Erkki Kurenniemi plays Dimi-A.
Photo: EKA, CAA, FNG

Erkki Kurenniemi's Electronic Music Instruments of the 1960s and 1970s

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For many, Erkki Kurenniemi is best known as an inventor of electronic music instruments. From 1963 to 1973 he designed and built a set of synthesizers which were experimental both

technically and in the way they were operated. The history, technology and user interfaces of these instruments have recently been studied in several articles (Ojanen et al. 2007; Ojanen and Suominen 2005; Städje 2009, 2012, 2013). This article is a brief and revised overview of Kurenniemi's instruments in the light of current research.

Introduction

When we initially started our research on Kurenniemi's instruments in 2004, it soon became clear that the information about the instruments was often inaccurate and a vague mix of fact and fiction. In our research we wanted to ensure that every piece of information would be as accurate as possible. We feel that Kurenniemi's instruments and their history are interesting enough without unnecessary exaggeration.

The main sources of our research were interviews and existing historical documents from the time the instruments were built, all of which we cross-checked for accuracy. Luckily, most of the instruments are still in working condition, which allowed us to gain first-hand experience on their functions. In many cases, we had to spend hours to go through each knob, jack and metal contact in different combinations by trial and error while reading the schematics of the instruments. The recordings made by using these instruments, when they were actively used, gave us

information that was useful when dating their construction while also revealing features that had stopped working over the years.

From the very beginning, Kurenniemi spent a fair amount of time in documenting the instruments during their design and construction process. The remaining documentation is mostly hand drawn on graph paper or note books, and it consists of sketches, timing charts, schematics, component lists and block diagrams. The original copies are located in both the Electronic Music Studio of the Department of Musicology, University of Helsinki (referred as the university studio in this text), and the Central Art Archives of Finnish National Gallery (CAA, FNG). The schematics are seemingly thorough, but during the renovation of the instruments, minor differences have been observed. It is probable that some of the schematics were made before the actual build, and changes made to the circuits during the actual construction work have not always been updated to the original drafts. Overall, the detail of documentation would allow for building new copies of most of Kurenniemi's instruments.

The design and functionality of these synthesizers have little in common with the digital synthesizers of today. Sound synthesis is mostly done by feeding the audio signal through a network of digital logic circuits. This closely resembles the approach taken by Stanley Lunetta in the 1970s with his CMOS synthesizers,

which are still actively built in the current DIY electronic music community (Lunetta 2013; electro-music.com 2013). None of the Kurenniemi instruments are capable of digital sound synthesis as we understand it today. They are not capable of real time PCM or wavetable synthesis, nor do they have DCOs similar to the synthesizers built during the shift from the analog to the digital (however, Kurenniemi experimented with wavetable synthesis on a 8-bit processor in the early 1970s but found the resolution too low for sound synthesis (Kurenniemi 1978).

Kurenniemi's instruments are filled with digital logic circuits. These are the fundamental building blocks of digital computers. Kurenniemi's vision of the automated composition process manifested itself in all of his instruments (Ojanen 2013). Kurenniemi saw music as a network of logical operations that could be mimiced with digital logic circuit technology. His early synthesizers mixed both voltage-controlled and digital circuits. After finishing Sähkökvartetti (Electric Quartet), he focused solely on digital control. The typical configuration which Kurenniemi used in many of his digital instruments had an ultrasonic square wave oscillator which was fed through a frequency division network and then low-pass filtered. In the instruments where the filtering of the sound was automated, the ordinary approach (only DIMI-6000 had digitally controlled VCFs) was simply to gate fixed analog filter circuits on and off; further adjustments were not possible (Documentation of

DIMI-6000; Documentation of Dico; Documentation of Sähkökvartetti).

Today, the extant Kurenniemi instruments are scattered around in five different locations. The largest collection of instruments is found at the premises of the university studio, where the remaining parts of the Integrated Synthesizer, Sähkökvartetti, Dico, DIMI-A, DIMI-6000 and a digital patch bay Dimix are located. The second hot spot is the Andromeda studio, which is located near Stockholm in the Swedish composer Ralph Lundsten's pink villa, Frankenburg. In Andromeda, Andromatic, DIMI-O and DIMI-S are all in active use. Two of the instruments are in museum collections: DIMI-A is stored in the Stockholm Music and Theatre Museum, and DIMI-S is in Helsinki in the Museum of Contemporary Art, Kiasma. DIMI-T was rented to the Department of Psychology of the University of Oslo in the 1970s for an undefined period, and it still remains in their possession.

