hanert Electrical Orchestra', was to provide a synthesis and composition tool that closed the gap between composer and performer allowing the composer to define all the aspects of the music in one session:

> "At present, the composer writes his mental symphonies as black symbols on white paper. He has no way of knowing wether they're just what he had in mind. Months or years may pass before he hears them played by a symphony orchestra. Not uncommonly he never hears his best work......with Kendal's grease pencil, the composer can, in effect, draw the grooves in the record. Working with a Composert-Tron....he can walk out of his study with his recorded composition under his arm."

Computer Music: Music1-V & GROOVE

fig. 89 Max Mathews

MUSIC 1, which was quickly replaced by MUSIC II running on an IBM 704 and written in assembler code was the first real computer synthesis programme, developed by Max Mathews of Bell Laboratories in 1957.
MUSIC III was written in 1959 for the new generation of IBM transistorised 7094 machines which were much faster and easier to use than the older models. The MUSIC series software went through a stage of elvolution folowing the deleopment of the IBM computer whhich ended in 1968 with MUSIC V written in FORTRAN and running on the IBM 360 machines.

MUSIC V was picked up and developed by various other programmers such as Barry vercoe at MIT who designed MUSIC 360 and MUSIC 10 by John Chowning and James Moorer at Stanford University.

The GROOVE System (1970)

In 1970, Mathews pioneered GROOVE (Generated Real-time Output Operations on Voltage-controlled Equipment), the first fully developed hybrid system for music synthesis, utilising a HoneywellDDP-224 computer with a simple cathode ray tube display, disk and tape storgae devices. The synthesiser generated sounds via an interface for analogue devices and two 12 bit digital to analogue convertors. Input deices consisted of a qwerty keyboard a 24 note keyboard, four rotary knobs and a three dimensional rotary joystick.
Mathews saw the function of the GROOVE system as being a compositional tool which the composer/conductor manipulates in real time:

> "The composer does not play every note in a (traditional) score, instead he influences (hopefully controls) the way in which the instrumentalists play the notes. The computer performer should not attempt to define the entire sound in real time. Instead the computer should retain a score and the performer should influence the way in which the score is played..... the mode of conducting consist of turning knobs and pressing keys rather than waving a stick, but this is a minor detail.......The programme is basically a system for creating storing, retrieving and editing functions of time. It allows the composition of time functions byt turning knobs and pressing keys in real time: it sotores the functions on the disk file, it retrieves the stored functions (the score), combines them with the input functions (the conductor) in order to generate control functions which drive the analogue synthesiser and it provides for facile editing of functions via control of the programme time..."

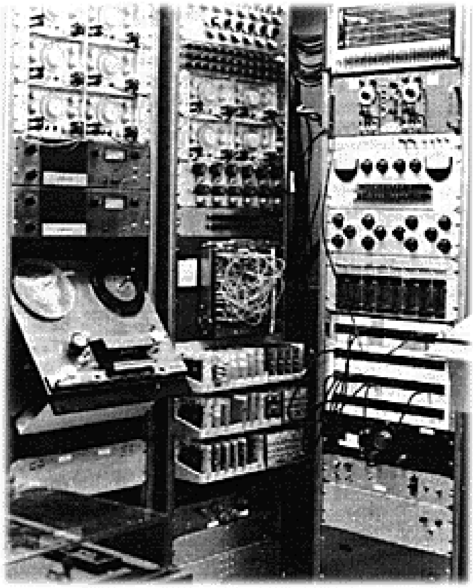


fig. 90 The GROOVE System at the Bell Telephone Labs , c1970

The GROOVE system remained in operation until the end of the seventies when Honeywell withdrew form the computer market.Max Mathews (Now professor emeritus at Stanford) is still actively involved in digital music performance. His "radio baton" hyperinstrument allows him to conduct a computer orchestra by simply waving a wand over an electromagnetic field. The father of computer music predicts that by 2010, "almost all music will be made electronically, by digital circuits."

Daphne Oram and 'Oramics' (1959)

The technique of Oramics was developed by Daphne Oram, an electronic composer working at the BBC Radiophonic Workshop, in England from 1959 onwards. It consisted of drawing onto a set of ten sprocketed synchronised strips of 35mm film which covered a series of photo-electric cells that in turn generated an electrical charge to control the sound fequency, timbre, amplitude and duration. This technique was similar to the work of Yevgeny Sholpo's "Variophone" some years earlier in Leningrad and in some ways to the punch-roll system of the RCA Synthesiser. The output from the instrument was only monophonic relying on multitrack tape recording to build up polyphonic textures.

fig. 91 Daphne Oram in the Oramics studio,1959

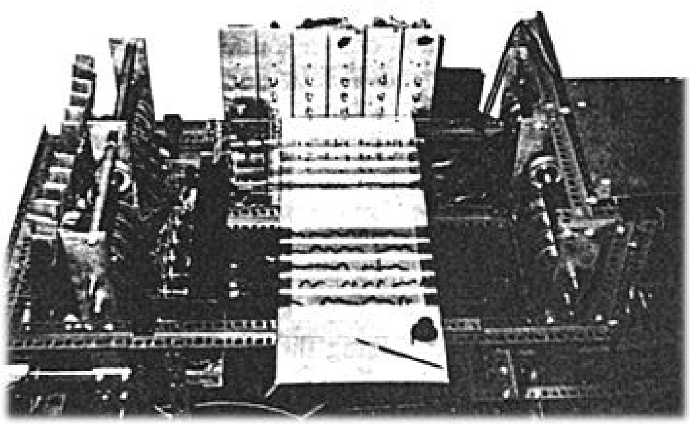


fig. 92 The 35mm film section of the Oramics Machine

The attraction of this technique was a direct relation of a graphic image to the audio signal and even though the system was monophonic the flexibility of control over the nuances of sound production was unmatched in all but the most sophisticated analogue voltage controlled synthesisers.
Daphne Oram continued to use the process throughout the sixties producing work for film and theatre including; "Rockets in Ursa Major"(1962), "Hamlet"(1963) and "Purple Dust" (1964).

The 'Siemens Synthesiser' or Siemens Studio For Electronic Music (1959-1969)

fig. 93 The editing room of the Siemens Electronic Music Studio c1962

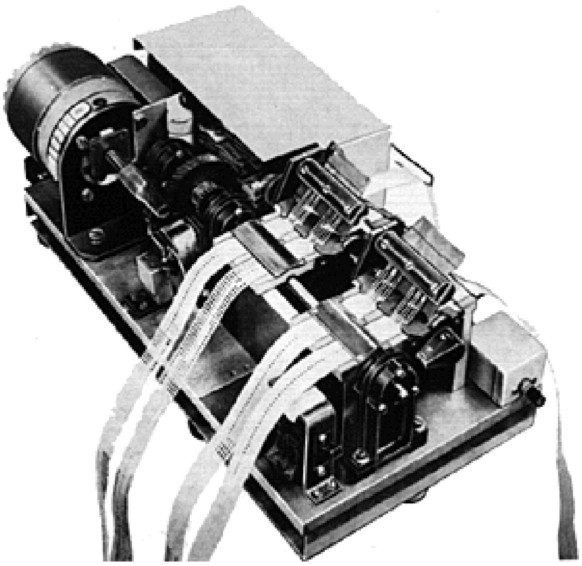


fig. 94 The Siemens punch-tape control mechanism

The Siemens Synthesiser or 'Siemens Studio For Electronic Music' was a German development similar to the RCA Synthesiser originally to compose live electronic music for Siemens's own promotional documentary films. The studio was a modular composition and synthesis system that generated musical sequences and synthesised and recorded the results. The Siemens Synthesiser was developed by Helmut Klein and W.Schaaf at Siemens Halske in Munich, Germany up to 1959 for the Studio Für Elektronische Musik in Munich. The Siemens system linked and controlled the studio using a similar system to the RCA Synthesiser, a set of four punch paper vary-speed rolls controlling the timbre, envelope, pitch and volume of a bank of (to a maximum in the later model) 20 oscillators, a white noise generator, a Hohnerola (a hybrid electronically amplified reed instrument marketed by Hohner-similar to the 'Multimonika') and an impulse generator. The synthesiser had a tonal range of seven octaves.

Additional input devices were also developed for the Siemens Synthesiser, a drawn sound technique (photoelectrically generated sounds) allowed the scanning of photographic slides using Siemens's specially designed 'Bildabtaster' technology. The German painter Günter Maas used this device to translate several of his paintings into musical compositions. Later models also had a Siemens Vocoder built in as a sound controller uniquely for its time, allowing the musician to give the sound vocal envelope characteristics.

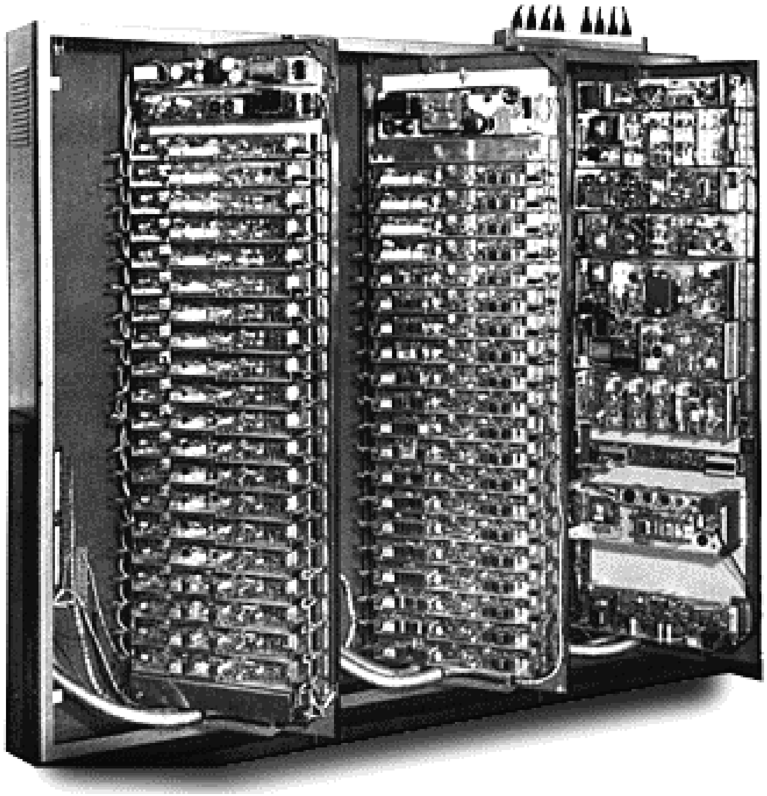


fig. 95 A Siemens Vocoder opened to show circuits

The development of the Siemens synthesiser continued after the Munich studio had relocated to Ulm and came to an end when the studio was dissolved in 1969. The Siemens system was used by many European experimental composers throughout the 50's and 60's including Mauricio Kagel, Bengt Hambreus, Milko Kelemen and the director of the Munich Studio Für Elektronische Musik, Josef Anton Riedl.

Technical Details of The 'Siemens Studio For Electronic Music'

(Translation of the original document by Helmut Klien: "Klangsynthese und Klanganalyse im elektronischen Studio", Siemens & Halske Aktiengesellschaft 1962)

fig. 96 The machine room at the 'Studio for Electronic Music'
(L-R:punch-paper controller, 2 four channel magnetic tape recorders, 'Bildabtaster' picture-scanner. Foreground:2 Master magnetic tape machines)

Introduction

The basic functions of the machines in the studio for electronic music are:

1. sound generation
2. sound storage
3. sound reproduction

The sounds are generated with tone-generators or tone-modulators of different kinds, their form can be determined by hand or by technical means. Sound generation can also include the revision of already existing sound material. The sounds and tones are registered to tape and reproduced via loudspeakers.

