INSTITUTE OF SONOLOGY - UTRECHT STATE UNIVERSITY

ELECTRONIC MUSIC REPORTS

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STUDIOS

PROJECTS

INFORMATION

o Translated by Ruth Koenig

Joh. G. Witteman

STEIM

ITS BEGINNINGS, AIMS AND WORKING METHODS

INTRODUCTION

STEIM is the abbreviated form of the Studio for Electro-Instrumental Music. The difference between STEIM and other existing electronic music studios is that the music is not fixed on tape, but made to sound directly. The sound-source can be a concrete one: musical instruments, percussion; but use can also be made of electronically controlled sound generators, played as instruments. The sound-source is made audible directly through loudspeakers.

ORGANIZATION

The STEIM work-group was started in July 1967 by the composers Louis Andriessen, Konrad Boehmer, Reinbert de Leeuw, Mischa Mengelberg, Dick Raaijmakers, Peter Schat and Jan van Vlijmen, with the following aims:

1. The establishment and exploitation of a studio for the construction and development of new musical instruments proceeding from electronic sound-sources and/or electrically amplified or modulated existing sound-sources or instruments.

2. The familiarization of musicians and technicians with the use of the above-mentioned instruments.

3. The propagation and stimulation of the use of these instruments in artistic circles and in general.

4. The organization of concerts and other events in the field of electro-instrumental music.

In order to realize these aims and to obtain the funds necessary for doing so, the official STEIM Foundation was set up on February 27th 1969 at Amsterdam. The managing committee of this foundation was nominated by the STEIM work-group. The foundation's aim is to promote electro-instrumental music and everything connected with it in the widest sense, and more specifically to support the aims of the STEIM work-group association, also at Amsterdam.

EQUIPMENT

During 1968 and 1969 an extensive basic instrumentarium was assembled, chiefly designed and constructed by Mr. van Kuilenburg and Mr. Scherpenisse, both of the Institute of Sonology at Utrecht University. The most important elements of the equipment are formed by the following components:

A universal switchboard. This instrument can be used during performance to set up the most complicated circuits in a trice because of its preset switches, crossbar system and special switch-manual which can be played as a musical instrument.

Mixer units

Microphone amplifiers with measuring circuits

Amplitude modulators

Ring modulators, multiplier type

Amplitude demodulators

Frequency demodulators

Compressors (automatic volume-contractors)

Inverters

Equalizers

Hand-operated oscillators

Voltage-controlled oscillators

Voltage-controlled filters

Microphones

Contact microphones

Stereo playback equipment

Revox recorders

<u>Uher portable recorder</u>

<u>Digital equipment</u>

<u>Portable Hammond organ</u>

<u>Hohner Clavinet</u>

<u>Hohner Pianet</u>

<u>Moog filters</u>

TECHNICAL DIRECTION

The daily care of the technical department is in the hands of Jan Herman Verpoorten, a musician and specialist in the design and construction of electro-instrumental equipment. Apart from designing and building new apparatus, Mr. Verpoorten also provides project guidance. This means that he assists the composer from the start of the latter's electro-instrumental composition by advizing him about, designing and building the special equipment necessary for the project. He is also present at the performance of a work in a concert.

STUDIO SPACE AND COMPOSERS' WORKING METHODS

All the equipment mentioned is based in the Amsterdam studio and - if not required elsewhere - ready for use. However, the equipment is intended to be as mobile as possible in order to fulfil the requirements of the 'live' character and application possibilities of all STEIM concerts wherever they may take place.

All composer-members of the STEIM work-group may work and experiment in the studio whenever and as often as they please. In practice, however, this occurs with the close collaboration of the project guide, who is also responsible for the equipment.

The studio is also open to composers and musicians who are not members of the STEIM work-group. They usually get in touch with one of the members of the work-group in order to make themselves acquainted. An appointment is then made with the project guide to visit the studio once or several times.

PRODUCTION AND PERFORMANCES

If a composer is commissioned to write a STEIM composition, the secretary of the STEIM Foundation makes an estimate of the costs involved in building and/or renting the necessary apparatus, and the costs of studio rent and project guidance. If the commissioner agrees with the estimate, preparations are then made. A separate estimate is made for the eventual performance(s).

COMPOSITIONS, CONCERTS, GRAMOPHONE RECORDS

Apart from the commissions montioned above, many STEIM works occur on the initiative of members of the work-group themselves. All the members have diverse typical STEIM compositions to their credit which are performed on special occasions (art exhibitions, general cultural manifestations, political events, lectures on contemporary music, etc.). An agreement is made with the secretary of the foundation as to the costs of such performances. Some STEIM compositions are: 'Interpolations' by Jan van Vlijmen, 'Hypothema' by Peter Schat, 'Opus II No. 1' by Louis Andriessen, 'Amaga' by Mischa Mengelberg, 'Weg' by Konrad Boehmer, 'Schaakmuziek' (*'chess music'*) and 'Nachtmuziek' by Dick Raaijmakers and the opera 'Reconstructie' by Andriessen, de Leeuw, Mengelberg, Schat and van Vlijmen, performed in the Holland Festival in 1969.

As well as these activities, STEIM also produces gramophone records of specific STEIM works. The first production (Opus 001) is on three stereo long-playing discs and is an integral performance of the opera 'Reconstructie'. Two thousand complete cassettes with libretto are on the market at a price of ƒ 23.50. More STEIM records are in store.

CONTACTS WITH OTHER ORGANIZATIONS

STEIM works in close cooperation with the Studio for Electronic Music at Utrecht University. Regular contact is also had with conservatories, private studios, theatrical companies, etc. At present a contact organization for all producers of electronic and electro-instrumental music in the Netherlands is being set up with the aim of achieving optimum coordination.

TUITION

As well as the possibility of individual project guidance in the studio, there are also plans for group-tuition in the form of a course, which has yet to be developed, on the significance, workings and use of STEIM equipment. A request for this has already been received from the foundation 'Jeugd en Muziek' (*'youth and music'*) in the Netherlands.

FINANCES

The foundation's funds consist of:

(a) subsidies, gifts, legacies and donations.
(b) income from performances, renting equipment, studio rent and gramophone productions.

Regular annual subsidies are received from the Ministry of Culture, the Cultural Fund of the BUMA (performing rights society) and others. Individual subsidies have been received from the municipality of Amsterdam and various other institutions.

ADMINISTRATION

Administration is carried out by the secretary and treasurer of the foundation committee, which answers in the annual meetings for the line adopted during the previous year. Annual costs are checked by a chartered accountant, and the budget for the coming year is discussed.

Studio: Prinseneiland 25, Amsterdam, tel. (020) 22 86 90
Secretary: Comeniusstraat 287", Amsterdam, tel. (020) 17 31 85
(after 7 pm)
Project guidance: L. Nieuwstraat 29, Utrecht, tel. (030) 1 20 01
Work-group: Louis Andriessen, Keizersgracht 740, Amsterdam, tel.
(020) 22 04 73

Will G. Bottje

EQUIPMENT IN THE ELECTRONIC MUSIC STUDIO AT SOUTHERN ILLINOIS UNIVERSITY, CARBONDALE

LARGE STUDIO

TAPE RECORDERS

MRS Variable speed, 2 channel (infinitely variable from c. 2" per second to c. 50" per second). Also fixed speeds (1 7/8, $3\frac{3}{4}$, $7\frac{1}{2}$, 15, 30, 60)

Scully 280 4 track $\frac{1}{2}$ inch ($7\frac{1}{2}$-15 ips)

Ampex PR-10 2 channel ($7\frac{1}{2}$-15)

Ampex 601 2 channel with special looping mechanism

Uher 4000L Portable tape recorder (4 speed)

VOLTAGE CONTROLLED EQUIPMENT

3 Moog 901 Oscillators

3 Moog 901B Oscillators

3 Moog 911 Envelope Generators

1 Moog 904A High Pass Filter

1 Moog 904C Filter Coupler

1 Moog 961 Interface (on order)

1 Moog 910 Power Supply

1 Moog 950 Keyboard Controller

1 Moog 901A Oscillator-Controller

3 Moog 902 Voltage Controlled Amplifiers

1 Moog 912 Envelope Follower

1 Moog 904B Low Pass Filter

1 Moog 960 Sequential Controller

1 Moog 962 Sequential Switch (on order)

1 Moog 956 Linear Controller

OTHER EQUIPMENT

1 Moog Scale Programmer (950B)

1 Moog 914 Extended range filter bank (half octave, 6 octave range plus high and low pass)

1 Moog 905 Reverberation unit

1 Bode Ring Modulator

1 Moog Console, mixer, filters, bridge, trunklines, attenuators

2 Eico 377 audio generators

1 Heath 10-12 Oscilloscope

1 Fairchild 658 Reverbertron

4 Dynaco Mark III Amplifiers

2 Fisher x/p1A speakers

1 Bogen B62 variable turntable

1 Moog 903 White Sound Source

1 Moog 1084 4 channel mixer (10 inputs each line)

1 Beckman Frequency Counter

1 Heath 10-22 Electronic Switch

4 Dynaco Preamplifiers

2 Altec 844A Speaker Systems

1 Electrovoice 666 microphone

1 Electrovoice 650 microphone

Jack panels, cabinets, test equipment (inc. wow and flutter meter).