Integrated Synthesizer

The first instrument Kurenniemi started to build was a complex system that was designed to be the heart of the university studio. Kurenniemi's vision was to create an automated composition system instead of a conventional tape music studio. This system consisted of three separate units: a tone generator unit, a mixer unit and a filter unit. The units consisted of several

modules, and many designs were later adapted to the later instruments built by Kurenniemi. The system never really had a name, and over the years it has been referred to as Sähkö-ääni-kone (Electric sound machine) (*Sähkö-shokki-ilta* 1968) or System 1 (Erkki Kurenniemi's letters, EKA). Later, it has commonly been called Integrated Synthesizer. (Ojanen and Suominen 2005, 18–20.)

The construction of the Integrated Synthesizer started in the 1963–1964 semester and continued until 1968. At that time, Kurenniemi did not have any formal education and only little experience in electronics (Kurenniemi 2004). As is often the case with experimental modular systems, new modules were added throughout the life span of the system, and it was never finished (*Kahdeksan tahtia tietokoneelle* 1967). However, Kurenniemi constructed the core parts of the systems rather quickly, and during the fall of 1964, the instrument was already operational (Ruutsalo 2000, 88). The Integrated Synthesizer was in active use in the late 1960s, but at the beginning of the 1970s it was replaced with other equipment (Ojanen and Suominen 2005, 18–20).

The schematics of the modules designed for the Integrated Synthesizer are found in a red folder which is full of sheets of graph paper. The list of modules is long: distorter, mixer, preamp, analyzer, signal splitter, phase shifter, circulator, cluster

generator, harmony generator, and many others (the documentation of Integrated Synthesizer). Today, only the tone generator unit and the remains of the mixer unit exist. A picture taken at the soirée Sähkö-shokki-ilta (Electric Shock Evening) shows an unidentified rack between Kurenniemi (who is operating the generator unit, which is barely visible in the photo) and Claes Andersson. This could be the lost filter unit of the Integrated Synthesizer, but as this is the only known photograph of this piece of equipment, this cannot be confirmed. The remaining part of the instrument does not have legends, and while the instrument itself is not currently in working condition, it is difficult to track which modules were actually built. The funding for a renovation project of the instrument is pending, and hopefully the Integrated Synthesizer will be restored in the near future.

Sähkökvartetti (Electric Quartet)

Kurenniemi built an instrument called Sähkökvartetti for the Finnish underground artist Mauri Antero Numminen in 1968. The men had met at a party at Claes Andersson's apartment in 1963. They immediately connected, and Kurenniemi ended up helping him to design a voice distortion unit called Laulukone (‘the song machine’) in 1964. Numminen attempted to make his already distinct yodeling singing style even more unbearable in order to

shake up the jury of a classical singing contest. Laulukone was soon dismantled as the components were desperately needed in the university studio. In 1966, excited about this experiment with electronic music, Numminen and Kurenniemi started to think about an instrument that could be used live with a complete band of musicians. The main idea was to have an electronic group equivalent to a jazz quartet. However, the sound of the machine should be out of this world and able to provoke the masses (Numminen 2006; Ojanen and Suominen 2005, 21).

A more serious design process continued in the fall of 1967 after Numminen had concluded his military service, and the actual build took place in the following spring. Numminen's longtime collaborator Kullervo Aura, who had earlier built Laulukone according to Kurenniemi's instructions, did the hands-on work together with Kurenniemi. In the long soldering sessions Numminen did his best to encourage both of them to stay focused in the work (Numminen 2006; Ojanen and Suominen 2005, 21).

Sähkökvartetti is a “collective” instrument consisting of a main unit (with tone generators and a sequencer) and a set of controllers (Melody machine, Electrical saxophone, Violin machine, Drum machine, filter bank controller and a light sword – a controller for distorting the vocalist’s voice). Each controller

controls individual circuitry within the main unit. Effectively, the instrument consists of four synthesizers, a voice distortion unit and a sequencer, which are built together as one instrument. The sequencer is patched with banana cables and may be used to control each button of any controller automatically.