Tone Generation

The studio contains the following machines:

1. An electronic tongue-instrument of 84 tones from C to H
2. An impulse or sawtooth generator with 84 tones
3. A white noise generator
4. A generator for statistic impulses which are made from white noise with the help of a trigger

5a. 4 sine tone generators [20 - 20'000 Hz]
5b. 20 special sine generators. These generators a 3 frequency spectrum, from 1r5 - 160 Hz, 150 - 1600 Hz and 1500 - 16000 Hz, with the option of continual change from sine to sqare wave.
6. A tone generator based on photo-electric principles
2, 4, 5b can be sequenced using the punch-paper ribbon controller

Tone Modulators

1. [analogue] reverb
2. echo
3. frequency transformer
4. frequency transformation in relation to echo
5. vocoder

The Sequencing Technique

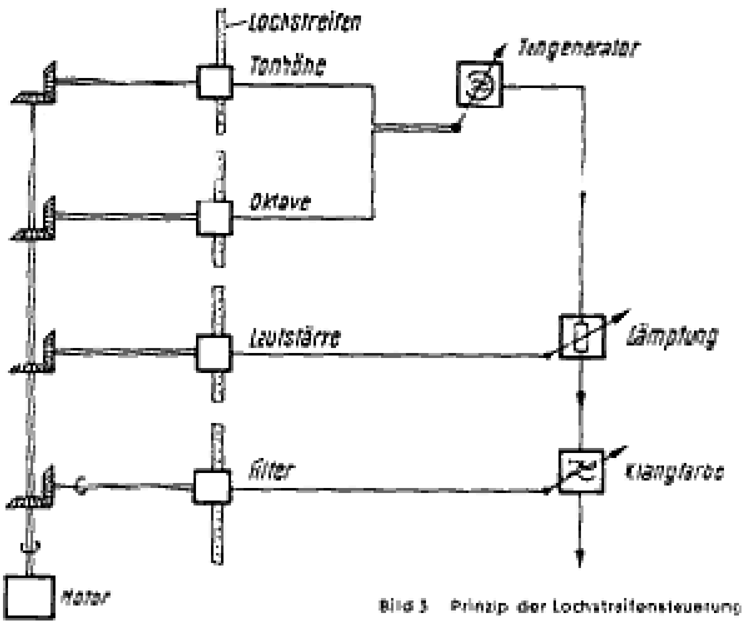


Bild 5 Prinzip der Lochstreifensteuerung

It is impossible to create and manipulate complex electronic sounds by hand at the same time, therefore the composer has at his disposal a sequencing technique allowing the control of four musical parameters: Pitch, Volume, Sound Colouring and Duration. These four parameters are sequenced using the punch paper roll controller (Lochstreifen-Schnellsender). See above diagram for an explanation of the principle: four synchronous motors guide 4 paper punch hole-tapes through a 'filter'. The filter is a metal brush that makes contact with a metal strip below the paper strip when it passes through a hole in the strip, thereby creating a signal. this signal is in turn passed to one and interpreted by the four parameters-volume, sound colour (timbre), duration and pitch.

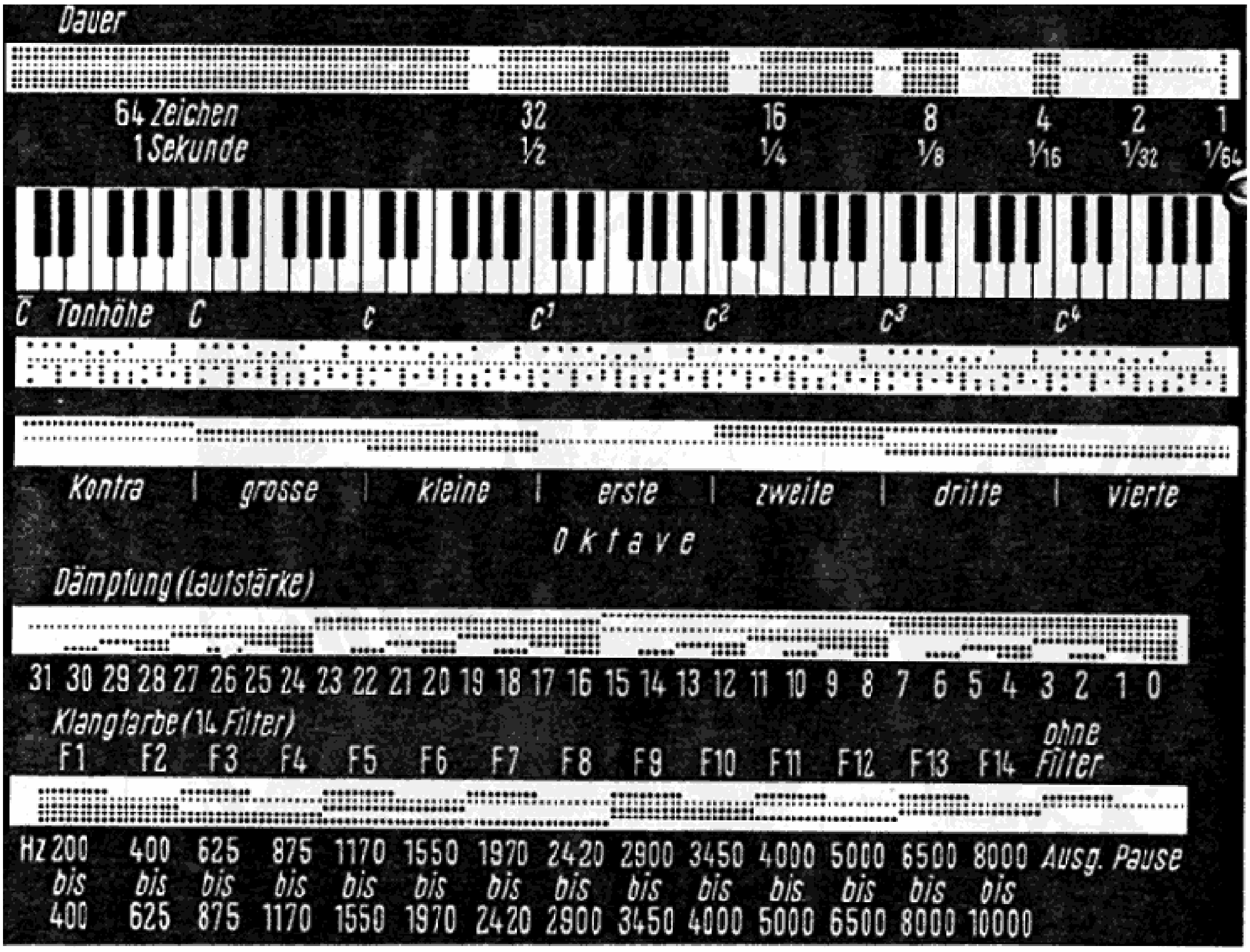


fig. 97 "Fig.1" shows the coding scheme of the paper roll controller: 4 parallel-run strips (similar to the way they are used with a telex machine) containing the musical information for a voice or level in binary code.

Pitch

The pitch is defined by two strips. One strip chooses the octave, the second the tones within the octave. There are 7 octaves , and 12 tones within those octaves, making 84 tones in total. They can be chosen in fixed tuning with the electronic tuner or in a tuning that can freely be chosen with the impulse generator and sine generators. Combinations allow the choice of several different generators.

Volume

The volume can be defined in 32 steps of 1,5 dB.

Timbre

The colouring (timbre) by a choice of 14 band filters or filter combinations

Duration

The duration of the signal is defined by the number of equal hole combinations in connection with the reading speed of the punch-paper strip **(see 'Dauer' in fig.1).** There are three different speed settings of the paper strip, 64, 90 or 128 signals a second. The normal speed is 64 signals per second, i.e. a duration of 16 ms per signal. The duration is a quarter note, played in Mäzel's Metronome MM = 120, is 0,5 s which equates to 32 equivalent hole combinations, an eighth note is then 16, a sixteenth note 8 hole combination.

fig. 98 Programming with the 'Semi Automatic Hole-strip Punching Machine'

Coding and punching the punch-paper strip

The coding and punching is done with a semi-automatic hole-strip punching machine . A pitch is chosen on a 5-octave-keyboard. The big octave can be switched to the contra-octave, the third to the fourth and vice versa. Therefore the slope of pitch is 7 octaves. The volume and colour is determined by a rotating dial. The number of the consequitive equal hole combinations are pre-chosen on an electronic counter with thirty settings. The punching, triggered by pressing a key, follows at 20 signals a second and is stopped automatically on reaching the pre-chosen number. Four different counters allow continuous control of the punched signals.

The punch-paper strip controller
(*Lochstreifen-Schnellsender*)

A synchronous-motor moves the paper strips across the reader. The 4 parallel moving strips are read by removeable steel wire brushes. The system can also be run in reverse.