Remote control for tape recorders, editing equipment etc.

SMALL TEACHING STUDIO - designed for Musique Concrète and as illustration of potentials in low budget category

1 Sony 353 (3 speed, 3 head)

1 Viking etc. variable tape deck

1 Heath Mono pre-amp, and amplifier

1 passive mixer (6 in / 1 out)

2 Continental Elc. speakers

1 Reverb. Master

1 Sony MX-65 mixer

1 Sony 252D (2 speed, 2 head)

1 Heath Stereo Amp.
1 Eico 377 audio generator
1 constructed ring modulator
1 Electrovoice 650 microphone
1 Allison 2ABR,HP,LP filter
1 Jack panel, etc.

The studio has a tape library of about 150 tapes collected over a period of several years, also nearly all recordings of present and past of electronic music.

A staff electronics technician is assigned the studio as a portion of his regular duties (c. 1/3).

Stan Tempelaars

A DOUBLE VARIABLE FUNCTION GENERATOR

INTRODUCTION

The double variable function generator (VFG) described in this article is an improved and enlarged version of the first VFG designed in the Utrecht studio a few years ago. The two pieces of apparatus will be referred to in the following as VFG1 and VFG2.

A VFG is a programmable voltage source (also known as a sequencer), the output signal being a direct voltage whose magnitude alters according to the programming of the apparatus. The alterations can be so rapid that there is not much sense in continuing to speak of direct voltage. Diagrammatically, the output signal is a kind of staircase curve as in fig.1, for example:

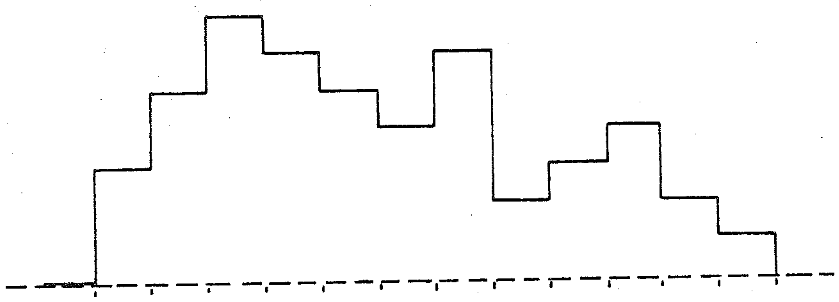
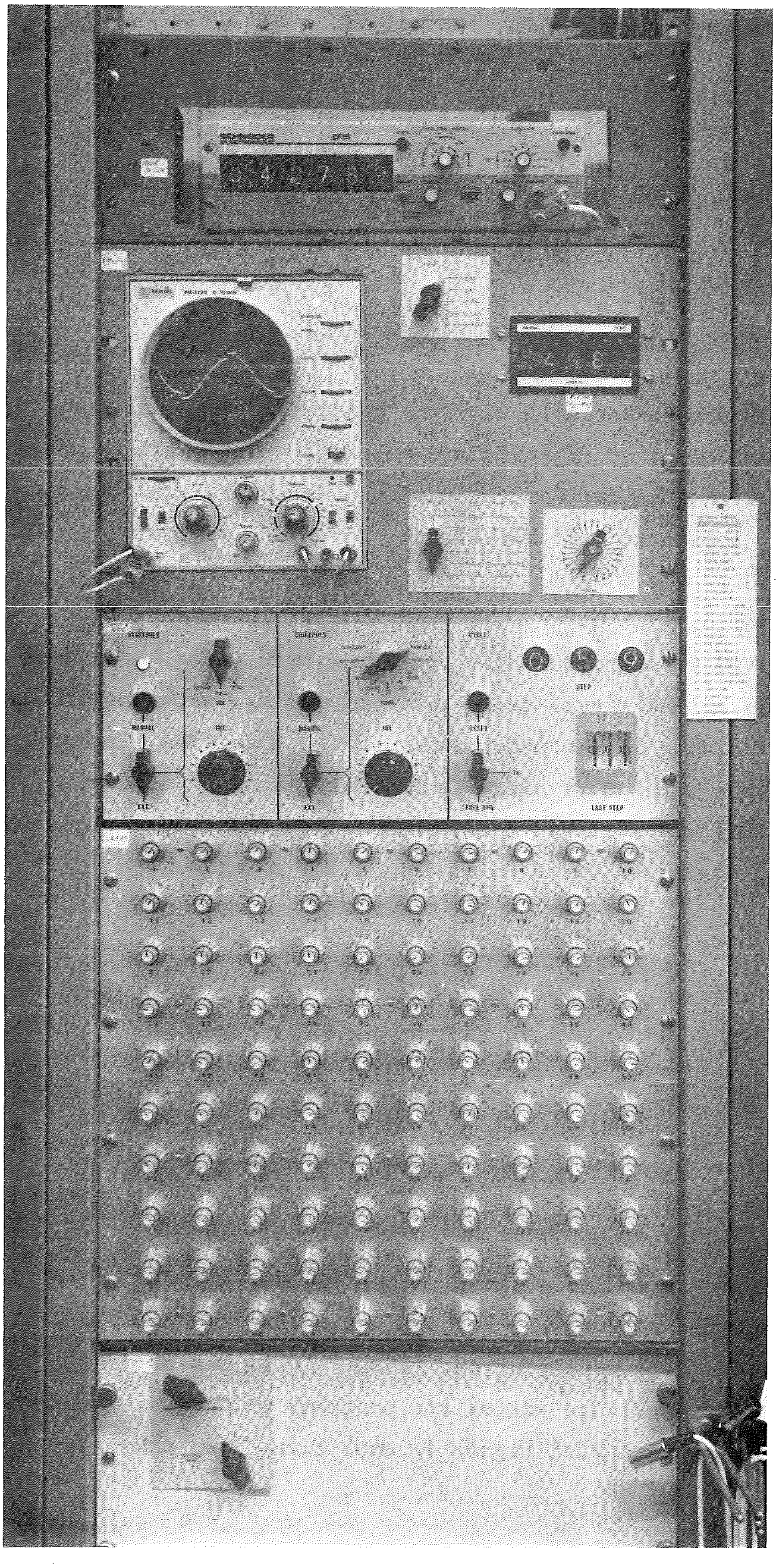


Fig. 1

For programming purposes, the VFG2 has a field of 100 double potentiometers. For each potentiometer two voltage values can be set independently of one another (VFG1 has 50 single potentiometers), and two voltage series are produced which are synchronous but independent with regard to amplitude. When the apparatus is started,



942789
458
CYCLE
STEP
LAST STEP

the programme is run through beginning at (double) potentiometer no.1 and ending at the potentiometer whose number has been set by means of thumbwheel switches. Any value between 2 and 100 may be selected for the length of the series (VFG1 has a fixed series-length of 50 steps).

Although the VFG was primarily designed as a source of control voltages for voltage-controlled studio equipment, it can also do excellent service as a waveform synthesizer and as a pulse generator, the possibilities again being greater than in the case of the VFG1.

OPERATION

The photograph shows the front view of the VFG2. Above the potentiometer field (the potentiometers have a big button and a little one and are numbered from 1 to 100, with a scale from 0 to 9. These numbers have no particular significance) are an oscilloscope on which the voltage curve can be shown, a digital voltmeter for accurate determination of the magnitude of each voltage, and right at the top a frequency counter for measuring the duration and repetition frequency of the voltage series. This measuring equipment is not built into the VFG, but can also be used for other measurements.

Below the potentiometer field is an operation panel divided into three sections. At this panel the characteristic magnitudes of a voltage series can be set, i.e. the moment it begins, the moments at which transition occurs from one level to the next and the number of steps of which the series must consist. At the extreme right-hand side there are three thumbwheel switches for setting the length of the voltage series; above them are three counting tubes showing the potentiometer to which the voltage currently at the output corresponds (the 'number of the staircase'). In this section there is also a switch with three positions ('up', 'right', 'down'). If this switch is 'up', the 'reset' push-button above it can be operated. This button has a stand-by function: once it has been pushed the apparatus is ready for use. If the switch points to the right (meaning 1×), a voltage series is produced once the apparatus is started. In the third position, 'free run', the voltage series is repeated without interruption when the apparatus is started.

The section at the left-hand side is for starting. To indicate that the VFG is ready to start, the lamp to the left at the top goes on. Here is another three-way switch in approximately the same place as in the section described above. There are three ways of starting a voltage series:

(1) 'up': by hand using the push-button,

(2) 'right': by means of start pulses from the built-in start pulse generator,

(3) 'down': by means of external start pulses.

If the start pulse generator is used, the duration between the pulses can be set with the switch and potentiometer which are in this section, the extreme values being 0.03 sec. and 30 sec.