The sequencer of Sähkökvartetti is in itself a revolutionary design. It combines a ten-step shift register sequencer with five and four bit counters. The former matches the design of what we would now call an ordinary analog sequencer, familiar from Buchla and Moog modulars, although in Kurenniemi's case, it only outputs digital trigger signals. Counters may be used to build complex rhythmic patterns when they are used to mute other trigger signals from different outputs of the sequencer. This enables the performer to program automatically transposing melodies or to create long, constantly varying rhythmic beats. Fortunately, it is not rare to see counter circuits in modular systems today. Both circuits are common building blocks of digital computers.

The sound of Sähkökvartetti successfully complements the singing voice of M. A. Numminen. Individual sound sources drift constantly out of tune, and the scales represent a relatively unequal version of the equal temperament. The drum sounds of the drum machine are more reminiscent of African drum

instruments than a Western drum kit. This all adds up to noisy, nasal and highly dissonant wall of sound.

Numminen formed a lineup to perform with the instrument and named the group after it. Sähkökvartetti was booked to perform in The World Festival of Youth and Students in Bulgaria before the instrument was even constructed. The festival took place in July 1968, and the instrument was barely finished in time. Sähkökvartetti was supposed to perform numerous times during the festival. However, after the first performance in front of an audience of 4,000 people, the festival organizers – shocked by the sound of the group – did not allow them to take the stage anymore (Kuljuntausta 2002, 468; Numminen 2006; Ojanen and Suominen 2005, 21).

Sähkökvartetti was notorious for playing only one song in their concerts: “Kaukana väijyy ystäviä”. The instrument was also used during the shows (or events) of Suomen Talvisota (The Winter War of Finland), which was a mixture of a rock group and a performing collective. These performances where often concluded with a short instrumental improvisation played with Sähkökvartetti (Numminen 2006; Kuljuntausta 2002, 468).

Today, Sähkökvartetti is located at the university and is in working order. Its main defects are a missing controller of the

violin machine and some minor malfunctions in the circuitry of the light sword.

Andromatic.
Photo: EKA, CAA, FNG

Andromatic

Soon after finishing Sähkökvartetti in the summer of 1968, Kurenniemi started working on another commissioned instrument, Andromatic (the name of the instrument is a

combination of the name of Lundsten's studio Andromeda and the word automatic (Städje 2012)). The instrument was first used in November 1968 in an exhibition in Gallery Samlaren, Stockholm, where it was used to control the lights installed in Olle Andrin's transparent sculpture. The piece was also exhibited in the Contemporary Crafts Museum in New York the following year. After the exhibitions, it was installed in Lundsten's studio and can be heard on a large number of his recordings (Ojanen and Suominen 2005, 22).

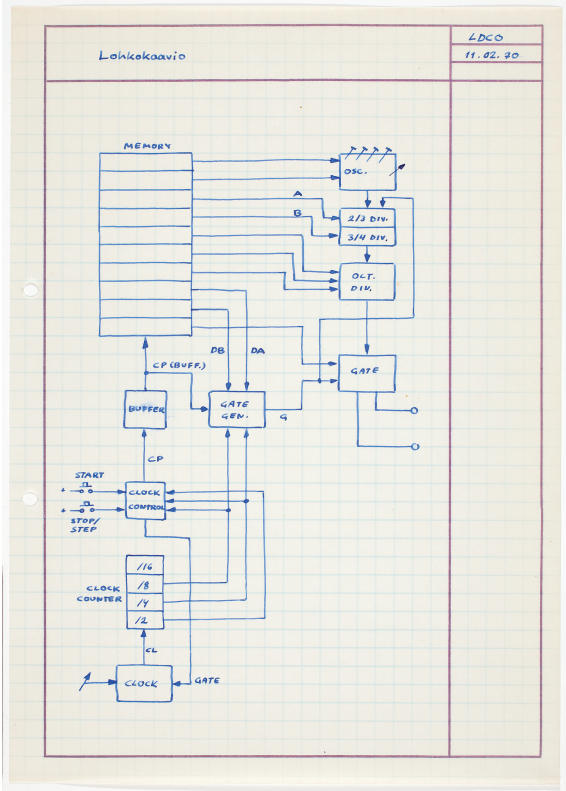
Ralph Lundsten and Kurenniemi met in 1965, and Lundsten soon visited the university studio to prepare material for his compositions. This triggered their collaboration, and eventually six of the Kurenniemi instruments ended up in the Andromeda studio in the course of the following years. Lundsten wanted Kurenniemi to build him a polyphonic synthesizer that was not attached to the standard western scales. Kurenniemi finished the instrument in the fall of 1968 and made a test recording of his own before delivering the instrument to Lundsten. This recording became *Antropoidien tanssi* (*The Dance of the Anthropoids*), which has been released several times, most famously on the album of the Finnish progressive rock band Wigwam (Städje 2002; Ojanen and Suominen 2005, 22).