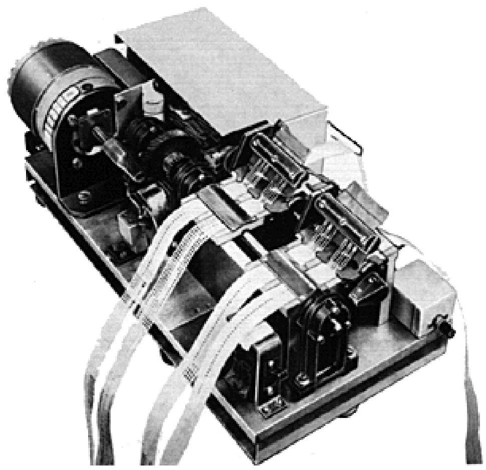


fig. 99 The punch-paper strip controller

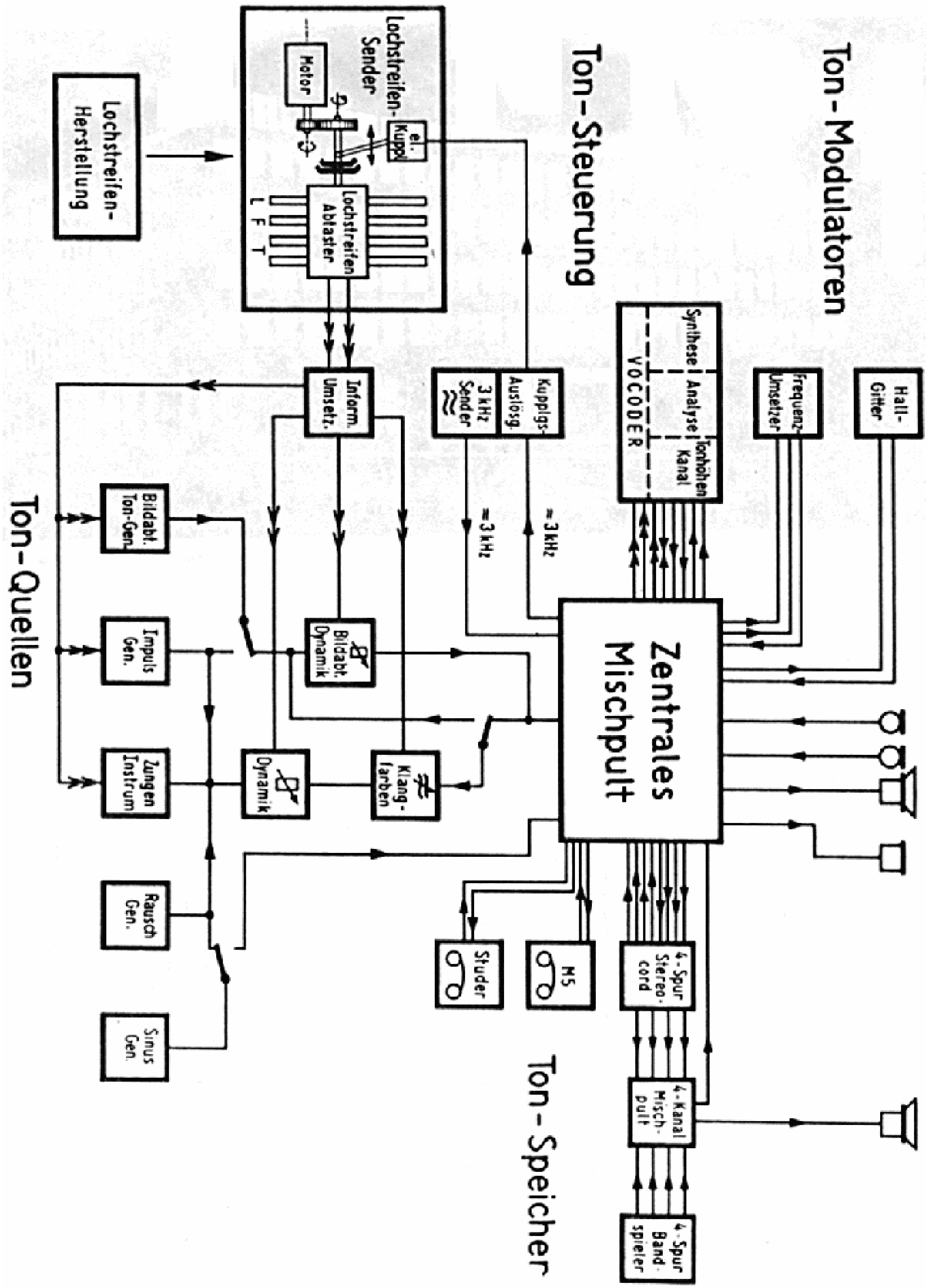


fig. 100 Overall studio diagram

History of the Siemens-Studios for electronic music

Autumn 1955.

-The directors of Siemens decide, inspired by the German composer Carl Orff, to create a soundtrack of electronic music for the documentary movie about the Siemens Company- "Impulse of our Time". To create this soundtrack Siemens began the devlopment of the equipment and apparatus necessary for the creation and manipulation of electronic sounds.

October 1956

-The work group of the Siemens Central Laboratory starts the construction of the equipment in the electro acoustic laboratory in Gauting, near Munich. The apparatus consisted of; a vocoder (already installed in the laboratory for the field of language & music modulation), a specially designed punch tape-strip controller that controlls the pitch, duration and colour of a bank of oscillators, A punch tape reader, a sawtooth generator, reverb plate and a mixing desk

Spring 1959

-Making of the music for the movie. Internal showing of the film. First showing of the film with live punch-tape contolled sequenced electronic music.

February 1960

-Visits ito the laboratory by Pierre Boulez, Herbert Brün, Werner Egk, Karl Amadeus Hartmann, Ludwig Heck, Ernst Krenek, Henri Pousseur, Fred K.Prieberg, Hermann Scherchen with his disciples.
-Due to interest caused by the showing of the Siemens documentary and from other composers it was decided on the 17th july 1959, to install a permanent studio for electronic music.

October 1960

-The electronic music studio moves into a two room area in the Siemens building at the Oskar-von-Müller-Ring, Munich.
-Installation of a picture scanner ("bildabtaster") for sound generation and volume modulation.
-Start of work in the field of applied music, electronic sound arrangement, electronic sounds for film, television, radio, theatre.
-Visits at the studio by Werner Meyer-Eppler, Gottfried Michael König, Abraham Moles.

July 1961

-Installation of the studio in six rooms in the Siemens building at Oskar-von-Müller-Ring.
-Start of permanent development work for the studio, amongst other things development of technique of sound synthesis, e.g. paper strip sequencing of 20 sine-generators with special installations.
-Possibility of two work shifts at the studio.
-Visits by Niccolo Castiglioni, Mauricio Kagel, György Ligeti, Andrzej Markowski, Jaques Wildberger, Yannis Xénakis.

July 1961 onwards

-1961 saw a concentration on individual composition and sound experimentation.Contacts were made with Pierre Boulez, Niccolo Castiglioni, Maurizio Kagel, Bruno Maderna, Henri Pousseur, Karlheinz Stockhausen and Yannis Xenakis who contributed to a series of record releases in 1961.
-"Introduction to Electronic Music" by Henri Pousseur released on vinyl record with a book.
-Visits by Boris Blacher, Gottfried von Einem, Franco Evangelisti, Jacques Guyonnet, Rafael Kubelik, Otto Luening, Myron Schaeffer, Karlheinz Stockhausen, Vladimir Ussachevsky.
Josef Anton Riedl.

Translation: Cristoph Fringeli

The Wurlitzer "Side Man" (1959)

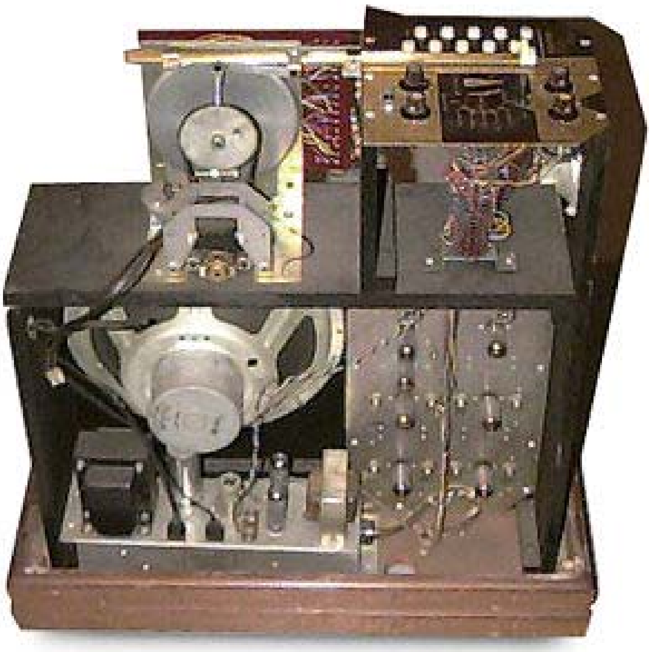


fig. 101 The Wurlitzer Sideman
(open casing showing internal speaker, rotating disk and circuitry)

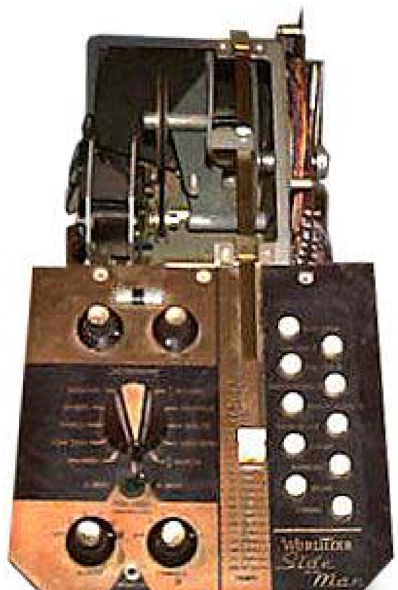
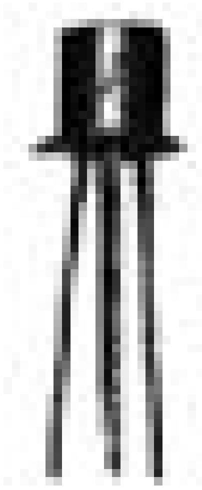


fig. 102 The top panel of the Sideman showing (L-R) pattern select control, tempo slider and manual triggers

The Side Man was the first commercial electronic drum machine, designed and built by Wurlitzer from 1959. The Sideman was intended as a percussive accompaniment for the Wurlitzers organ range. The side Man allowed a choice of 12 electronically generated predefined rhythm patterns with variable tempos. The sound source was a series of vacuum tubes which created 10 preset electronic drum sounds. The drum sounds were 'sequenced' by a set of rotating discs with metal contacts on the edge spaced in a certain pattern to generate parts of a particular rhythm. combinations of these different sets of rhythms and drum sounds created popular rhythmic patterns of the day -waltzes, fox trot etc., these combinations were selected by a rotary knob on the top of the Sideman box. The tempo of the patterns were controlled by a slider that increased the speed of rotation of the disc.

The sideman had a panel of 10 buttons to manually trigger drum sounds and a remote player to control the machine while playing from an organ keyboard. The Sideman was housed in a wooden cabinet that housed the sound generating circuitry, amplifier and speaker.



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Milan Electronic Music Studio

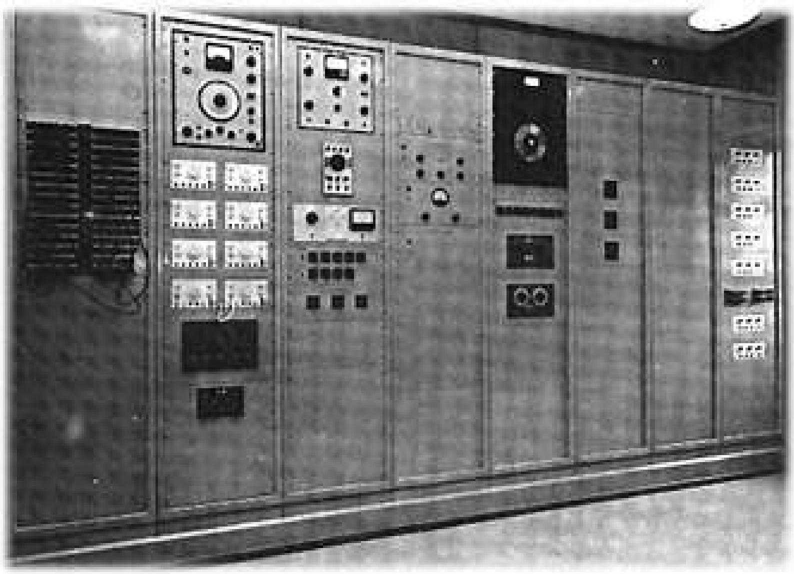


fig. 103 Milan Electronic Music Studio c1960.