The middle section is practically identical to the left-hand one, and provides the same selection and control facilities for shift pulses. These are pulses which bring about the transition from one voltage level to another and thus the duration of the entire series. If the built-in shift pulse generator is used, the duration can be regulated between 0.05 ms and 500 ms per step. The use of external shift pulses and the fact that two voltage series are produced make it possible to set a particular duration for each step. For this, one of the two series is connected to a voltage-time convertor (not built-in), which delivers a pulse after a period of time depending on the magnitude of the voltage with which it is supplied. If this pulse is used as a shift pulse, the length of each step can be programmed.

At the bottom, finally, there are two more switches, which are concerned with a possibility to be discussed in more detail presently: the filtering of one of the two series (the one which is set with the 'little' buttons of the potentiometer field and which is referred to as 'B'), which causes the square shape of the signal to change into a sawtooth shape with a rise or decay time depending, among other things, on the setting of the switch on the right ('filter slope').

Since the voltage series can be produced so rapidly as to cause an audible vibration, provision is made for passing the output signal through to the audio patch panel. The other switch can be used to choose either signal A (the series set by the 'big' buttons), signal B or signal C. This last signal is the sum of A and the filtered version of B.

CONSTRUCTION

Philips circuit blocks were used on a large scale in the construction of the apparatus. They are digital units composed of discrete components in a block of synthetic resin.

The VFG can be imagined as being in two sections:

a shift register with output amplifiers and adding networks, functioning as an electronic switch and with which the set voltage levels are sensed,

and the generators and logical networks for purposes of control.

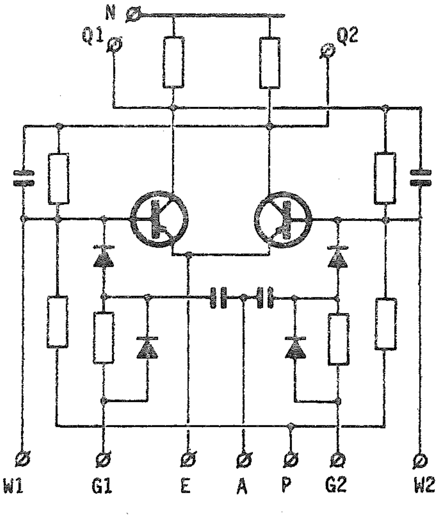


Fig.2

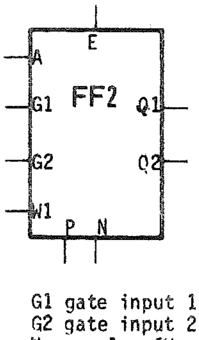


Fig.2a

A AC input		
W1 DC input 1	G1 gate input 1	Q1 output 1
W2 DC input 2	G2 gate input 2	Q2 output 2
E common supply 0V	N supply -6V	P supply +6V

A. <u>The shift register</u>

This consists of 101 flipflops (type FF2, see fig. 2 and 2a). When the apparatus is in action, one flipflop is always in the '1' position (see below), the others being in the '0' position. Entirely in accordance with the principle of a shift register, this '1' shifts one place further when the A-inputs of the flipflops are supplied with a pulse. The Q-outputs of each flipflop are connected to the W-inputs of each subsequent flipflop. Furthermore, the S (set)-input of flipflop 0 and the R (reset)-inputs of the flipflops are used to put the register in the stand-by position or to break off the series when the desired number of steps has been produced. How this is done is discussed below.

A flipflop is in the '1' position, or 'on', if there is a voltage of −6 volts at Q1. The other output, Q2, then provides about 0 volts. In the '0' or 'off' position, the situation is exactly the reverse.

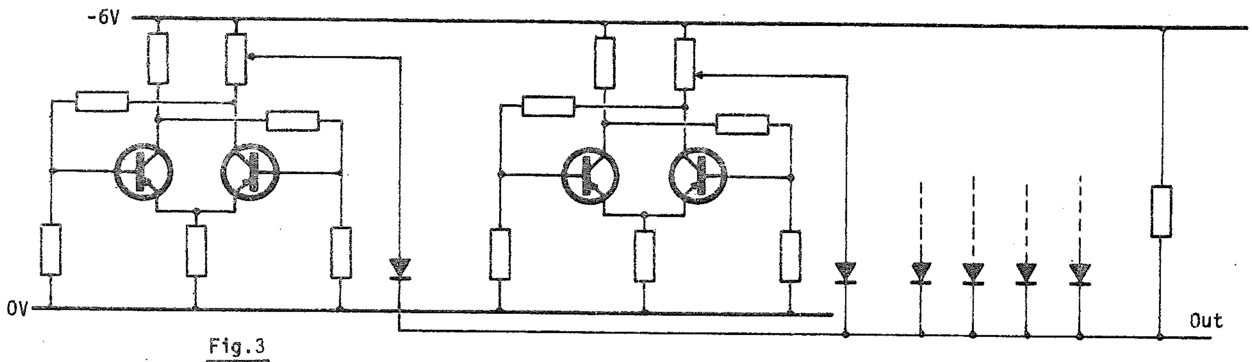


Fig.3

The flipflops are numbered from 0 through 100. Flipflop 0 has merely to see that a '1' is ready for flipflop 1, so that this '1' shifts to flipflop 1 at the first shift pulse. When this happens, voltages occur at outputs A and B of the apparatus depending on the position of double potentiometer 1.

This might be realized as follows (fig. 3):
the collector resistance of the flipflop's transistor, which does not conduct current in the '0' position, is replaced by a potentiometer. The collector voltage is the same as the supply voltage (-6 volts), so that -6 volts are delivered regardless of the potentiometer's position. This applies to all the flipflops in the register except for the one in the '1' position. Here the collector voltage is approximately 0 volts, and a voltage between 0 and -6 volts is delivered depending on the position of the potentiometer's slider. This voltage also appears at the output because all the sliders of all 100 potentiometers are connected to an OR-gate with 100 inputs. Only if the slider voltage is more than -6 volts does the diode conduct and pass on the set voltage. This is thus the case with one potentiometer only.

Since it was not possible to replace the collector resistances of the FF2 flipflop by potentiometers, and since we also wanted to use the flipflop's other transistor (which usually *does* conduct current; no use can therefore be made of the adding mechanism already described), each flipflop was provided with two simple amplifiers consisting of one transistor and made so that both transistors block when quiescent (see fig. 4).

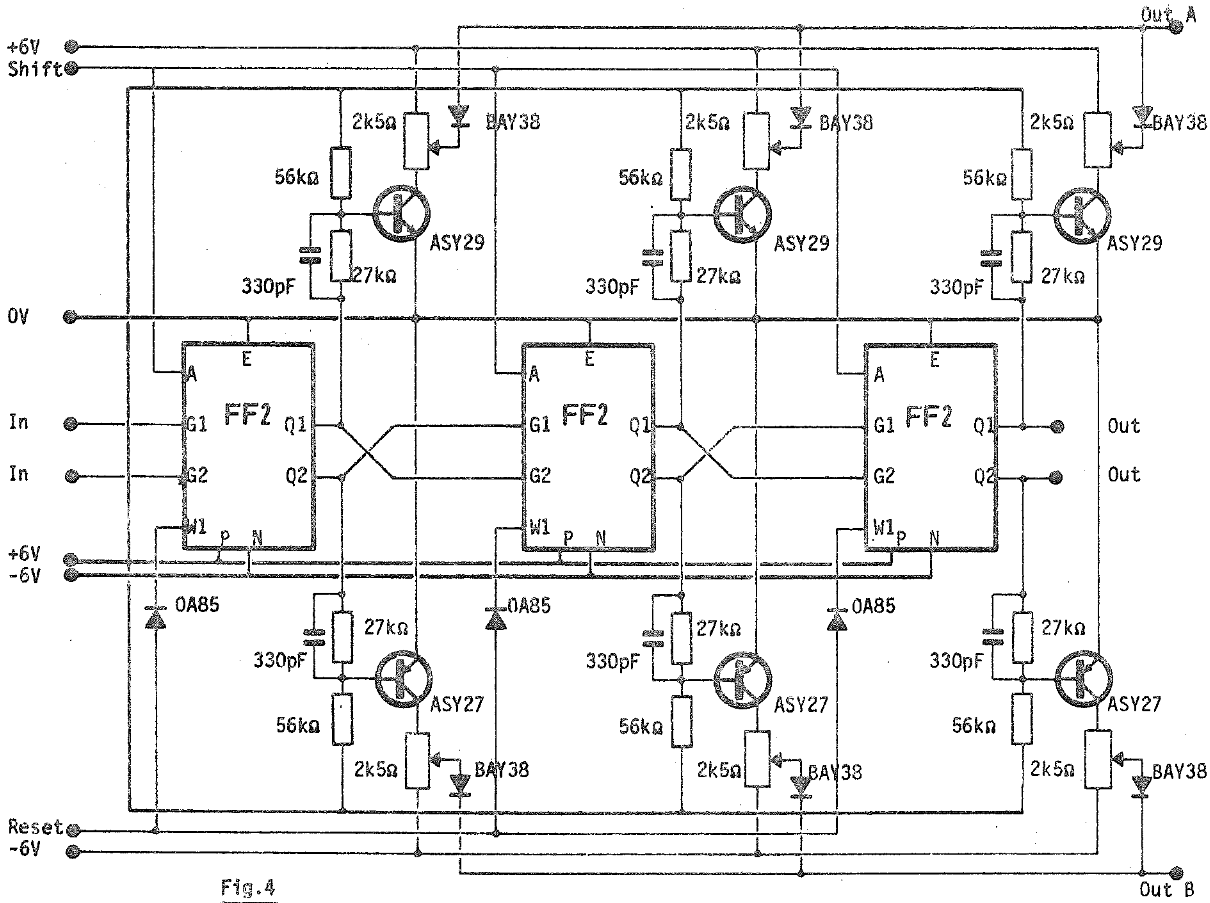

Out A
+6V
Shift
2k5Ω
BAY38
56kΩ
ASY29
330pF
27kΩ
0V
A
E
FF2
In
G1
Q1
In
G2
Q2
W1
P
N
+6V
-6V
Out
Out
OA85
ASY27
Reset
-6V
Out B

Fig.4

As collector resistances, these transistors were given potentiometers, and the above-mentioned circuit was thus realized in duplicate.