Andromatic has a 10-stage sequencer, where every stage controls an individual oscillator. The configuration of the

sequencer makes Andromatic unique: the way each stage is connected to the other stages can be changed with a switch. This allows for the use of a stage in either a shift register or a counter mode. If all stages are in the shift register mode, the sequencer functions as a conventional step sequencer. When in counter mode, a long sequence of 1,024 steps is reproduced. The typical way of using the sequencer is to combine stages in each mode, which enables the combination of melodies and harmonies and the creation of somewhat complex generative patterns (Städje 2002). (Documentation of Andromatic.)

Dico

Erkki Kurenniemi started working on a custom synthesizer for composer Osmo Lindeman (1929–1987) at the end of 1968, and the instrument was finished in 1969. Lindeman's input during the design process is not known. The end result was a monophonic synthesizer with a 12-step sequencer. Sequencers were rare items in the 1960s, but what made the sequencer of Dico even more special was the fact that each step was stored in the digital memory as one 10-bit word. Lindeman used Dico as the primary sound generator in his studio for years (Ojanen and Suominen 2005, 23; Riikonen 1978).



Dico, a block diagram.
EKA, CAA, FNG, photo: Jenni Nurminen

From the player's perspective, Dico is a monophonic synthesizer with a digital sequencer. The idea of the sequencer is based on Kurenniemi's experience with the early digital computers (Kurenniemi 2004). The state of each sequencer step is represented by 10 light bulbs (the remaining two were left as a "future expansion"). On each step the user can adjust the

diatonic pitch (four bits), octave range (three bits), articulation (two bits) and the output channel (one bit).

The values of the bits of the memory are changed through a matrix of three rows by twelve columns of screw heads. Initially, the idea was only to use two rows of contacts, which would then be grounded with a stylus of some sort. Grounding the upper row will set the pin on, while the lower row sets the pin off. The finished instrument adds a row of grounded screw heads between the rows. This allows one to use a metal brush for connecting the middle row to either the pin above or below it. The metal brush was soon replaced with a piece of electrical wire acting as a stylus. Both the brush and the stylus option are handy for creating fast arpeggios. With a light touch, the player may change the state of random steps when the sequence is edited while the sequencer is running. The 4x4 patch bay of Dico may be used to connect the signal from the oscillator to either an attenuator bank or a band-pass filter bank and further to either of the two main outputs (Documentation of Dico).

The electronic block diagram reveals a setup typical of Kurenniemi's instruments (Documentation of Dico). His instruments rarely used voltage-controlled oscillators that were typical of the synthesizers at that time. Instead, they used frequency division, a technology familiar from electric organs (Douglas 1976, 43). During the 1960s, the stability of oscillators

was still a major problem among synthesizer designers (Pinch and Trocco 2002, 226), and frequency division offered a simple way to keep the instrument in tune as it required only one oscillator which does not need to be voltage controlled (the most common electric organ design uses 12 oscillators, one for each note of the scale). The oscillator is tuned above the audible frequency range, and all notes of the synthesizer are made by dividing the frequency with whole numbers. The technique is easiest to implement when the waveform of the signal is a pulse wave, which is why it is the waveform of choice in most of Kurenniemi's instruments. In Dico, Kurenniemi experimented with this technology for the first time and continued to use four oscillators to form intervals above the harmonic scale, which are then connected to a frequency division network. In later designs, only one main oscillator is used (Ojanen and Suominen 2005, 37).