Robert Moog and Moog Synthesisers

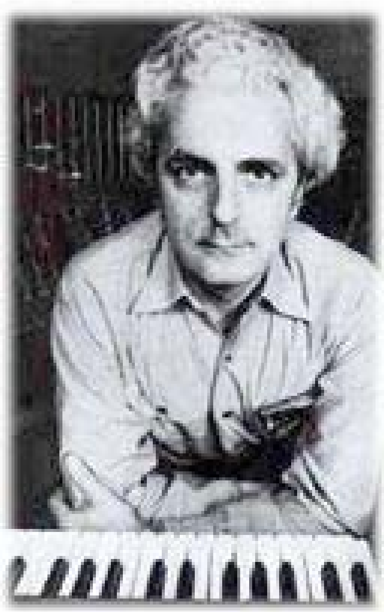


fig. 104 Robert Moog

Robert Moog developed his ideas for an electronic instrument by starting out in 1961 building and selling Theremin kits and absorbing ideas about transistorised modular synthesisers from the German designer Harald Bode.
After publishing an article for the January 1961 issue of the magazine 'Electronics World', Moog sold around a 1000 Theremin kits from 1961 to 63 out of a three room apartment. Eventually he decided to begin producing instruments of his own design. After toying with the idea of a portable guitar amplifier, Moog turned to the synthesiser. Whilst attending a convention in the winter of '63, Moog was introduced to the idea of building new circuits that would be capable of producing sound. In September 1964 he was invited to exhibit his circuits at the Audio Engineering Society Convention. Shortly afterwards in 1964 Moog begin to manufacture electronic music synthesisers. Moog's synthesisers were designed in collaboration with the composers Herbert A. Deutsch, and Walter (later Wendy) Carlos.

fig. 105 Wendy Carlos

After the success of Carlos's album "Switched on Bach", entirely recorded using Moog synthesisers, Moog's instruments made the first leap from the electronic avant garde, into commercial popular music. The Beatles bought one, as did Mick Jagger who bought a hugely expensive modular Moog in 1967 (unfortunately this instruments was only used once, as a prop on a film set and was later sold to the German experimentalist rockers, Tangerine Dream). Though setting a future standard for analogue synthesiser, the Moog Synthesiser Company did not survive the decade, larger companies such as Arp and Roland developed Moog's protoypes into more sophisticated and cost effective instruments. Robert Moog has returned to his roots and currently runs 'Big Briar' a company specialising in transistorised version of the Theremin

Moog Production Models

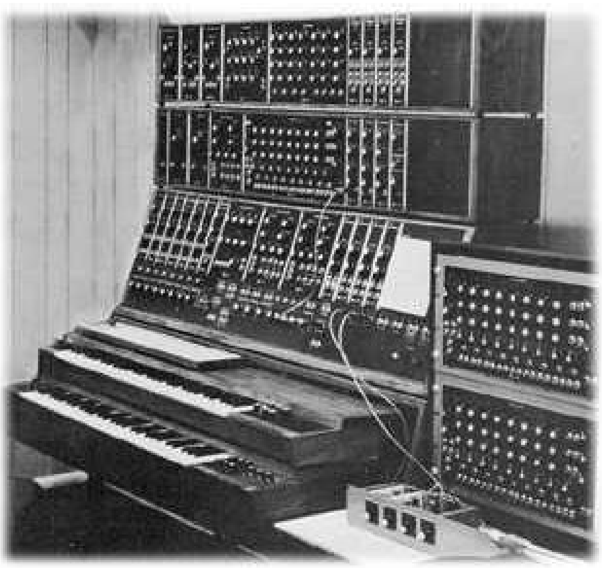


fig. 107 Modular Moog Synthesiser c1967

fig. 106 Another Modular Moog Synthesiser

fig. 110 Moog Prodigy Synthesiser

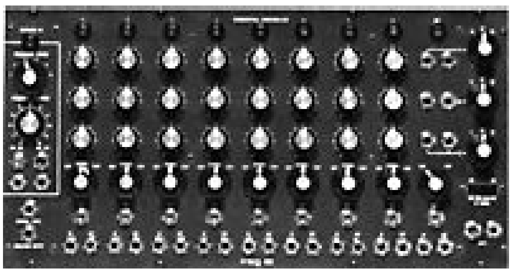


fig. 111 Moog 960 Analogue Sequencer

fig. 109 Multi Moog Synthesiser

Mellotrons and Chamberlins

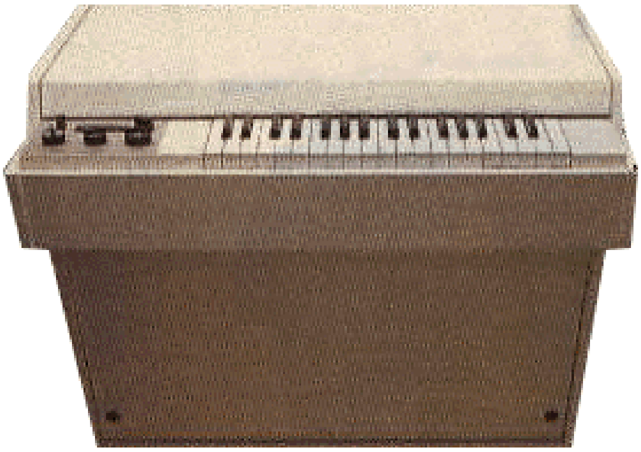


fig. 112 The Mellotron MkIV

The Mellotron (1963-1986)

Mellotrons and Novatrons were produced in England by Streetly Electronics from the early '60s until the early '80 by Leslie Bradley and his brothers Frank and Norman. The original Mellotron was designed as an expensive domestic novelty instrument.
The Mellotron was a precursor of the modern digital sampler. Under each key was a strip of magnetic tape with a recorded sound that corresponded to the pitch of the key (The Mark II had two keyboards of 35 notes each making a total of 1260 seperate recordings). The instrument plays the sound when the key is pressed and returns the tape head to the begining of the tape when the key is released. This design enables the recorded sound to keep the individual characteristics of a sustained note (rather than a repeated loop) but had a limited duration per note, usually eight seconds. Most Mellotrons had 3 track 3/8" tapes, the different tracks being selectable by moving the tape heads across the tape strips from the front panel. This feature allowed the sound to be easily changed while playing and made it possible to set the heads in between tracks to blend the sounds.

Despite attempting to faithfully recreate the sound of an instrument the Mellotron had a distinct sound of its own that became fashionable amongst rock musicians during the 1960's and 1970's. The Novatron was a later model of the Mellotron re-named after the original company liquidised in 1977.

fig. 113 The Chamberlin

The Chamberlin

The Chamberlin was the original US keyboard instrument from which the Mellotron was copied, designed by Harry Chamberlin in the USA during the 1960's. The Chamberlin used exactly the same system as the Mellotron for playing back tape samples yet had a sharper more accurate sound.

Buchla Synthesisers

Donald Buchla started building and designing electronic instruments in 1960 when he was commisioned by the Avant Garde composer Morton Subotnik to build an instrument for live electronic music and composing. With a grant from the Rockefeller Foundation Buchla started building his first modular synthesisers in 1963 under the name "San Fransisco Tape Music Center", the name of Subotnik's music studio. Buchla's early synthesisers were experimental in design to accomadate the experimental music they were intended to produce, utilising unusual control features such as touch sensitive and resistance sensitive plates. Buchla's early pioneering work included the first analogue sequencers.

Buchla started to commercially produce his synthesisers in 1969 with a manufacturing deal from CBS/Fender. This deal eventually came to an end as CBS were unwilling to fund further research into instrument design. Today, Buchla continues to produce electronic musical instruments in the form of MIDI controlllers: Buchla & Associates.

Some Buchla Synthesiser Models

fig. 114 The Buchla Electric music box model 101

fig. 115 The Buchla Electric Music Box model 200

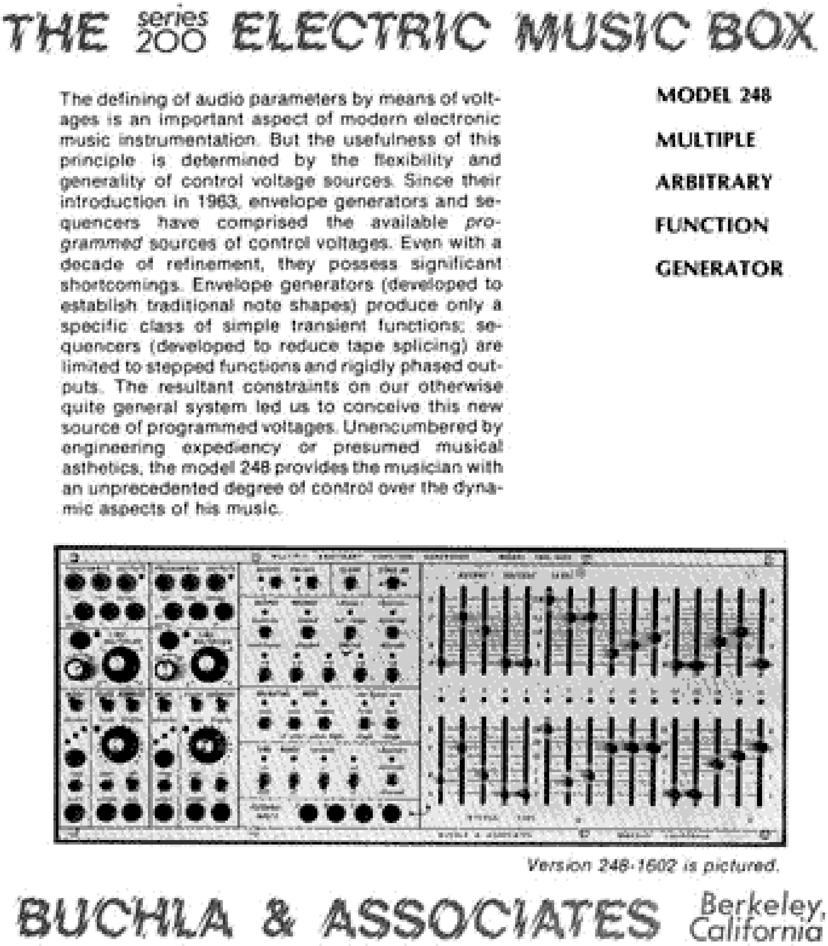


fig. 116 Promotional material for the Electric Music Box 200

fig. 117 The Buchla Touche Synthesiser

The Donca-Matic DA-20 (1963)

The Donca-Matic or Disc Rotary Electric Auto Rhythm machine DA-20 was a japanese electro-mechanical drum machine designed as an improvement on the Wurlitzer Sideman rhythm machine. This instrument was the first product for what was to become the Korg Musical Intrument company. The DA-20 despite being a primitive machine was a major breakthrough in its day, the DA-20 was soon replaced by an all electronic solid state model in 1966 the Donca DE-20.

The Synket (1964)

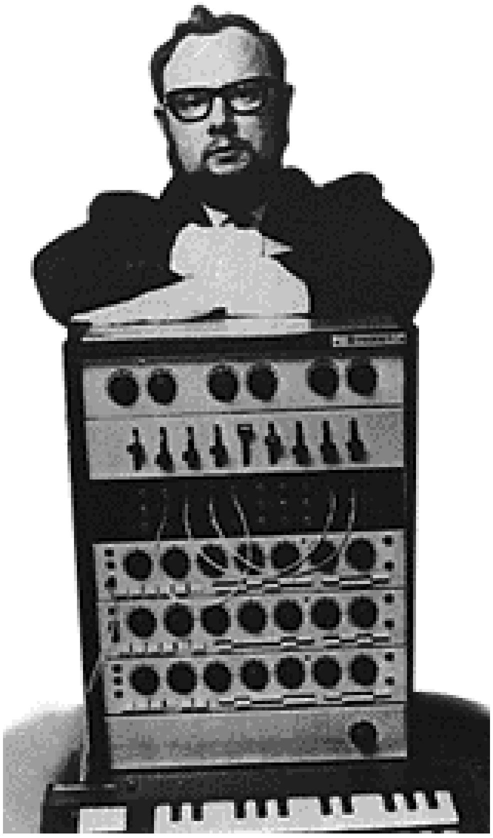


fig. 118 John Eaton with the Synket (1964)

The Synket was the first portable voltage controlled synthesizer, made in Rome, Italy in the mid 1960's and Designed by Paul Ketoff for the composer John Eaton. Eaton used the Synket on several of his works such as "concert Piece for Synket and Symphony Orchestra" 1967, "Blind Mans Cry" (1960), "Mass" (1970).