Both signals are set to the outputs by means of operational amplifiers. These amplifiers are used not only as buffers but also to shift the signals, making the output voltages vary between 0 and +5 volts, since this voltage area is normalized for control voltages.

The filtering of signal B and the combination of the filtered signal B with A, resulting in C, is described separately.

All the flipflops are connected with a decoder circuit. With this

(a) the number of the 'on' flipflop is shown on the counting tubes,

(b) a voltage is produced which is proportional to this number. This voltage is passed to the x input of the oscilloscope. When the voltage series is made visible, this voltage can be used instead of the time base. In this way an extremely stable image of the curve is obtained.

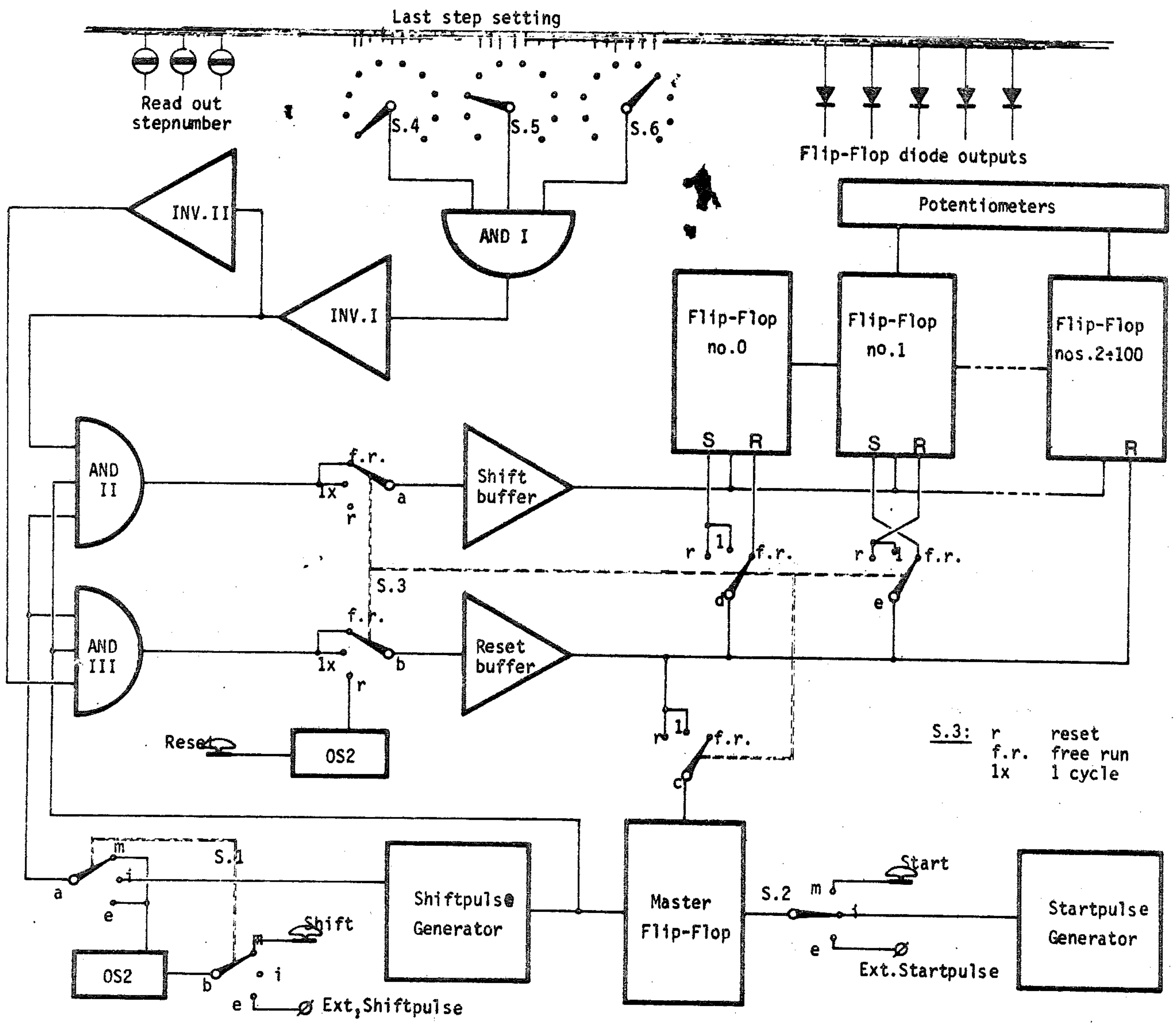

Last step setting
Read out stepnumber
S.4
S.5
S.6
Flip-Flop diode outputs
INV.II
AND I
Potentiometers
INV.I
Flip-Flop no.0
Flip-Flop no.1
Flip-Flop nos.2÷100
S R
S R
R
AND II
f.r.
1x
r
a
Shift buffer
r 1 f.r.
r 1 f.r.
d
e
S.3
AND III
f.r.
1x
b
r
Reset buffer
Reset
OS2
r 1 f.r.
c
S.3: r reset
f.r. free run
1x 1 cycle
m
S.1
a
i
e
Shiftpulse Generator
Master Flip-Flop
S.2
m
Start
i
Startpulse Generator
e
Ext.Startpulse
OS2
b
Shift
i
e
Ext.Shiftpulse

Fig.5

B. Control

The block diagram of the equipment supplying the necessary start and shift pulses can be seen in fig. 5.

Before the equipment can be set in action, the shift register must be in the stand-by position, i.e. flipflop 0 'on', flipflops 1 to 100 'off'. This is brought about by switch S3 (in the 'reset' position). The pulse produced by operating pushbutton 'Reset' is sent to the S input of flipflop 0 and to the R inputs of the other flipflops. After that, S3 must be set to position '1×' or the 'fr' (free run) position. Only zeros are sent to flipflop 0 otherwise; a second 'one' can thus not shift into the register.

The start pulse, which comes from the start pulse generator, or from pushbutton 'Start', or from an external source, depending on the position of S2, causes a flipflop, the master flipflop, to turn over. This makes the shift pulse generator start, a '1' being presented at the same time to the middle inputs of the two AND-gates. Whether the shift pulse generator is used, or whether shift pulses are produced by hand ('Shift'), or supplied externally, depends on the setting of S1. The shift pulses are also sent to the two AND-gates. The third signal to be sent to these gates comes from an AND-gate which normally supplies a '0'. A '1' therefore comes from inverter I and a '0' from inverter II, and AND-gate II is thus normally open and AND-gate III closed. The shift pulses are sent to the flipflops via S3a and an amplifier, and the 1 ready in flipflop 0 shifts along the register. The counting tubes show which flipflop is 'on' at which moment.

The same signal that controls the counting tubes is sent to the three thumbwheel switches. As soon as the number of the 'on' flipflop agrees with the number set on this switch, AND-gate I delivers a '1', AND-gate II closes, AND-gate III opens. The next shift pulse is put on another line via S3b and an amplifier. What happens now depends on the position of switch S3:

In position 1× (a) flipflop 0 is set to 1
(b) the other flipflops are set to 0 via the reset input (or they stay in the 0 position)
(c) the master flipflop is set back again.

This results in the series' being broken off, the shift pulse generator's stopping, the closing of AND-gates II and III, and the apparatus is ready for a new start pulse.

In position 'free run' (a) flipflop 1 is set to 1
(b) all the other flipflops change to or remain in the 0 position.

The master flipflop also remains 'on', so that flipflop 2 changes to '1' at the next shift pulse. The series therefore continues without interruption until the moment that S3 is set to 'r' or '1×'.