According to recent research, there are several different names for Dico. The schematics from December 1968 to February 1970 use three different names for the instrument (in chronological order): DIGO, DCO and LDCO (Documentation of Dico). At this stage of research, all the known sources from the last century refer to it is as DIGO (or Digo) (Riikonen 1978, 32; CV-sketch, EKA). In the 21st century, the instrument has commonly been called Dico. However, it is unclear where this spelling comes from. Taking into account the history of DIMI-A, where the

“official” title gradually shifted from DIMI to DIMI-1, and eventually to DIMI-A in the span of two years (Ojanen and Suominen 2005, 25; Erkki Kurenniemi's letters, EKA), Dico may well have a similar history, as the actual name of the instrument may not have been necessarily important. Another plausible theory is the “broken telephone effect” of interviews (Digo easily transforms to Dico when pronounced by a Finn). However, all the different names are acronyms of the same title: digitally controlled oscillator (the 'L' on LDCO most probably referring to Lindeman himself).

DIMI-A

The layout of the DIMI-A touchpad is an eye-catcher and for many the most noticeable of Kurenniemi’s instruments. It was built in 1970 as a research project, the focus of which was to explore the potential applications of digital techniques in producing electroacoustic music. DIMI-A is basically a two voice synthesizer with a sequencer equipped with a digital memory. It was also the first instrument intended for the commercial market. However, the unconventional interface together with unprofessional marketing efforts ensured that the instrument was never mass produced, and only two units were built (Ojanen and Suominen 2005, 25).

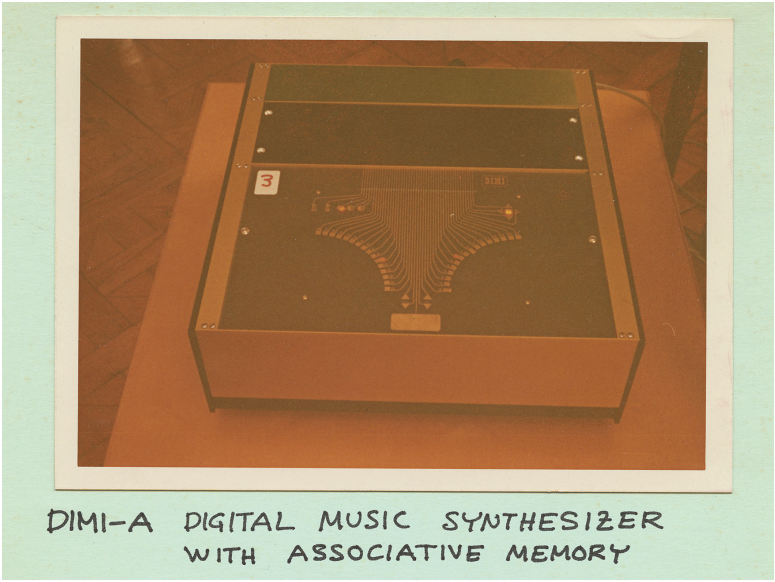


Photo: EKA,CAA, FNG

The first DIMI-A was finished in August, 1970. Kurenniemi had convinced SITRA (The Finnish Innovation Fund) to support him in developing an instrument, which would later become DIMI-O. However, SITRA could not support private persons, and in order to receive the grant, Digelius Electronics was founded in September 1970. DIMI-A then became the first product of Digelius, and before long a 7" promotional single DIMI 1 (DIMI is born) was released. Kurenniemi contacted several institutes abroad to sell DIMI-A, but many of the institutes either found the equal-tempered scale too limiting or had just acquired EMS VCS3, which had just been released to the market. Kurenniemi

attempted to sell DIMI to Peter Zinovieff's EMS and flew to London in December, 1970. Instead of making the sale, Kurenniemi ended up buying a VCS3 for the Department of Musicology (Erkki Kurenniemi's letters, Finnish National Archives). Eventually, one unit was sold to Ralph Lundsten, who used it for a few years but ended up donating it to the collections of Stockholm Music Museum (Musikmuseet, Stockholm Music and Theatre Museum since 2010). The remaining unit is located at the university studio (Lundsten 2004; Ojanen and Suominen 2005, 25).