Tonus/ARP Synthesisers

fig. 119 The ARP 2500

fig. 120 The ARP 2500

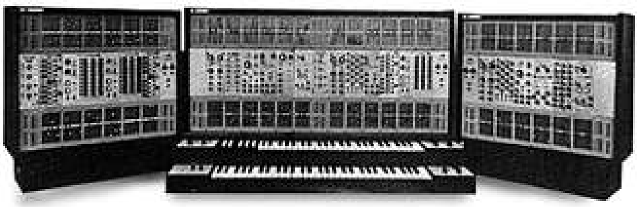


fig. 121 The ARP 2500

fig. 122 The ARP 2600

The ARP 2600

The ARP 2600 was designed as an easy to use version of the 2500 aimed at schools and university music departments. The 2600 had a printed front panel showing the various routings and signal paths and had all the synthesiser functions in one metal casing (including speakers and soring reverb unit) with an external keyboard. The first production run had blue panels, painted sheet-metal cases, and polished wood handles which became known as the 'Blue Marvin' or 'Blue Meanie' later models were housed in a vinyl-covered luggage-style case with a dark gray panel. this model 2600 remained in production from 1971 to 1981.

ARP Odyssey

Developed during the mid 1970's the Odyssey was a popular 3 oscillator synthesiser. The Odyssey had two syncable vco's and a dedicated low frequency oscillator which could be used as a pulse width modulation source. The Odyssey had a duophonic keyboard and sample and hold and ring modulation.

ARP Avatar

The Avatar was a pitch to voltage guitar synthesiser developed by ARP in the late 1970s. The synthesiser component was an Odyssey in a metal box.

ARP Axxe

The Axe was a single VCO synthesiser released in the mid 70's to compete with Moog's entry level Micromoog. The Axxe was essentially a cut down easy to use version of the Odyssey.

The ARP Sequencer

The ARP Sequencer was a simple yet usable 2 X 8 step event sequencer with a built in synthesiser. The notes were added in real time to a sequences by using one of two sets of eight pitch sliders while the seqence progress was marked by a series of flashing red lights.

The Arp Little Brother

The Little Brother was a synthesiser expander playable from a remote keyboard or synthesiser.

ARP Pro-Soloist / Pro-DGX

The Pro-Soloist was marketed as a domestic keyboard rather than a serious instrument. The Pro-Soloist had a bank of preset voices, which although limited, became popular with rock groups such as Kraftwerk and Genesis during the 1970's .

ARP Omni

The Omni was a string synthesiser with simple filter and ADSR controls. The Omni became popular with Disco music producers during the late 1970's.

fig. 123 ARP Quadra

ARP Quadra

The Quadra was a cumbersome and expensive instrument developed at the end of the ARP companies existence.The Quadra was marketed to compete against a new generation of polyphonic synthesisers but was essentially a glossily packaged hybrid of an ARP Oni and a Solus.

PAiA Electronics, Inc (1967)

PAiA Electronics is an Oklahoma, USA based company selling mail order electronic musical instument kits. Their range of products includes MIDI analogue synthesisers, vacuum tube preamplifiers, audio effects and processors and a version of the Theremin called the "Theremax".

fig. 124 The Gnome Micro-Synthesiser

fig. 125 The Paia Programmable Drum set

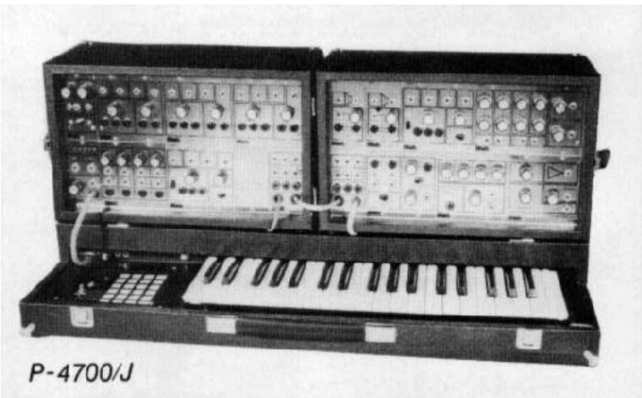


fig. 126 The PAiA P4700/J Synthesizer with built in sequencer

fig. 127 The PAiA OZ

Computer Music: MUSYS III (1962) hybrid system

fig. 128 Peter Zinovieff at the MUSYS studio, Putney, London

MUSYS was a commercial venture initiated created by Peter Zinovieff of EMS Synthesisers. The aim was to create an electronic computer hybrid studio for commercial use. The original MUSYS studio was a manual voltage controlled system but when the device became too complex (over 700 different controls were used) it was suggested that a computer be used. The basic studio system was designed by the EMS designer David Cockrell, using two PDP 8 minicomputers running software by Peter Grogno controlling an EMS Synthi 100. From a traditional composers point of view the system was flexible and user friendly, input to the system was via qwerty keyboard or via velocity sensitive keyboard.

The MUSYS studio was active until the demise of EMS in 1979. Works produced in the studio included "Chronometer" by Harrison Birtwhistle and Hans Werner Hense's "Glass Music".

EMS Synthesisers 1969-1979

fig. 129 Peter Zinovieff working the EMS Synthi 100

In 1969 the English electronic engineer and composer Peter Zinnovieff created EMS (London) Ltd to exploit the new market of electronic musical instruments. EMS created some of the most innovative and sometimes eccentric instruments of their time. EMS's most well known product was the VCS 3: a 3 VCO monosynth with a routable pinboard and a joystick housed in a distinctive angled wooden case.
The VCS3 was designed and engineered by David Cockerell, who was responsible for most of the EMS product range. (David Cockerell went on to work for Electro-Harmonix and currently designs the Akai samplers).

Apart from developing hardware synthesis, EMS created the forerunner of software synthesis, the MUSYS computer synthesis language.
EMS was competing directly against Moog, Buchla and ARP, non were to last the decade. EMS (London) Ltd folded in 1979 due to investing in complex equipment which had little market demand, but have recently surfaced as a small company selling and modifying the original EMS Synthesiser range:

fig. 130 EMS Logo

fig. 131 EMS's main product: The VCS 3 "The Putney" 1969

The **VCS3** had 3 Voltage Controlled Oscillators, a Noise Generator, 2 Input Amplifiers, 1 Ring Modulator,1 Voltage Controlled Low Pass Filter,1 Trapezoid Envelope Generator, a Voltage Controlled Reverberation unit, 2 Stereo Output Amplifiers and a Joystick. Routing the various functions of the instrument was done via a small pin patchboard.

fig. 132 The VCS 4 (not commercially produced) 1969. (2 VCS3's and a keyboard)

fig. 133 The EMS Synthi A "The Portabella", a portable VCS3 in a briefcase (1971)

fig. 134 The EMS Synthi AKS . A VCS3 in a briefcase with a sequencer in the lid (1971)

fig. 135 EMS Synthi Sequencer 256. 256 Event x 42 bit Memory sequencer (1971)

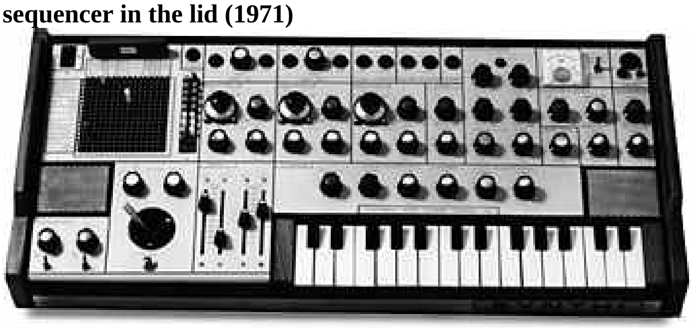


fig. 136 Synthi Keyboard 1 (not commercially produced) A VCS3 housed with a 29 note miniature keyboard (1970).

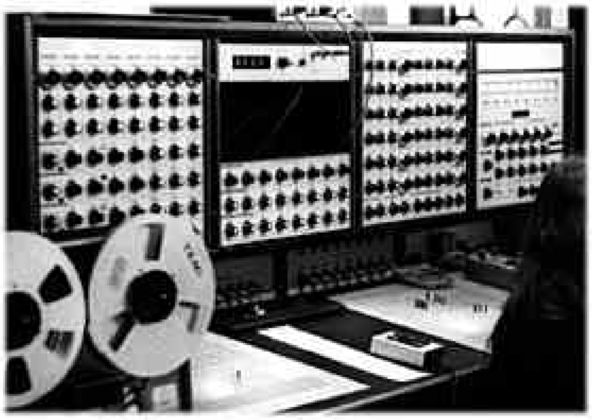


fig. 137 The EMS Synthi 100.12 VCOs, 2 keyboards and a 256 step sequencer

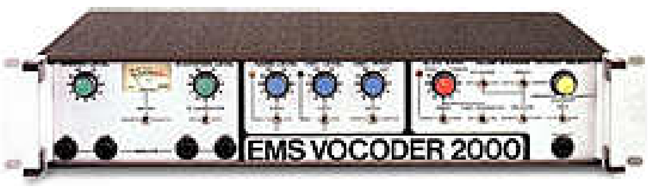
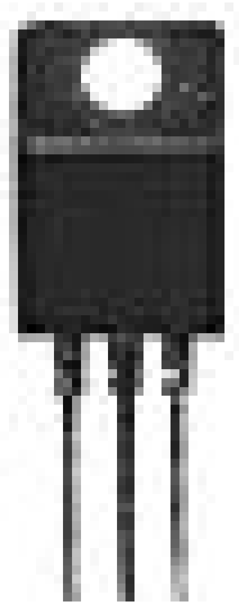


fig. 138 The EMS Vocoder 2000. voice synthesiser



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The 'Optigan' and 'Orchestron'(1971)

fig. 139 The Optigan Corporations 'Optigan'

The Optigan was a novelty instrument built and marketed by the Optigam Corporation (a subsidiary of Mattel) in Compton, USA in the early 1970's. The unusual feature of the Optigan was its method of sound synthesis; the Optigan optically read graphic representations of waveforms from a series of 12" celluloid LP sized discs, hence the name Optigan - 'Optical-Organ'. The Optigan read the discs by passing a light beam through the transparent discs, the beam was interrupted or reduced by the shape of the printed waveform and picked up by a photoelectric cell causing a variable voltage which was in turn amplified and passed to the speakers.

The Optigan was essentially an optical sampler, the disks contained 57 loops of sounds which were recordings of real instruments, 37 of the loops were reserved for keyboard sounds (with individual loops for each key) the other 20 loops being sound effects, rhythms etc. The celluloid discs were sold as a collection for Optigan owners and were mainly sustained organ sounds, as the continually spinning loops had no beginning or end it was impossible to create an attack or decay.

> "The Optigan Music Maker. The most revolutionary musical instrument ever. Because it's EVERY musical instrument. And every combination. You've never heard anything like it because there's never been anything like it. And you have all the talent you need in your little finger to play the OPTIGAN. The "soul" of the OPTIGAN is the Music Program Disc. Organs try to mimic or imitate different musical sounds. But with the OPTIGAN you actually play the real sounds of pianos, banjos, guitars, marimbas, drums and dozens more. The sounds are on the Programs. You choose the sounds you want -to play the songs you want- on our piano-style keyboard and left-hand accompaniment panel. And you choose from Classic guitar to old time Banjo Sing-Along to Nashville Country to Rock and Roll. It all depends on the Program and there's a Program for every musical taste."

from the Optigan users manual

The Optigan Corporation marketed the Optigan as a novelty home instrument for a number of years, selling the instrument in high street stores for as little as $150 and eventually passed on the business to the Miner Company in New York (organ manufacturer) who continued to manufacture the instruments and discs under the company name of Opsonar. An unsuccessful 'professional' version of the machine was later marketed by a company called Vako under the name 'Orchestron', only about 50 were built and the company soon folded.

Some Optigan Disc Titles

Banjo Sing-Along

Big Band Beat

Bluegrass Banjo

Bossa Nova Style

Cha Cha Cha!