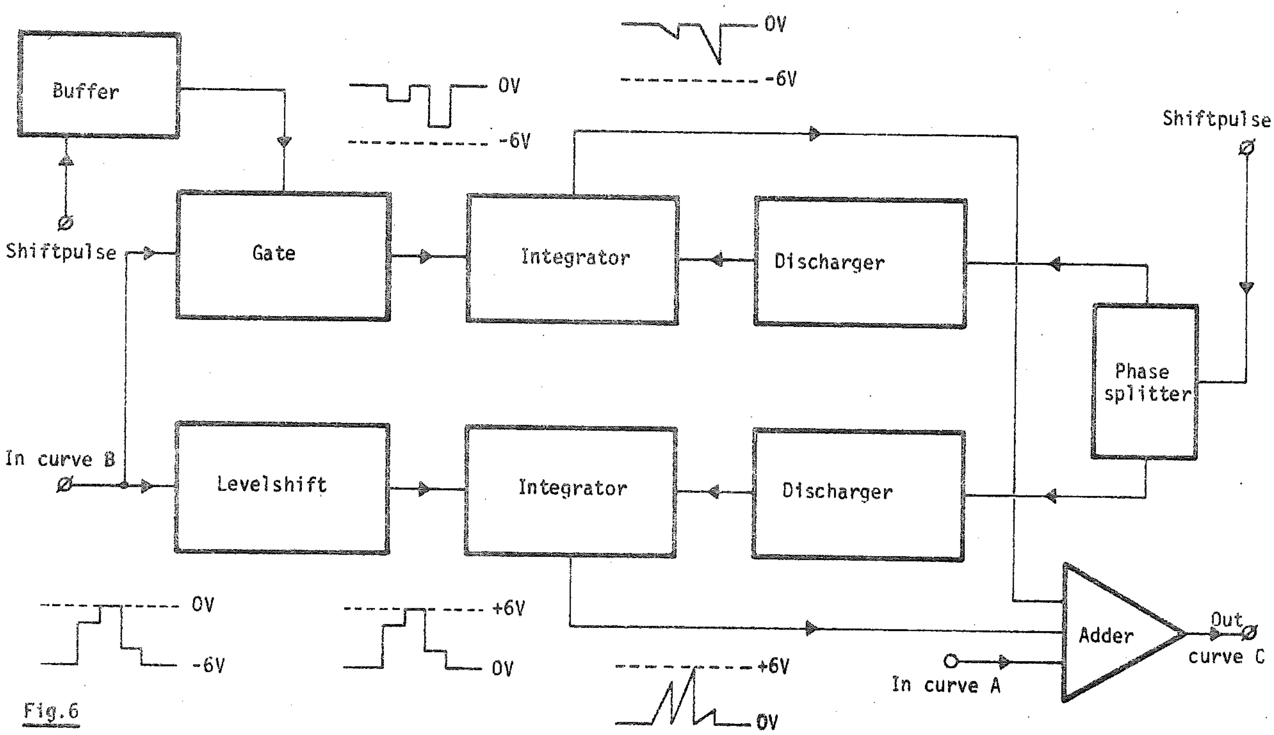


Fig.6

THE FILTER

The VFG can be used as a waveform synthesizer. The desired waveform is approximated by a staircase curve. It is usually necessary to filter this signal, but this leads to deviations from the waveform which one wishes to approximate. In the VFG2 the following solution was found for this problem (see block diagram, fig. 6):

Output signal B before the operational amplifier, which is in the area of -6 volts (quiescent) to 0 volts, is sent to a gate circuit which only opens if the master flipflop is 'on', thus if a series is produced, and it is also sent to a circuit which shifts the entire signal 6 volts in the positive direction. This results in two signals, x and y, both of which are 0 volts when quiescent, but which consist when in action of negative steps (signal x) and positive ones (y). Both signals are sent to integrators which are coupled to dischargers, which deflect the charge from the integrating capacitor at each shift pulse, thus causing the voltage across these capacitors to go to 0 quickly.

This results in sawtooth signals instead of the triangular signals which occur in normal integration.

Here is an example proceeding from an input voltage of -4 volts; x becomes -4 volts and y +2 volts. After integration two sawtooth voltages have been formed, x' and y', having respectively a negative amplitude of -4 volts and a positive one of +2 volts. These are added together, the final result being a sawtooth with an amplitude of -2 volts. Other examples:

if B = -3 volts, x = -3 volts and y = +3 volts; amplitude of x' + y' : 0 volts.

if B = -3 volts, x = -2 volts and y = +4 volts; amplitude of x' + y' : +2 volts.

This shows that in this manner a sawtooth series occurs with positive and negative elements which can be set separately. This series is added to signal A (this addition actually takes place at the same time as that of x'+y', see fig.7). In this way a voltage curve finally results consisting of line-segments with adjustable slopes (B) and starting points which can be set (A). The complete diagram can be seen in fig. 7.