DIMI-A was designed as a sound generator and filter for studio use, and as such was not intended for live use. It is programmed by touching the metal contacts on its touchpad with two styluses. Parameters are chosen through pads on the left hand side, and the values are entered through the pads on the right. In the digital memory, 100 events may be stored in a score of a maximum of 256 steps. In order to have a score larger than the size of the memory, an associative memory scheme (hence the ‘A’ in DIMI-A) was used.

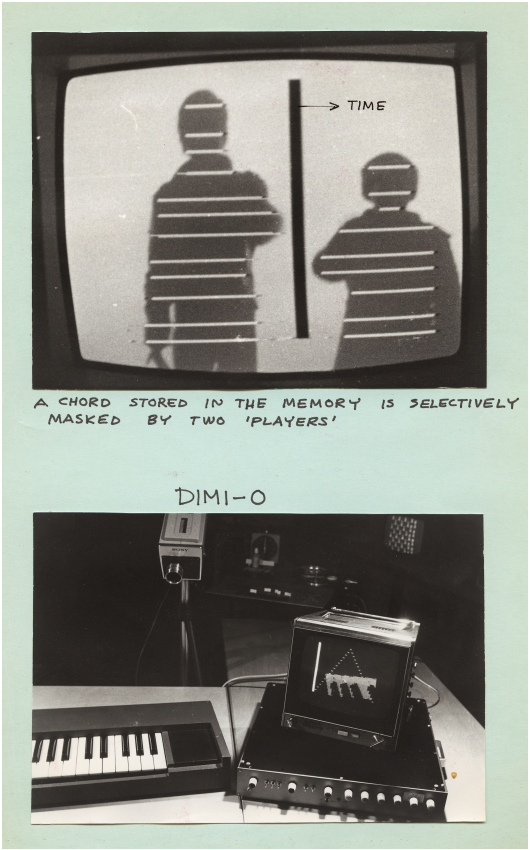


Photo: EKA, CAA, FNG

DIMI-O

With the funding for the prototype of a video-controlled organ secured from Sitra, the Finnish Innovation Fund, the construction of DIMI-O started in the fall of 1970 and was completed in April, 1971. In addition to Kurenniemi, electrical engineer Hannu

Viitasalo played an important role in designing and constructing the instrument. O stands for optical input, a video camera that could be used to alter the memory contents of the digital sequencer in real time. Only one prototype unit was built (Erkki Kurenniemi's letters, EKA; Ojanen and Suominen 2005, 27).

The central unit of DIMI-O includes a 48-note traditional electric organ keyboard and a memory unit with a 32-step sequencer. On the video screen, there is a 32 x 48 grid visualizing the memory contents. On the screen, the 32-step sequence is presented horizontally, and the four-octave key range (i.e. 48 notes) vertically. This fixes the obvious shortcoming of DIMI-A where the contents of the memory could not be viewed at all. On the other hand, DIMI-A is capable of storing multiple parameters in its memory while DIMI-O only stores the information of the playing notes (Ojanen et al. 2007; Städje 2013).

The most experimental feature of DIMI-O is obviously the optical input through video camera. Video image can be combined with the memory contents in real time. The image data is thresholded and then used as ones and zeros. Similarly, the keyboard may be used either to enter the data in memory or to play the instrument in real time (Ojanen et al. 2007; Städje 2013). An article by Städje (2013) contains a more thorough description of DIMI-O.

In September 1971, a demonstration video with a ballet dancer was made by the Finnish National Broadcasting Company YLE, but it was never used. During the following year, DIMI-O was used in an “intermedia” piece “Deal” as well as in psychological experiments at Department of Psychology at the University of Oslo. In Finland, DIMI-O was exhibited in an exhibition by the artist group Elonkorjaajat. Kurenniemi also performed Strauss's Blue Danube as a soloist for the Oulu Symphony Orchestra. Pleased by the performance, he (humbly!) said that it “sounded like Strauss – but better!” (Kurenniemi 1978). Until the mid-1970s, DIMI-O was mostly kept at the university studio. As the financial situation of Digelius Electronics kept deteriorating, DIMI-O was sold to Lundsten. It quickly became the centerpiece of the Andromeda studio, and Lundsten used it in numerous compositions. As the Andromeda studio has been a popular destination for journalists and TV-teams, DIMI-O has received worldwide exposure over the years – even the members of Led Zeppelin played it during their visit to the studio of television channel TV4 (Lundsten 2006; Ojanen and Suominen 2005, 29).