Dixieland Strut

Folk & Other Moods-Guitar

Gay 90's Waltz (6/8 time)

Gospel Rock

Guitar Boogie

Guitar in 3/4 Time

Hear and Now

Latin Fever

Nashville Country

Polynesian Village

Pop Piano Plus Guitar

Rock and Rhythm

The Blues-Sweet and Low

Waltz Time (3/4 Time)

Conbrio Synthesisers (1978)

fig. 140 CONBRIO Logo

THE ADS (Advanced Digital Synthesizer) 100 was a high end (there was no given price when the 100 system was introduced) analogue synthesiser, probably most well known for providing the sound effects for 'Star Trek' TV series. The first model 100 system was a dual manual splittable keyboard (microtonally tuneable) ,a video display for envelopes, 'control cube' disk drive with computer hardware, and a multi-coloured buttoned front panel for 64-oscillator additive synthesis and real-time sequencing.

The smaller, and commercially viable ($30,000.) compact ADS 200 had a four track sequencer combined with CV and gate interfaces , phase modulation, frequency modulation, nested phase and frequency modulation controlling 64 oscillators.

fig. 141 The Con Brio ADS 2000

In 1982 Con Brio released the ADS 200-R a 32 voice (expandable to 64) featuring a 16-track polyphonic sequencer with 80,000 note storage capability with 'editing functions' available from the scoring screen.

The end of the Con Brio company came in the early 1980's when they failed to exploit the digital evolution and the simplicity of digital design that more commercial companies such as Yamaha created with their DX Synthesiser range.

The Roland Corporation

The Roland Corporation was established in Japan in 1972 and released its first musical instrument, 'Japans first synthesiser', the SH1000 in 1973. The SH1000 was a portable and affordable analogue synthesiser.In the same year Roland released a domestic electronic combo-piano.

In 1976 Roland released their System 700 modular studio system synthesiser. Aimed at the broadcast market this synthesiser was used by NHK in Japan and BBC in England.

Roland continued to produce innovative instruments, in 1977 with their GR500 series analogue guitar synthesisers and the first commercial rhythm machine, the "Compurhythm" CR78. In the early eighties Roland released a range of inexpensive synthesisers, sequencers and drum machines, the MC202 sequncer, TB303 synth/sequencer, the SH101 monsynthe and the TR-808 drum machine which were compact and affordable yet had some versatile features that has ensured their popularity into the 1990's.

Early Roland Synthesisers

Roland System 700 modular synthesiser

The Roland System 700 synthesiser was Rolands first modular synthesiser released in 1976 and aimed at the corporate broacasting studio market.

Roland System 100 modular synthesiser (1976)

The System 100 was a modular analogue monophonic synthesiser, a more affordable version of the System 700. The System 100 with one VCO per voice (or 2 with an expander), the machine was controlled by a 37 note keyboard. The 1976 models modular units comprised of : 101, the synthesiser, 102 expander, 103 mixer, 104 sequencer, 109 monitors, RV800 stereo reverb, GE810 graphic eq and PH830 stereo phaser.

Roland SH101 synthesiser (1980)

Roland's popular SH101 was a monophonic analogue synthesiser with one VCO (with a sub oscillator for modulation) controlled by a 32 note keyboard housed in a light plastic casing with an optional 'guitar style' handle controller.

Roland SH2 synthesiser (1976)

The Roland SH2 was a dual oscillator analogue synthesiser controlled by a 37 note keyboard.

Roland CR 78 "Compurhythm" drum machine

One of the first commercial drum machines. The CR78 had a number of preset rythms with switchable voices.

Roland Jupiter 4 synthesiser

Roland TB303 "Bassline" synthesiser/sequencer

Roland Jupiter 8 Polyphonic synthesiser

The Jupiter 8 is an 8-voice polyphonic synthesizer with a 61-note keyboard with 2 VCOs per voice. VCO1 is switchable between triangle, sawtooth, pulse, and square waves and can be switched between 4 octaves. VCO2 has the same options with the addition of a noise generator switch. The Jupiter 8 allowed the VCO's to be synced. The Jupiter 8 voice has two filters. In addition to its lowpass, resonant VCF it has an adjustable, non-resonant, and non-modulatable highpass filter. The VCF can be modulated by one of the envelopes, the LFO, and keyboard tracking. The Jupiter 8 had a 64 patches and 8 "patch presets" memory. Patch presets can store keyboard splits, along with arpeggiator settings , voice assign mode, hold, portamento, as well as modulation settings. The Jupiter 8 features keyboard split or layer. Split allows you to assign a patch to 4 voices above the split key and a patch to the 4 voices below it.

Roland MC202 synthesiser/sequencer (1983)

The MC202 was a 2 track sequencer and 1 VCO monophonic synthesiser with a 32 button key 'keyboard'

Roland TR808 Drum machine

Maplin Synthesisers (1973)

Trevor G Marshall started building synthesiser kits in Australia in 1973, the first models being the 3600 and 4600 which were hybrid digital and analogue synthesisers. The original company was bought by the UK based Maplin Electronics and these models were marketed as the Maplin 3800 and 5600.

fig. 142 The Maplin 3800 Synthesiser

fig. 143 The Maplin 5600 Synthesiser

The Synclavier

fig. 144 The Synclavier (1975)

The Prototype Synclavier (1975) was developed at Dartmouth College, New Hampshire, USA, (Sydney Alonso, who developed the hardware designs, Cameron Jones, who developed the software, and Jon Appleton, musical advisor to the project) as a self contained digital synthesiser based on a network of integrated circuits and micro-processors. In 1976 the New England Digital Corporation was created to market the machine. The user was shielded from the software complexities by a comprehensive push-button keypad, later models had an added VDU, QWERTY keyboard and hard disk. A touch strip allowed continuous pitch control.

fig. 145 The original Synclavier development group 1975: Sydney Alonso (hardware designs)left, Cameron Jones (software) right, Jon Appleton (musical advisor) seated at keyboard

Korg Synthesisers

Korg MS10 (1975)

The MS10 was Korg's entry level monophonic synthesiser. The MS10 had 1 VCO that was patchable through Korg's standard 1/4" jack front panel patchbay to the VCF and VCA and mixable with a noise (white/pink) generator.

Korg MS20

A dual VCO version of the MS10.

Korg MS50

The Korg MS50 was a modular monophonic analogue synthesiser, the flagship model of the MS range

Korg PS 3100 polyphonic Analogue Synthesiser

The PS 3100 was a modular analogue polyphonic synthesizer designed for "high playability and flexible control".The PS-3 100 had a built-in VCO, VCF, VCA, and EG for each of the keys on the keyboard for a total of 48 synthesizer circuits and included a ring modulator, tremolo modulator and three resonating filters. The modules of the synthesiser were completely separate and routed by using Korg's standard patching system.

Korg PS 3300 polyphonic Analogue Synthesiser (1977)

The PS 3300 was the top of Korg's polyphonic PS range and was sold as the worlds first completely polyphonic synthesiser. The PS3300 was similar to the 3100 with independent VCO's, VCF's, VCA's, and EG's for each note on the keyboard which was microtonally tuneable. The 3300 had a mixing module, general envelope generator, sample and hold patchable through the SG, DLPF, EM, and RESO modules for glides, polyphonic glissando etc.

Korg VC10 vocoder (1978)

The VC10 was an affordable and easy to use polyphonic Vocoder/synthesiser

Korg SQ10 analogue sequencer

The SQ10 was an analogue 24-step sequencer/synthesiser.

Korg MonoPoly

The MonoPoly was a 4 VCO analogue synthesiser with 44 note keyboard, it was 4 voice Polyphonic with a built in basic step sequencer and arpeggiator. The MonoPoly had Portamento, arpeggio sync, CV/Gate, VCF and VCO mod inputs.

Korg PolySix

A 6 note polyphonic analogue synthesiser with a built in chorus effect unit and 64 patch memory bank.

Korg Poly800 mkII

The Poly800 & Poly800 mkII were 2 VCO , 8/4 voice polyphonic 'affordable' and portable synthesisers, cheaper versions of the larger DW-8000. The poly800's had a built in 1000 note step sequencer and in the mkII a digital delay and were equipped with MIDI in/thru/out ports.

The Electronic Dream Plant "Wasp" (1978)

fig. 146 The EDP Wasp c1979

The EDP Wasp was released in the UK in 1978 as a budget monosynth: "One of the biggest advances in synthesiser design - an ultra low cost, high performance instrument" and was one of the most unusual looking modern synthesisers. The Wasp was built in garish black and yellow plastic with a flat yellow laminated carboard 'keyless' two octave keyboard. The instrument weighed no more than a couple of pounds. The sound from the instrument came from two digital VCO running through an analogue VCF which gave the instrument a distinctive and powerful sound belying its awkward appearance. The Wasp was designed by the british designer Chris Hugget who was also responsible for the "Oscar" Synthesiser.

Other products from the Electronic Dream Plant were:

- **Deluxe Wasp**: an upgraded Wasp with a sturdier body and real keyboard.
- **Spider Digital Sequencer**: a 252 note step or 84 note real time sequencer
- **The Caterpillar**: a 3 octave master keyboard for controlling Wasp synthesisers, 8 Wasps could be connected and played polyphonically.
- **The Gnat**: An even smaller, cheaper single VCO version of the Wasp.

Yamaha Synthesisers

fig. 147 The founder, Torakusu Yamaha 1887

The Japanese company Yamaha who also market furniture ,motor bikes, guitars,archery equipment, bathtubs, pianos, skis, tennis rackets and construction machinery amongst others came into the musical instrument market in 1900 with the construction of pianos for the Japanese market, their first electronic instrument the Electone D-1 electronic organ was designed and built in 1959. Early synthesiser products included the GX1 synthesiser, the CS-80 polyphonic synthesiser, the Cx5 digital music computer and the revolutionary DX7 digital synthesiser

The Yamaha GX1 synthesiser (1974)

fig. 148 The 2/3 ton GX1 synthesiser

The GX1 was Yamaha's first polyphonic synthesiser although innovative for its time the instrument was out of the price range of most musicians selling for £30,000 in 1976, Yamaha sold very few models.

The CS-80 Synthesiser (1976)

Fig. 149 The Yamaha CS80 polyphonic Synthesiser

The Yamaha CS80 polyphonic Synthesiser was a development on the GX1 model at an affordable price range (£5,000 in 1976) and competing with several other early polyphonic synthesisers such as the ARP Omni and the Moog Polymoog. The CS80 was a complex polyphonic synthesiser with 16 oscillators, 32 filters, 32 envelopes allowing voices to be split and layered and stored in a six part memory allocation. The keyboard was velocity sensitive with poly-aftertouch sensitivity.

The Yamaha CX5 Music Computer

Fig. 150 A Yamaha CX5 minus the VDU unit

The CX5 music computer was an FM multi-timbral digital synthesiser controlled by a keyboard and VDU . The synthesiser was edited on the VDU screen using the CX5's proprietary software, programs included composition software for multi-timbral sequencing and notation, FM voicing of the internal synthesizer, DX7 VOICING software for programming and manipulating patches in the DX7 synthesizer and more. Since the CX5M is completely MSX compatible, word processing, spread sheets, games and other general purpose computer programs are possible. At the time the CX5 was the only affordable computer synthesiser on the market.