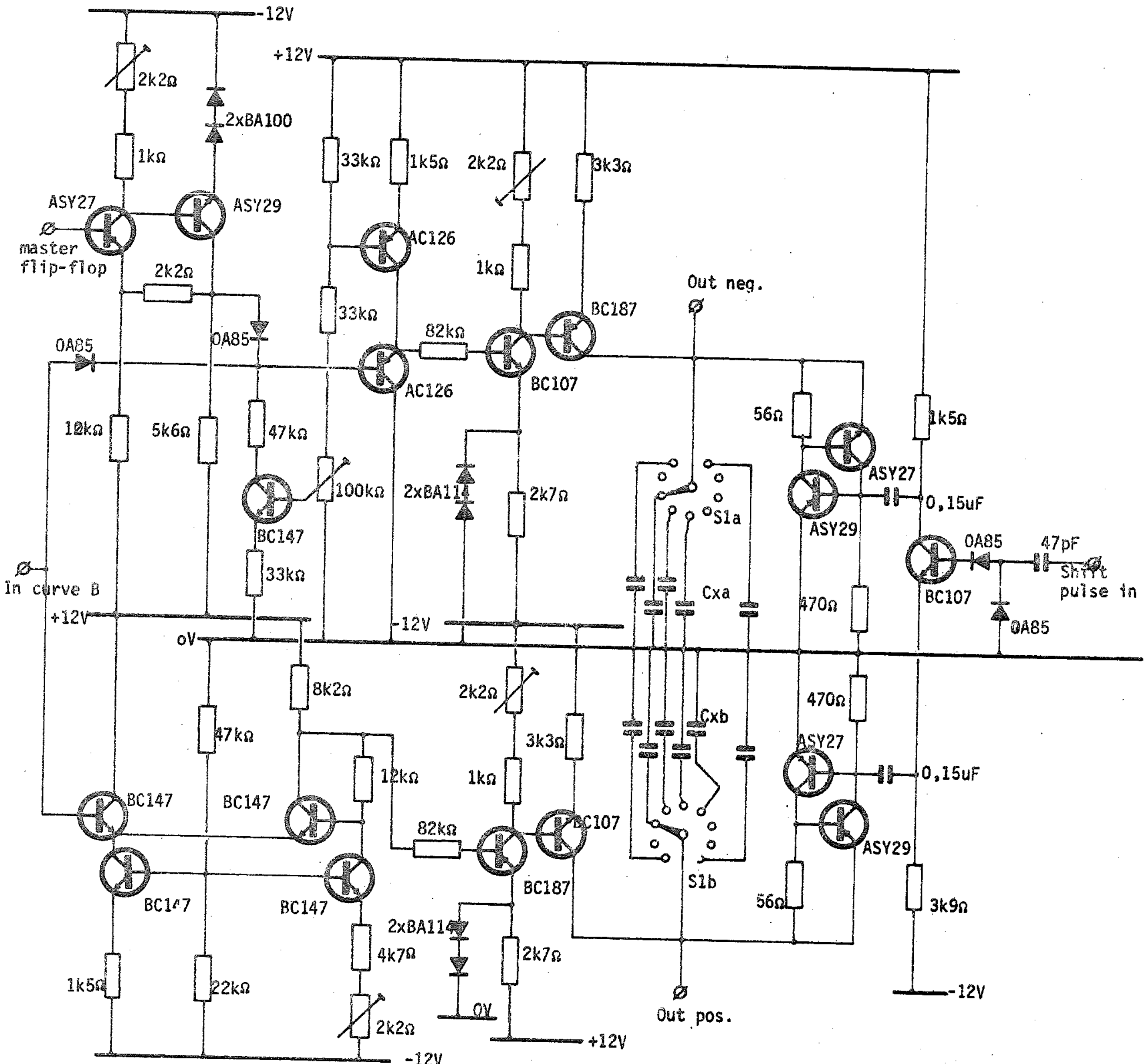


Fig.7

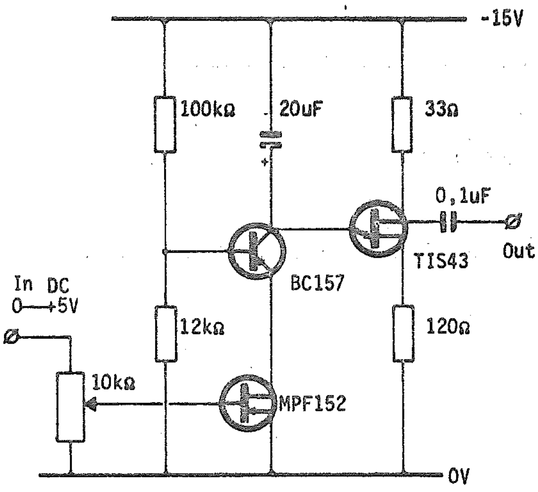


Fig.8

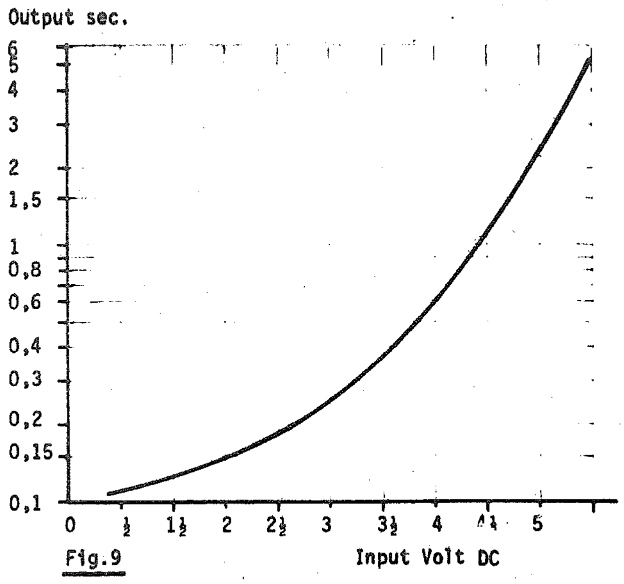


Fig.9

VOLTAGE-TIME CONVERTOR

One of the two voltage series can be used to programme the length of time for which a particular step is at the output. Use must then be made of a voltage-time convertor, a circuit, which, when supplied with a particular direct voltage, delivers a pulse after a period of time depending on the magnitude of this voltage.

Fig. 8 shows a diagram of this. It can be used to set the duration of each step of a voltage series separately, the minimum duration being 0.1 sec. and the maximum 5 sec. The relationship between voltage and duration was intentionally made non-linear, see fig.9.

In fig. 10, finally, a diagram of the circuit required to produce this effect is shown.

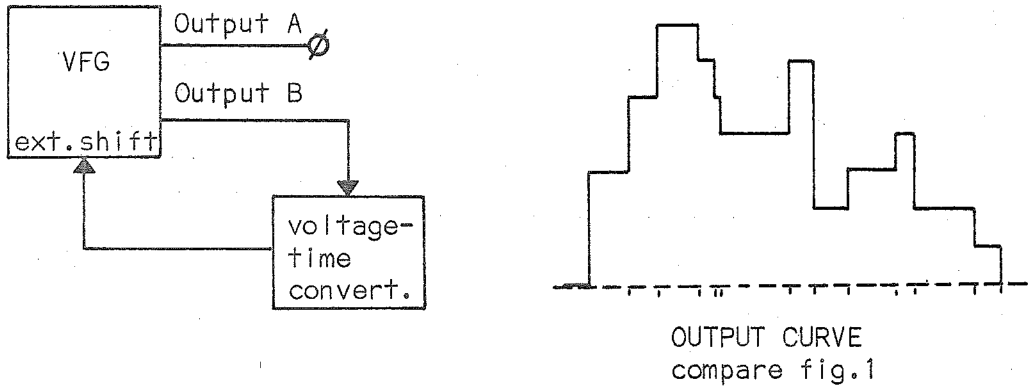
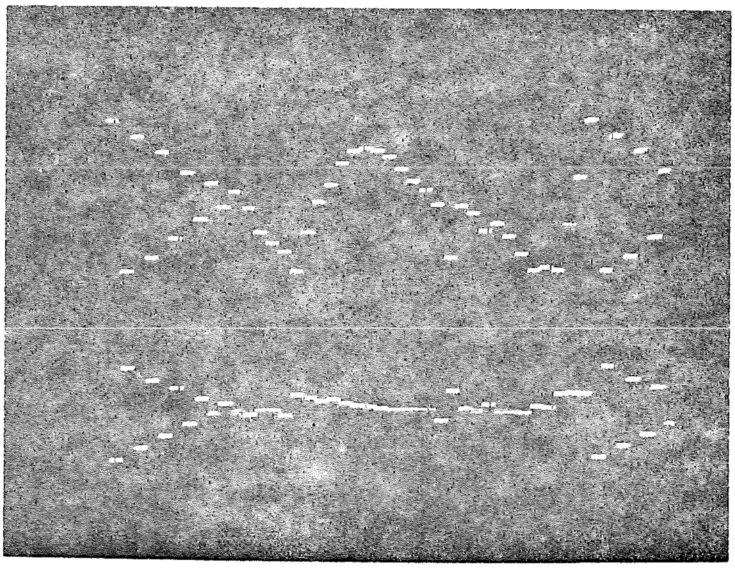


Fig. 10

APPLICATIONS

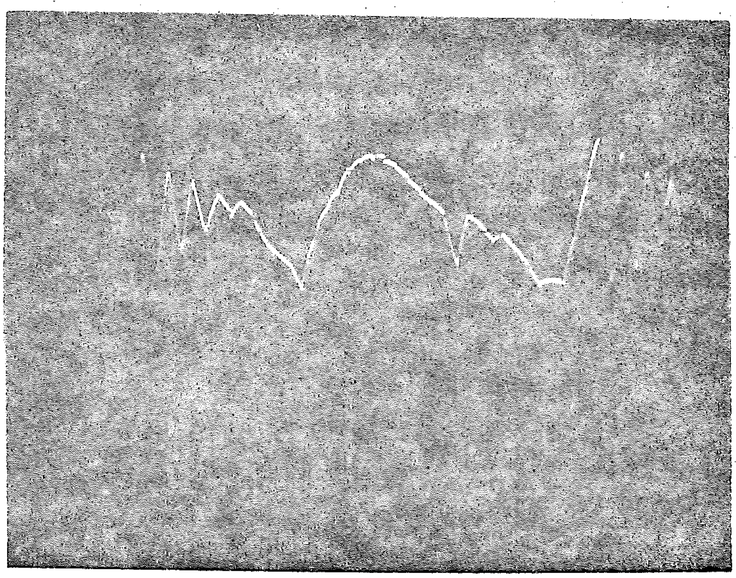
For applications possible with this equipment the reader is referred to my article on "Voltage Control in the Utrecht University Studio" in Electronic Music Reports No. 1.

Fig. 11 shows a few registrations of signals produced by the VFG2.



(a) Curve A

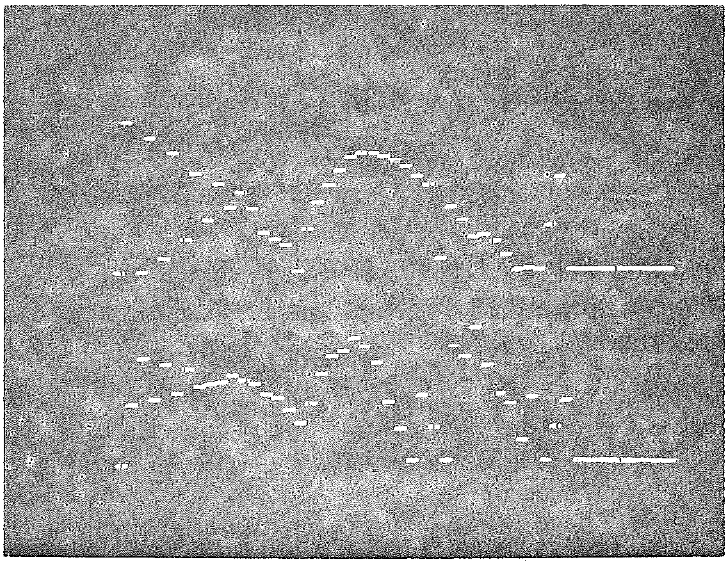
(b) Curve B



(c) Curve C :
combination of A and B,
see page 29.

A and B consist of 40 steps each. The photographs were taken with the VFG set to "free run", which is why the start of the recurring period is visible at the right.

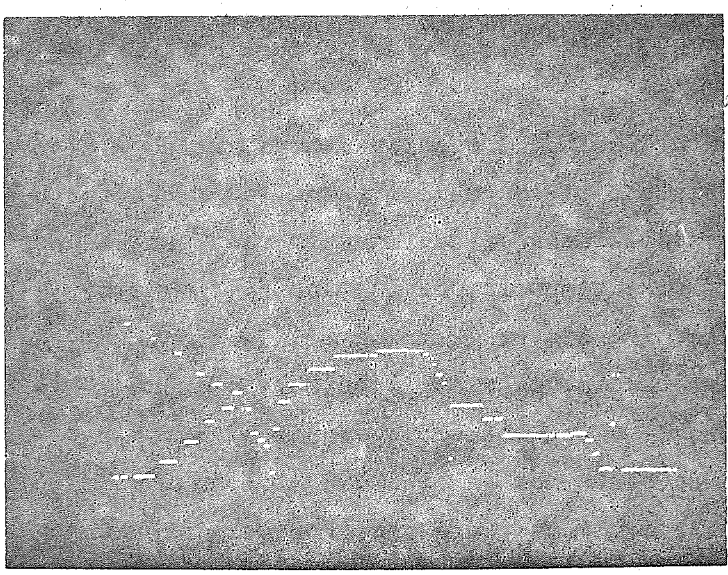
Fig. 11 a-c



(d) Curve A (as in fig.11a)

(e) Curve B (different from fig.11b, so as to demonstrate the effect of the voltage-time convertor more clearly)

These two photographs were taken with the VFG set to one period only.