Dimix

Dimix was a digitally controlled mixing console and patch bay. Only one prototype was built and installed to the university studio in 1972. It remained in active use until the early 1980s (Ojanen and Suominen 2005, 28).

Dimix consists of a central unit and a television monitor. The central unit has a numerical keyboard for entering the patch state of 8 stereo channels. The panel also has sliders for adjusting the volume of the signals fed through it. From the video monitor one could monitor volume levels and observe the current patch state. It was also possible to connect a video camera for monitoring the studio space from the monitoring room, but this feature was not used.

At the moment, the whereabouts of the detailed documentation of Dimix is not known. Currently, Dimix is partly functional: the video circuitry and input channels work. The patch bay itself was built using digital relay chips, many of which have been mechanically stuck to one state after years of being unused, making it impossible to change the current patch.

DIMI-S

DIMI-S could be better defined as a musical toy than a true instrument. Ralph Lundsten had an idea of *kärleksmaskin* (love machine) – an emotional lie detector, a synthesizer that would react to people touching each other, creating a sound that would reflect and affect the overall mood of the players (Ojanen and Suominen 2005, 29; Städje 2009). Kurenniemi's take on

Lundsten's vision is an unconventional, collectively operated polyphonic synthesizer (DIMI-diary 1971–1972).

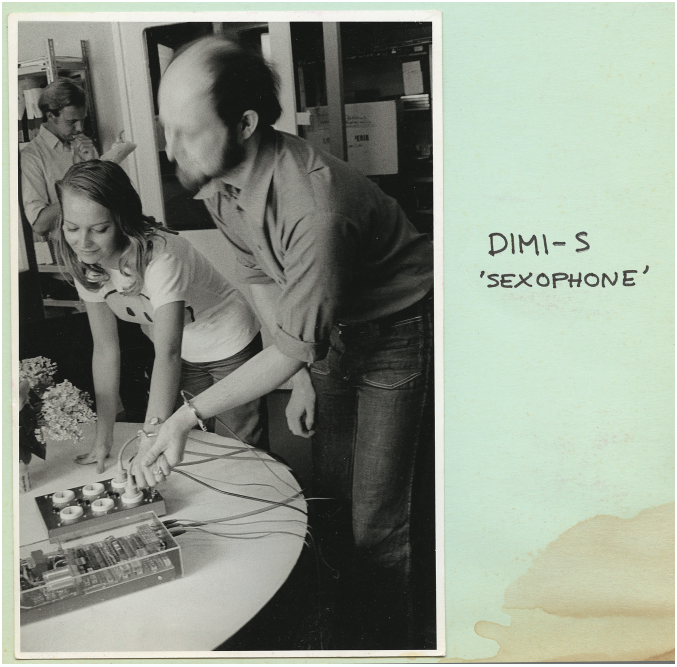


Photo: EKA, CAA, FNG

The design process of DIMI-S started at the end of 1971. Eventually, Kurenniemi built two versions of DIMI-S. The first version was prepared for the exhibition Pripporama that was held at Pripps brewery in 1972. For the exhibition, Lundsten painted a large scale painting with integrated light bulbs which were connected to the synthesizer. The second version was installed to the Andromeda studio, and its light outputs were

connected to the ceiling lights of Lundsten's villa. The most significant difference between the units is their case. The first DIMI-S had a futuristic case, where its electronics could be viewed through a plastic dome. The case of the second DIMI-S was a flat metal box with a lid made of transparent plastic. After the exhibition was finished, the first DIMI-S returned to the Andromeda studio. In 2007, it was sold to the Finnish Museum of Contemporary Art, Kiasma (Documentation of DIMI-S-02; Kurenniemi's e-mails; Ojanen and Suominen 2005, 29; Städje 2009).