The DX7 Synthesiser and DX range

Fig. 151 The Yamaha DX7 mkII Synthesiser (1983)

The DX7 synthesiser was the first truly digital synthesiser and was released with great commercial success in 1983, selling over 180,000 units. The DX7 used a type of synthesis Yamaha called "Frequency Modulation" developed by Professor John Chowning at Stanford University in the 1970s. In FM synthesis sounds are created by interacting units known as 'operators', which can act as 'carriers' or 'modulators'. Each one is a sine wave that can be shaped and given its own pitch. When connected, one modulates the sound of the other to produce a new pitch and tone. The arrangement of operators and their relative pitches determines the final timbre produced. The DX7 has six operators that can be placed in 32 arrangements ('algorithms'). There's a also host of other parameters and a complex envelope that has two values for each point.

The LCD input controls of the DX7 appeared daunting to most keyboard players used to traditional analogue sliders and knobs. Most users only touched the surface of the synthesis possibilities of the DX7, instead relying on a series of sound card cartridges marketed by Yamaha to overcome the programming complexity.

The DX7 was one of the first synths with a full complement of MIDI ports. It also has a unique breath controller input port. This device allowed the user to manipulated the instruments timbre using breath pressure via a mouth held tube. The DX7 has 16-note polyphony, a 61-note velocity and an aftertouch-sensing keyboard, 32 onboard memories, additional cartridge memory and monophonic output.

The Yamaha DX Range

- **GS-1** and **GS-2**; Early piano style FM synthesis instruments.
- Yamaha **DX1**: a double DX7 with a wooden case, piano keys and easier programming.
- Yamaha **DX5** digital synthesizer. The DX5 has many of the features found on the DX1 but is more affordable. The DX5 was basically 2 DX7's with features that include: 32 patches x 2, 64 performance memories, 16 note polyphonic per channel, dual rom/ram slots, low Z or high Z outputs, extended keyboard note scaling, 76 key velocity & a touch sensitive keyboard.
- **DX7**.Yamaha's best selling FM synthesiser.
- **TX7**. the TX7 was a modular (rackmounted) version of the DX7
- Yamaha **DX9**. The DX9 has the same FM digital sound generation capability as the DX7, but with 4 operators and a choice of 8 algorithms. The DX9 has a 16-note polyphonic keyboard and is supplied with 420 pre-programmed voices on an external data cassette tape. Newly programmed voices can be saved on cassette tape to build up a personal voice library.

Fig. 152 The Yamaha DX100 synthesiser

- Yamaha **DX 21**, **27** and **100**. The Yamaha DX27, DX27S, and DX100 were the low end versions of the professional Yamaha synthesizers -the DX7. They had smaller 61 note non velocity sensitive keyboards. The sound source was a 4 operator, 8 algorithm FM Tone Generator that could give 8 note polyphony. The DX21,27,and 100 were basically the same machine with slight variations of effects and portability.
- Yamaha **DX7II**: an updated DX7
- **DX11** and **TX81Z**. Yamaha added more waveforms and multitimbrality for the DX11 and TX81Z, these instruments eventually became the protoypes for the recent SY77 and 99.
- **TX816**.The TX816 is eight rack-mounted DX7 modules together in one casing.

Palm Productions GmbH (1975 - 1987)

PPG or 'Palm Productions GmbH' was created by Wolfgang Palm in Hamburg, Germany, 1975. PPG's early models included the Model 300 synthesiser, the PPG 1002, which Palm called "the first programmable synthesizer",the 340/380 System and the 360 Wavecomputer.

Palm began experimenting with all-digital synthesizer designs in 1977. Between then and 1980/81 he developed the first digital wavetable synthesizers.Deciding that the technical limitations of the period prohibited an all-digital design Palm opted for digital wavetable oscillators feeding into analogue filters and VCAs. The resulting instrument was the 'PPG Wave 2', which in turn developed into the 'Waveterm' and the 'Wave2.3' in 1985. Palm had designed a unique proprietry communication protocol for his instruments called 'PPG Communication Buss', unfortunately this was discontinued when the slower MIDI protocol became an industry standard a year later.

Palm's last product for PPG was the 'realizer', an innovative 16-bit/44.1Khz hard disk recorder and FM/wavetable synthesiser in 1986, this model never went into production and PPG closed in 1987. Palm continued his work with the German company 'Waldorf Electronics' supplying them with designs for the wavetable chip used in the 'Waldorf Microwave'.

Fig. 153 The PPG wavecomputer

Fig. 155 The PPG Waveterm

Fig. 156 The PPG Wave

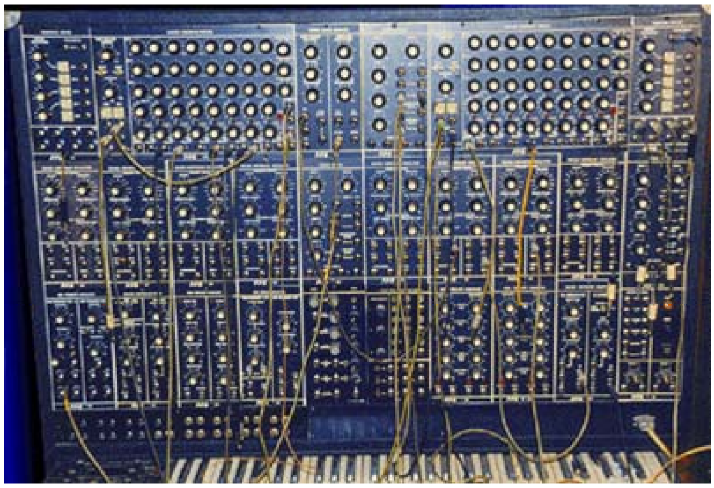


Fig. 154 The PPG 300 Synthesiser

Oberheim Electronics (1973)

Oberheim Electronics is a company, founded in 1973 by Tom Oberheim (a former design engineer at Maestro), which manufactured audio synthesizers and a variety of other electronic musical instruments. Originally a manufacturer of electronic effects devices, and briefly an ARP Instruments dealer, Oberheim went on to create several ground-breaking products in the early days of synthesizers and electronic music including the DS-2 (one of the first analogue music sequencers) and the Synthesizer Expansion Module (SEM). The first commercially available polyphonic synthesizers, available in two-, four-, and eight-voice configurations were based on these modules.

Oberheim's later synths like the OB-X and OB-Xa abandoned the relatively bulky SEMs in favor of individual voice cards, and common cabinetry and power supplies. Oberheim continued to make synthesizers until the late 1980s. Other notable Oberheim synthesizers include the OB-1 (monophonic), the OB-8, the Matrix-6, the Matrix-12, and the Matrix 1000.

Oberheim closed its doors in 1986, when it was acquired by Gibson Guitar Corporation, a larger musical instrument manufacturer.

The trade mark was later licensed to Viscount International SpA, an Italian digital-organ producer, by Gibson. Viscount developed in a few years various instruments that were very innovative for the time and are still requested: the digital synth Oberheim OB12, the guitar DSP GM-1000 with lot of effects, the MC series of master keyboards, and the OB3^2, a portable and inexpensive imitation of the popular Hammond series of organs.

Serge Synthesisers

Fig. 158 The Serge Modular Synthesiser (1979)

Fig. 157 Serge Tcherepnin, in the 80's

Serge gets its name from Serge Tcherepnin (pronounced "Cher - epp - nin"), a multitalented composer and electronic designer born of Russian-Chinese parents and raised in France. Self-taught in electronic design and circuit building, Serge enjoyed doing 'junk electronic' projects early on, making tape compositions using various electronic noisemakers cobbled together out of transistor radios and the like.

After studying music and physics at Harvard and Princeton, he taught music composition at the California Institute of the Arts. This was the early 70's, the heyday of Moog, ARP, and Buchla synthesizers. Calarts had a few Buchla-equipped studios. These were expensive, highly sought-after instruments, kept under lock and key. Getting studio time on one at Calarts meant being either a recognized staff composer or someone who manoeuvred themselves into favor. The Buchla, ARP, and Moog synthesizers were interesting in their way, but could be improved upon. They were both expensive and bulky, a system with a decent number of functions could take up a whole wall in a small room. Serge and students Rich Gold and Randy Cohen wondered what they could do about this. After kicking around some ideas, they decided they were going to do their own synthesizer.

The first modules were designed, soldered, and built at Serge's home in what was essentially a kitchen tabletop operation. Before long, the word got out to other professors, students, and musicians about this new synthesizer. They wanted a piece of the action. Serge set up a strange sort of guerrilla manufacturing operation at Calarts on a second-story courtyard balcony. People paid $700 upfront for parts, worked on the 'assembly line' soldering and building modules, and eventually got themselves a six-panel system. Somehow, the Calarts administration either didn't find out or wasn't too bothered by this.

Another interesting player in this drama was composer Morton Subotnik, a professor at Calarts. He had a long association with instrument designer Don Buchla in the early 60's, the two of them collaborating on fundamental aspects of synthesizer design. When Mort spoke, Don listened. Serge caught on to this, and sought to woo Morton away from the Buchlas, but that was difficult. Eventually, Serge did build Mort some custom equipment.

The Fairlight CMI

Fig. 159 The Fairlight CMI IIx Synthesiser/Sampler

The Fairlight was designed by two Australian engineers, Peter Vogel and Kim Ryrie who had already established the Fairlight company manufacturing and selling video special effects boxes. The prototype was known as the QASAR M8 (1978) subsequently developed into the Fairlight Computer Music Instrument in 1979.

The Fairlight CMI was the first commercially available digital sampling instrument, instead of generating sounds from mathematical wave data, the sampler digitises sounds from an external audio source via an analogue to digital convertor for re-synthesis or processing. The original Fairlight models used two standard 8 bit 6800 processors, updated to the more powerfull 16 bit 68000 chips in later versions. The Fairlight was equiped with two six octave keyboards an alphanumeric keyboard and an interactive VDU where sounds could be edited or drawn on the screen using a light pen. The whole instrument was controlled by proprietary software allowing editing, looping, mixing of sounds as well as the ability to draw soundwaves and sequence samples.

Fig. 160 A Fairlight CMI IIx Synthesiser/Sampler

During the early eighties the fairlight and the Synclavier were the high-end option for synthesis and sampling and way beyond the reach of all but the most up-market studios. This situation came to an end with the advent of complex and affordable digital synthesisers and samplers by instruments such as Ensoniq's "Mirage" (1986), Emu Systems' "Emulator" and AKAI's S1000 sampler range.

1 9 8 0

Casio Synthesisers (1982-1992)

Casio, the Japanese consumer electronics company, was in the professional synthesizer business until 1992. All of their synthesizers were digital, and involved menu driven programming interfaces. The CZ line used what they called 'Phase Distortion Synthesis'. The VZ line used 'Interactive Phase Distortion' and the FZ line were 16 bit sampling units. The CZ line was among the first commercially available MIDI keyboards.

The Casio Synthesiser and Sampler range (1982-1992)

CZ101

49 key mini-keyboard, 16 ROM patches, 16 RAM Patches. Polyphonic, non-velocity sensitive, multi-timbral(4part) "Phase Distortion" synthesiser.mono output, cartridge and cassette interface

CZ1000

a CZ-101 with full size keys

CZ5000

Two CZ-101s with full size keys and an onboard real-time & simple step-edit sequencer.mono output, built in chorus and a cassette interface

CZ-3000

The CZ-3000 is the CZ-5000 minus the sequencer.

CZ-1

Full size a 5-octave, 61 Key keyboard. Named patches, 64 ROM/RAM. Velocity +Aftertouch. 8 note poly/multitimbral.

Fig. 161 The Casio FZ10m sampling module

FZ-1

full size digital sampling keyboard. 16 bit/30k sampling (up to 2 megabytes).oversized 64x96 backlit LCD with menu-driven OS, visual editing of waveforms, up to 64 split points per patch (8 patches loaded simultaneously), 3.5" HD floppy (optional SCSI interface), 8 individual outputs (plus mix output), 16-way multitimbral (but only 8 notes polyphonic).