(f) Curve A rhythmified by curve B by means of the voltage-time convertor.

Fig. 11 d-f

Gottfried Michael Koenig

PROJECT 1

PROJECT 1 is the name of a program for the calculation of musical structures. It was conceived in 1964 and tested in its earliest form at the University of Bonn (Germany). Further revisions since 1965 have led to the second and final form. The first form was written in FORTRAN II for use on an IBM 7090; the second is in ALGOL 60 for use on an ELECTROLOGICA X8.

Since then a more extensive composing program called "PROJECT 2" has been completed, tested and used (a manual for this program is planned as no. 3 or no. 4 of ELECTRONIC MUSIC REPORTS), it seems logical to indicate the position of PROJECT 1 in this series of developments.

As the following description of PROJECT 1 clearly demonstrates, a particular compositional principle is concealed behind the rules for selection and combination of the elements, a principle that can be derived from the serial method of composition. In 1963/64 the writer took a course in the "Construction and Programming of Electronic Data Processing Equipment" at the mathematical institute of Bonn University with the intention of using the computer for electronic sound production (at that time there was an IBM 7090 at Bonn). Indeed, this intention was already five years old. However, it soon became obvious that neither the mathematical institute at Bonn nor the West German radio station at Cologne, where the writer was at that time working in the studio for electronic music, was ready for such an undertaking. It seemed more important that - after experience gained in electronic music - the musical sound was no longer a prescribed quantity only requiring to be written down in scores, but an acoustic event which itself must first be "composed". Apart from serial compositional technique, which is a kind of programming system, the writer had at that time hardly any practical experience in programming musical structures. These two reasons made it seem advisable to carry out some exercises in programming, in the hope that the experience thus gained would benefit sound production (= sound composition).

Serial compositional technique presented itself as a control system that had become more or less codified both in instrumental and in electronic music of the first years in Cologne. However, serial technique was to a great extent understood as (although not called) a sort of *ersatz* for the lost art of motivic or thematic composition because of the fact that the tones or intervals in a "series" could be arranged according to principles which could hardly be accounted for outside motivic relationships, and the permutations of such a series could also be fitted into a pattern which if at all possible had to be derived from the series too. In spite of this the writer was under the impression that experience in listening to music gives the lie to this: it is not the order of certain intervals that is perceived but the rate at which they occur, and this results in the "harmonic timbre" of a structure. The same applies to all other parameters. What is more, the compulsion which arranges tones into series continues in its effect: series also have to be terms of larger units (permutation cycles, groups of series, etc.). This results in a remarkable hierarchy within the system that is so keen on equality: with intervals, there must be so many permutations during the course of a work that even big differences within a series are effaced; with groups of series, the organisatory principle can just be recognised; with the overall form, the serial commandment of permutation can no longer be obeyed - the longest series only occurs once and is at the same time a single element that is not even a term of a series.

It appears that the trouble taken by the composer with series and their permutations has been in vain; in the end it is the statistic distribution that determines the features of a composition. Seen from this viewpoint, serial technique appears as a special case of aleatoric compositional technique.

Of course, the musical structure achieved by PROJECT 1 is not entirely free of formal articulation of a serial kind. The overall form of the composition is divided up into form-sections, but primarily to make it possible to have various combinations of equal or similar quantities. The serial principle is also frequently applied within the form-units; however, the subprogram SERIES merely sees to it that the elements of a stockpile occur in turn without repetition; the order of the elements within such a series is random. In this fashion the need for variation is satisfied without there having to be the pretence that somewhere deep inside the work the twenty-fifth permutation is still being systematically derived from an original series.

The user of PROJECT 1, which was in any case written for private use, has hardly any influence on the course of the program. The program produces a new composition each time, each of which, however, conforms the same plan. The writer had the program run three times, and transcribed two of the results into score and had them performed. However, the experience gained in using this program and its results led directly to the conception of PROJECT 2, which, as opposed to PROJECT 1, does not contain any fixed elements, but gives the user an entirely free hand. PROJECT 2 is still based on experience acquired in musical composition and in composition tuition, and was consequently conceived against a background of a compositional theory which is influenced by the writer's personality. But one might ask whether it is at all possible to have objectivity without arriving at it via subjectivity.

o o o o o

PROJECT 1 permits the formation of a number of variants; the result each time is a "version" (a piece of music) consisting of 7 form-sections; points in time are distinguished in each form-section. The points in time are marked by chords of 1 to 6 tones. The number of points in time per form-section is the same within a version, but must be fixed by the user for each version. The standard number of points in time on which the program is constructed is 108 per form-section (thus 756 for the entire piece).

Apart from the number of points in time, the following constants must be defined: a list of 6 metronome tempi, a list of 28 entry delays and a starting number for the random generator. The standard lists for tempi and entry delays are as follows:

	tempi		entry delays						
(1)	60.0	(1)	1/1	(8)	2/5	(15)	1/2	(22)	0/0
(2)	52.0	(2)	4/5	(9)	3/8	(16)	2/5	(23)	1/4
(3)	45.5	(3)	3/4	(10)	1/3	(17)	3/8	(24)	1/5
(4)	39.5	(4)	2/3	(11)	1/4	(18)	1/3	(25)	1/8
(5)	34.5	(5)	5/8	(12)	1/5	(19)	1/4	(26)	0/0
(6)	30.0	(6)	3/5	(13)	1/8	(20)	1/5	(27)	1/8
		(7)	1/2	(14)	0/0	(21)	1/8	(28)	0/0

The starting number for the random generator must be less than 1 and may not be less than 0. It can be used for numbering the various versions (e.g. 0.01, 0.02, etc.).

The entry delays denote sections of a metric unit (e.g. quarter-note) to which the metronome tempo refers. 0/0 means "as fast as possible", i.e. grace-notes. The repetitions of entry delays in the above list are meant to allow the shorter values a greater amount of probability.

PROJECT 1 takes the following parameters into consideration: timbre, rhythm, pitch, sequence, octave register, dynamics. - In the rhythm parameter, entry delays, tempi and rests are decided; a rest is always succeeded by a new tempo (unless the random generator delivers the same tempo again). - Sequence is a spare parameter. It can refer to the tones in the chord if the octave register is not taken into account, or to the timbre if groups of instruments are defined instead of single instruments and the importance of single instruments within a group is to be graduated. - The parameters are independent of one another, with one exception: the size of a chord depends on the entry delay. The chord's size is therefore ascertained together with the entry delay; this size is then obligatory for the parameters of pitch, sequence and octave register.

PROGRAM CONSTRUCTION

The program of PROJECT 1 consists of the main program and the subprograms ALEA and SERIES.

The main program contains 6 program blocks for the parameters mentioned and the printing program. Every program block (with the exception of the sequence parameter and the printing program) consists of some subprograms, a program branch and 7 program sections (see fig. 1).

ALEA is a random program delivering a whole number between two limits. SERIES is a random program delivering a whole number between two limits with repetition check. This means that a number is not repeated until all numbers between the limits have been found. The number of elements over which this check extends is variable.

Each program block is for the calculation of a parameter. The order in which the parameters are calculated is always the same. The 6 program blocks are run through for every form-section; all the data are assembled in the printing array.

The printing program causes all the data of a form-section to be printed in a suitable layout.

The program branch at the beginning of the program blocks is for the selection of one of the 7 program sections. This subdivision into program sections is meant to effect a gradual transition from aperiodic formations to periodic ones. By aperiodicity, the sequence of as varying as possible parameter values is meant here; by periodicity, the sequence of similar parameter values.

In program section 1, the repetition exclusion extends to all the elements of a parameter. In program section 2 and 3, it is increasingly limited so that small groups of unrepeated elements occur.

In program sections 5-7, there are repetition orders for the purpose of producing groups of similar elements. The repetition exclusion of program section 1 applies to the sequence of elements themselves.

In program section 4, finally, a compromise between the two principles is sought. For each series of various elements, a group of corresponding size containing similar elements is demanded.

Each version resulting from PROJECT 1 contains 7 form-sections because the 7 program sections are to be used for each parameter (except sequence). The sequence of the program sections in each parameter is free; thus several parameters can follow the same program section in a form-section.

In the following explanations of the individual program blocks, program sections 1-3 go under the name of PR1; program sections 5-7 are called PR7; program section 4 is called PR4.

PROGRAM BLOCKS

Timbre

The number of elements is 9. The numbers appearing at the output can be interpreted by the composer as he pleases.

PR1: The repetition exclusion extends over 9, 6 and 3 elements in program sections 1, 2 and 3. Subprogram APER calculates the aperiodic series using subprogram SERIES.

PR4: For the compromise between periodic and aperiodic processes, we distinguish "proposition" (P) and "correction" (C). A given number of P-series is followed by the same number of C-series. Here, each periodic series is replaced by an aperiodic one, and vice versa.