The basic principle of playing the instrument may not be obvious for the players, but it is rather simple. In the basic setup, four people play the synthesizer simultaneously. Each player will hold an electrode (a knob, a handcuff) in their hand through which they will be connected to the electrical circuits of the synthesizer. This allows DIMI-S to detect when players make skin contact with each other.

Four players can form pairs in six ways, and one synthesizer voice has been associated with each of these pairs. When two players are touching, the voice associated with the pair is heard, otherwise it will be muted. Moreover, when skin contact is made, the frequency of two synthesizer voices is changed. Depending on the voice, one of these voices may or may not be the one that is gated. The frequency of each voice is divided by a frequency

divider circuit with a number between one and sixteen. For one voice connected to a single player pair, this divisor number will step down one unit while the other will step up (the value of the divisor is set between 0 and 15). Musically, the divisor circuit chooses one note from an inverted harmonic series. In addition to these functions, two pairs also control the speed of the vibrato of the synthesizer. Players are able to form different pairs concurrently, and consequently all six voices can be audible at the same time. It should be noted that only the information of whether the players touch each other is used. The actual resistance reading between the players has no effect. An article by Städje contains a more thorough description of DIMI-S (Documentation of DIMI-S; Städje 2009).

DIMI-T

DIMI-T (1973) was an attempt to connect a human mind straight to a synthesizer. It was inspired by Manford L. Eaton (with whom Kurenniemi exchanged letters at the time (Letters of Kurenniemi)) and his concept of biofeedback music. DIMI-T is controlled with the brain waves that are measured through electrodes on the player's earlobes. The synthesizer itself is the simplest one Kurenniemi ever built: the measured brainwaves control the frequency of a single oscillator. To maximize the safety of the player, DIMI-T is not connected to an electrical network in any way: it gets its power from a battery, and sound

is output through an embedded speaker (Documentation of DIMI-T; Kuljuntausta 2002, appended image; Ojanen and Suominen 2005, 30).

DIMI-T functions in the following way. The brain waves measured by electrodes are first amplified. Excessive noise is then filtered out, and only a ~10Hz alpha wave remains. The volume envelope of the alpha wave is constructed and used to control a sine wave oscillator (ICL8083 sine wave generator IC, Documentation of DIMI-T). The instrument is currently under renovation.

DIMI-6000

The Intel 8008 microprocessor was introduced in 1972 (Eilers 2013). The processor had computing power close to the amount of micro controllers used in the currently popular Arduino boards, but in the early 1970s this was something revolutionary. Kurenniemi saw the possibilities of this chip and started to sketch an instrument based on it. This meant halting the design process of DIMI-U, the instrument that should have combined the power of both DIMI-A and DIMI-O. DIMI-6000 was a computer-controlled analog synthesizer with no external interface (Ojanen and Suominen 2005, 30–31), a design that resembles the legendary Commodore 64 computer, but seven

years earlier (*Commodore 64 MicroComputer User Manual* 1984, 88).

The story of DIMI-6000 is tightly linked with the founding of the *Experimental Studio* (Kokeilustudio) of the Finnish National Broadcasting Company, YLE. The studio was founded in 1973, and it needed gear suitable for making electroacoustic music. Kurenniemi started to work on an instrument, and in April 1975 DIMI-6000 was handed over to the studio. Another copy of DIMI-6000 was also made and delivered to the Andromeda studio. However, Lundsten did not find an instrument which was only controlled by programming useful for his purposes and never used it (Ojanen and Suominen 2005, 31; Städje 2009).

DIMI-6000 has eight voltage-controlled modules: four VCOs, two VCFs and two VCAs, all of which can be controlled trough software. It also contains four ring modulators. Modules can also be patched together through software (Documentation of DIMI-6000). DIMI-6000 is operated through an ADDS serial terminal. Initially, software called Discord was used, but in 1977 Jukka Ruohomäki wrote a more advanced software called Dismal. It allowed the user to enter a score which the synthesizer would then perform automatically. (Ruohomäki 1977.)

Currently the DIMI-6000 of the Experimental Studio of the Finnish National Broadcasting Company is located in the university studio. Lundsten's DIMI-6000 has been taken to pieces, but one panel still shares a rack with DIMI-O and Andromatic in his studio. Working copies of the Discord or Dismal software are not known to exist.

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