FZ-10M

Rack modules FZ-1. 8 individual outs, 2 Mbytes standard memory. The inputs/outputs are balanced (XLR) AND unbalanced (1/4" phone jack) It had some OS enhancements over the FZ1 and could perform additive synthesis (48 harmonics), and also had some basic waveforms (sawtooth etc).

FZ-20M

FZ-10M + a SCSI Hard disk interface. Rare and highly coveted.

VZ-1

Full size programmable (interactive Phase Distortion) keyboard (61 Key) Velocity & aftertouch. 16 note polyphony. 8 oscillators per note (128 oscillators total).The VZ-1 is multitimbral, although it doesn't have dynamic note allocation. You can get it respond to up to 8 MIDI channels at once in multimode. No sequencer.

VZ-8M
8 note polyphony expander module for VZ-1/10m. Provisions for Guitar and Wind synth usage. Lacks graphical envelope editor.

VZ-10M
16 voice rackmounted VZ module.

SZ1 multitrack Sequencer
The SZ1 was a 4 track real time/step MIDI sequencer, 3600 note memory with a data cartridge or cassette interface.

SK-1
Toy keyboard with a two second sample memory and a small embedded microphone.It is to some extent programmable, but it has no way to save patches.

SK-5
A SK-1 follow on. 4 sample memories.

DH-100
Digital Horn. A MIDI wind controller. 6 preset tones that you can play through the handy built in speaker. silver colour.

DH-200
DH-100 in black.

RZ-1
Sampling Drum Machine. .8 seconds of sample memory, that can be split 1, 2, or 4 ways. Easy programmability.

CTK-1000 & CTK-770
These are the currently produced MIDI consumer keyboards. They have built in sounds, with some sort of sound editor, a limited effect section, and MIDI.

Casio Guitar Synths

The Casio VL-1 Tone
Looking more like a large calculator, the VL-tone was 12 inches long and 2 inches wide with a 2.5 octave 'button' keyboard. The VL-tone allowed editing of 9 preset sounds via a simple (ADSR) envelop shaper and modulation via vibrato and/or tremolo. The VLtone had a simple rhythm box and a 100-110 note real time sequencer.

The McLeyvier (1981)

The McLeyvier was created by the musician David McLey and built and marketed by the Hazelcom Industries Company in Canada. The McLeyvier was and early high end (Priced between $15,000 and $30,000) computer controlled analogue synthesiser and composition tool. The McLevier's functions included the ability to store up to six hours of music on disk, up to 128 voice polyphony and a music score display, editing and printing system. The McLeyvier computer controller was programmable 'in any language, including Braille'.

The McLeyvier was an analogue instrument that had appeared at the exact time when digital synthsisers were starting to dominate the electronic musical instrument market, an attempt as made to create a digital version of the machine (with software written by Laurie Spiegel) but McLey's interest in the venture had faded, concentrating instead on his own musical works, and the Hazelcom Company dropped the project.

EMU Systems (1980)

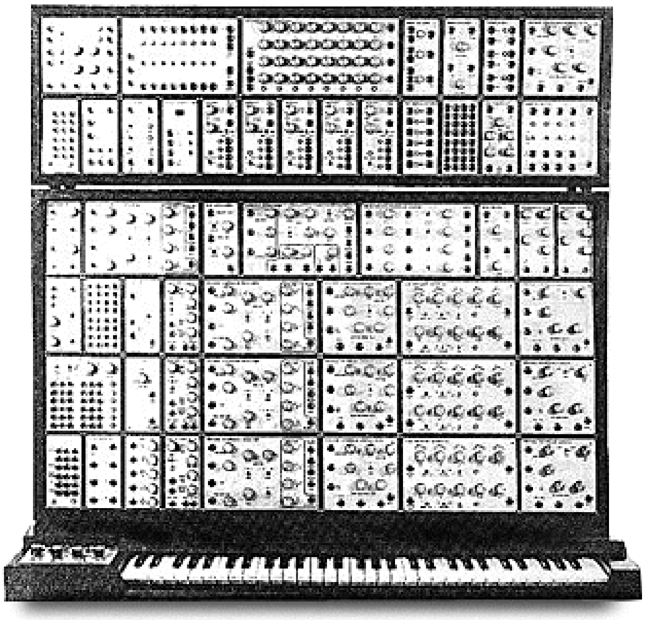


Fig. 162 EMU Modular Synthesiser

E-mu Systems®, Inc. is the leading developer of innovative digital audio products based on digital sampling technology for the musical instrument and computer controlled sound markets. E-mu® products feature high resolution CD quality sound, extensive programmability and superior ease of use. E-mu is a wholly owned subsidiary of Creative Technology, LTD. and is headquartered in Scotts Valley, CA.

Waldorf Electronics

Fig. 163 Waldorf Electronics Logo

The German company 'Waldorf Electronics' was founded in 1986 and is based in a castle near the village of Waldorf, Germany. The first product released in 1988 was the 'Microwave' wavetable synthesiser followed by the 'Wave' synthesiser in 1992.

The Waldorf Wave wavetable synthesiser

Fig. 164 The Waldorf Wave wavetable synthesiser

16,32 to 48 voices, each with 2 Oscillators, 2 Wavetable generators plus 1 Noise generator, Osc. Mixer, Multimode Filter, Amplifier, Panorama, 2 Aux Sends, 2 LFOs (6 shapes each), ADSR Amplifier envelope, DADSR Filter envelope, 8 Stage Time/Level Wave envelope, 4 Stage Time/Level Free envelope, Control Mixer, Control Shaper, Control Delay, Control Sample&Hold and Control Comparator.

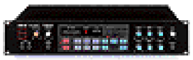
Oxford Synthesiser Company "Oscar" (1983)

Fig. 165 The Oscar Analogue synthesiser

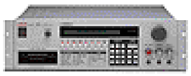
The Oxford Synthesiser Company and Electronic Dream Plant Ltd were two Oxford, UK based synthesiser companies run by the designer Chris Huggett, manufacturing innovative yet affordable synthesisers during the 1980's.

The OSCar was a compact dual oscillator analogue synthesiser built into a rubberised casing. The OSCar had two wide-range DCO's, capable of producing both analogue-style waveforms and programmable digital additive waveforms; dual resonant multimode VCF's with overdrive and separation controls; a wide-range LFO; two additional LFO's for PWM. The OSCar came with an inbuilt step sequencer of 580, later 1500 notes and an arpeggiator it also had memory (12 RAM/24 ROM) locations for storing yoursounds, waveforms and sequences. An upgraded MIDI and EPROM upgrade version was released in 1984.

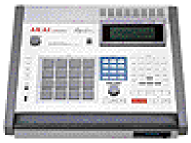
Akai Electronic Instruments (1984)



The Akai S612 sampler (1985)

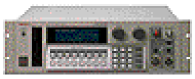


The Akai S900 sampler (1986)

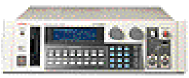


The Akai MPC60 Digital Sampler/Drum Machine and MIDI Sequencer (1987)

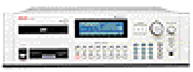
The Akai EVI1000 Digital Wind Instrument (1987)



The Akai S1000 sampler (1988)



The Akai S1100 sampler (1990)



The Akai CD3000 Digital Sampler (1993)

The Akai MPC3000 Digital MIDI Sequencer/Synth/Sampler (1994)

Akai Electronic Musical Instruments

Akai Electronic Musical Instruments, a division of the Japanese audio and video consumer electronics company Akai Electric Company, Ltd, entered the electronic musical instrument world in 1984 with the first in a series of affordable samplers the S612, an 8bit digital sampler module. The s612 was superceded in 1986 by the 16 bit range of professional s900-s3000 available as rackmounted modules or as keyboard versions. The current model the S3000 includes a built in CD ROM drive, hard-disk audio recording, Q-list programming, a SMPTE reader/generator, expanded sample editing and Assignable Program Modulation (ASM) for adding analog synth style processing to sampled sounds and digital outputs.

Akai also produced several Digital MIDI Sequencers/ Synthesisers such as the MPC range (MIDI Production Center) an integrated sampler/drum machine/MIDI sequencer and the MPC3000 a 32-voice polyphonyic, 16-bit sequencer/synthesiser.

Ensoniq Corporation

Fig. 166 The Ensoniq Mirage DSK

Crumar Synthesisers

Fig. 167 Crumar DS2 Synthesiser

Fig. 168 Crumar Stratus Synthesiser

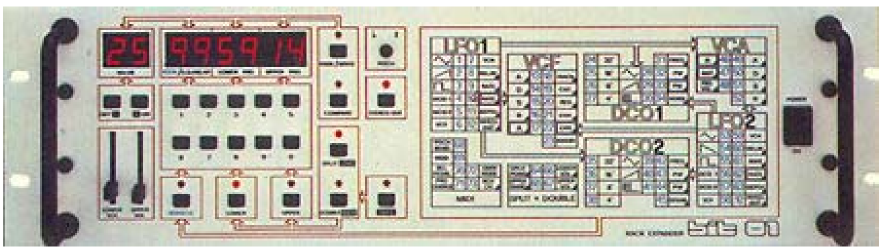


Fig. 169 Crumar Bit 01 Synthesiser

Kurzweil Music Systems Inc.

Kurzweil Music Systems Inc. was founded by inventor Raymond Kurzweil, who had developed a revolutionary reading machine for the blind that scans written materials and reads them aloud in a synthesized voice. The Musician Stevie Wonder, a customer for the reading machine, challenged Raymond Kurzweil to create an electronic instrument that blended the richness of acoustic sound with the control and sound modification of electronics. The Kurzweil engineers then developed the first ROM-based sampling keyboard, the K250, to successfully reproduce the full complexity of acoustic instrument sounds in 1983.

Fig. 170 Kurzweill PC 88 Synthesiser

In 1990 Kurzweill Systems was bought out by the Korean musical instrument manufacturer Young Chang and set up its R&D institute in Waltham, MA, USA. Raymond Kurzweil left the company which has continued to the present to produce sophisticated digital synthesisers and samplers.

The Alesis Corporation (1984)

The Alesis Corporation was formed by the former MXR engineer Keith Barr in Hollywood, California in 1984. The company aimed to create high quality affordable instruments and audio equipment. The first products of the company were a series of digital effect units such as the XT Digital Reverb (1985), the first of the MidiVerb series the MicroVerb, the MicroEnhancer, the MicroGate and the MicroLimiter.

In 1987 Alesis produced the The MMT-8 Multitrack MIDI Recorder and HR-16 High Sample Rate Drum Machine. The HR16 was a 16 bit digital drum machine with 49 preset drum sounds, velocity-sensitive keypads, and a full MIDI implementation, housed in a grey plastic housing with rubber pads and and LCD display. The MMT-8 was an eight track midi sequencer housed in a matching casing. The HR-16 was updated to the HR16-B in 1989 and eventually the SR-16 in 1991.

Fig. 171 The Alesis Quadrasynth

1993 saw the release of Alesis's first keyboard synthesiser the QuadraSynth, a 64 Voice 76 Key digital synthesiser wich came as a keyboard version and rack-mountable module version, the S4 64 Voice Sound Module. The QuadraSynth had 16 MB of onboard sample ROM, and was the first synth to offer the ADAT Optical Digital interface for direct recording into ADAT.

Recent instruments include The DM5 18 Bit Drum Module, the QS6 and QS8 Voice Expandable Synthesizers and ADAT recording systems.