The maximum number of P-series arrived at by ALEA is 6. The maximum number of elements per series (serial compass) arrived at by ALEA is also 6. The type of each series (periodic or aperiodic) is also arrived at aleatorically.

Compass and type of each P-series are stored in a list.

For the C-series, the list is questioned by means of SERIES so that every serial compass of the proposition occurs once, but with the opposite type in a different sequence than in the proposition (fig. 2).

PR7: Groups of 1-5, 3-7 and 5-9 similar elements are set up for program sections 5, 6 and 7 by means of subprogram PER.

APER: This subprogram produces at each call a series of unrepeated elements by means of SERIES. The elements are stored in a printing array. A counter controls the number of elements in the form-section and directs the course of the program to the rhythm parameter.

PER: This subprogram produces at each call a group of similar elements. Storing and control as in APER.

Rhythm

PR1: By means of SERIES a tempo is selected; by means of ALEA the number of series having the same tempo is found out (at the most 4). In program section 1, entry delays 1-13 are aleatorically selected; in program sections 2 and 3, all the 28 entry delays. Subprogram CHECK determines the number of tones in the chord. The serial compass is 12 elements in program sections 1 and 2, 6 elements in program section 3. Subprogram REST selects a rest with ALEA (3 rests are distinguished), a tempo with SERIES and the number of series having the same tempo with ALEA (at the most 4).

PR4: Selection of tempo and number of series having the same tempo as in PR1. The number of P-series, found by ALEA, is maximally 4. The number of elements per series (with ALEA) is maximally 9; serial compass and type (aleatoric) are stored in a list. For subprogram REST see PR1.

The C-series follow the list again, determined in their sequence by SERIES.

PR7: Selection of tempo and number of series having the same tempo as in PR1. The elements themselves are aleatorically taken from the complete catalog (28 elements). The compass of the groups of similar elements is 4, 8 and 12 for program sections 5, 6 and 7.

APER: This subprogram, called in PR4, selects with SERIES from among the 28 entry delays, stores the elements in the printing array and calls subprogram CHECK for each element.

PER: This subprogram, called in PR4, selects with SERIES from among entry delays 1-14, stores and calls CHECK for each element.

REST: This subprogram selects with ALEA one of the 3 rests (short, medium, long) whenever the required number of series having the same tempo has been set up;with SERIES it selects a new tempo and with ALEA a new number of series having the same tempo.

CHECK: This subprogram fixes the size of a chord for each entry delay. For the entry delay 0/0 (grace-note) the chord's size is 1, for 1/8 max. 2, for 1/4 and 1/5 max. 3, for 1/2, 2/5, 3/8 and 1/3 max. 4 and for 1/1, 4/5, 3/4, 2/3, 5/8 and 3/5 max. 6 (all with ALEA). The subprogram also checks the number of elements in the form-section and directs the course of the program to the pitch parameter.

Pitch

Harmony is based on a variable twelve-tone series. The individual tones are delivered by subprogram GENERATOR. For each point in time in the form-section, the chord's size calculated in the previous program block is taken into account.

PR1: The repetition exclusion extends to 12, 8 and 4 series for program sections 1, 2 and 3. Subprogram APER is called for each series.

PR4: Subprogram PER is represented in the fourth program section by subprograms TONE and GROUP.

First a decision is aleatorically made between aperiodic and periodic series for the proposition.

Aperiodic proposition. The maximum number of series is 3 (ALEA); the series are produced by APER. For purpose of correction by periodic series, a decision is aleatorically made among "tones", "groups" and "series". Subprogram TONE is called for "tones"; subprogram GROUP for "groups" and "series". For GROUP, the number of groups is three times the number of P-series.

Periodic proposition. First a decision is aleatorically made among "tones", "groups" and "series". The maximum number of "tones" or "groups" is 9, the maximum number of "series" is 3 (in both cases by means of ALEA). The series are set up by TONE or GROUP. At the same time, the total number of single tones in the periodic proposition is registered. According to whether this does not exceed 18 or 30, or does exceed 30, the number of series in the aperiodic correction is 1, 2 or 3. The C-series are set up by means of APER.

PR7: First, a decision is repeatedly made (with ALEA) as to whether "tones", "groups" or "series" are to occur.

Tones. The number of "tones" is between 4 and 12, 8 and 24 or 12 and 36 (always by means of ALEA) for program sections 5, 6 and 7. The "tones" are produced by TONE.

Groups. The number of "groups" is between 3 and 8, 6 and

16 or 9 and 24 (always by means of ALEA) for program sections 5, 6 and 7. The "groups" are produced by GROUP.

Series. The number of "series" is between 1 and 3, 2 and 6 or 3 and 9 (always by means of ALEA) for program sections 5, 6 and 7. The "series" are produced by GROUP.

When the required number of "tones", "groups" or "series" has been set up, the process starts all over again (aleatoric decision among the three categories).

APER: This subprogram is responsible for making each twelve-tone series begin with a different initial tone (with SERIES). To avoid repetition of tones within a chord, the twelve-tone series is broken off in favour of a new series as soon as the chord is larger than the remainder of tones in the series.

Subprogram GENERATOR produces the individual tones, after which they are stored in the printing array. At the same time, the size of the form-section is checked and the course of the program is directed to the sequence parameter.

TONE: This subprogram produces "tones" (with SERIES). However, single tones are not repeated; the selected "tone" merely remains the initial tone of all chords (the number of "tones" is thus the number of chords with the same initial tone). The remaining tones in the chord are produced in turn by GENERATOR and transferred to the printing array. Thus various chords having the same initial tone occur.

GROUP: The variable twelve-tone series in PROJECT 1 consists of 4 three-note groups. If a decision for "groups" has been made in program block "pitch", one of the three-note groups is repeated in a transposition given by SERIES as often as is necessary, regardless of the chord's size, to set up the required number of groups.

In analogy, this also applies to "series"; in this case an entire twelve-tone series is correspondingly often "broken up" into chords.

GENERATOR: This subprogram generates twelve-tone series (or groups) according to the following principle: a three-note group consists of
minor second, major third (both ascending), or
minor second, major third (both descending), or
minor second, minor third (both ascending), or
minor second, minor third (both descending).

4 three-note groups of similar construction form a series, the transpositions of groups 2 to 4 being calculated in such a way that no repetition of tones occur. For the combination of minor second/minor third, however, the sequence of intervals must be inverted for two groups of a series.

Sequence

For each chord, SERIES is applied to select as many numbers as the chord has tones.

Octave register

The number of elements is 4. The numbers appearing at the output can be interpreted by the composer as he pleases.

PR1: The repetition exclusion extends to 4, 3 or 2 elements for program sections 1, 2 and 3. The sizes of the chords and points in time in the form-section are checked, too.

PR4: The maximum number of P-series (by means of ALEA) is 9. The type of proposition is arrived at for each series by ALEA; the series themselves are set up by APER or PER. Serial compass and type are stored in a list.

For the correction, the list is questioned by SERIES; every periodic P-series is replaced by an aperiodic

C-series of the same compass and vice versa.

PR7: Subprogram VALUE fixes the group compass of repeated elements and selects an element for each group (by means of SERIES). Program sections 5, 6 and 7 check the chord's size and points in time in the form-section.

APER: This subprogram produces aperiodic series (serial compass = chord's size) by means of SERIES, and checks the points in time in the form-section.

PER: This subprogram produces groups of similar elements (group quantity = chord's size). The elements themselves are chosen by SERIES. The points in time in the form-section are checked, too.

VALUE: This subprogram fixes the number of groups of similar elements: 4-12, 8-24 or 12-36 groups for program sections 5, 6 and 7.

Dynamics

The number of elements is 8: they are ppp, pp, p, mp, mf, f, ff, fff. One dynamic value per point in time is arrived at.

PR1: The repetition exclusion extends to 8, 6 and 4 elements for program sections 1, 2 and 3. The series are set up by means of APER.

PR4: The maximum number of elements (arrived at by ALEA) is 8. The type of proposition is arrived at aleatorically. The series is set up for proposition by APER or PER. Correction is immediately made in the form of an equally-sized series of the opposite type. A counter checks the points in time in the form-section and directs the course of the program to the printing program.

PR7: The groups of repeated elements consist of 4-8, 6-16 and 8-24 elements (by ALEA) for program sections 5, 6 and 7. Subprogram PER sets up the groups.

APER: This subprogram selects one of the 8 elements (by means of SERIES) and checks the points in time in the form-section.

PER: This subprogram selects one of the 8 elements (by means of SERIES) and stores it according to the group's compass. The points in time are also checked.

Printing program

The printing program causes the results to be printed according to the following scheme:

At the beginning of every form-section, the selected program sections are stated for each parameter (without sequence).

The points in time come next, line for line and with the following details:

current number of the point in time,
timbre,
tempo (if required),
entry delay,
rest (if required),
pitches in the chord,
sequence (number of figures = size of chord),
octave register (number of figures = size of chord),
dynamics.

Further symbols indicate the beginning of a new series in each parameter, and - in program section 4 - the beginning of P- and C-series.

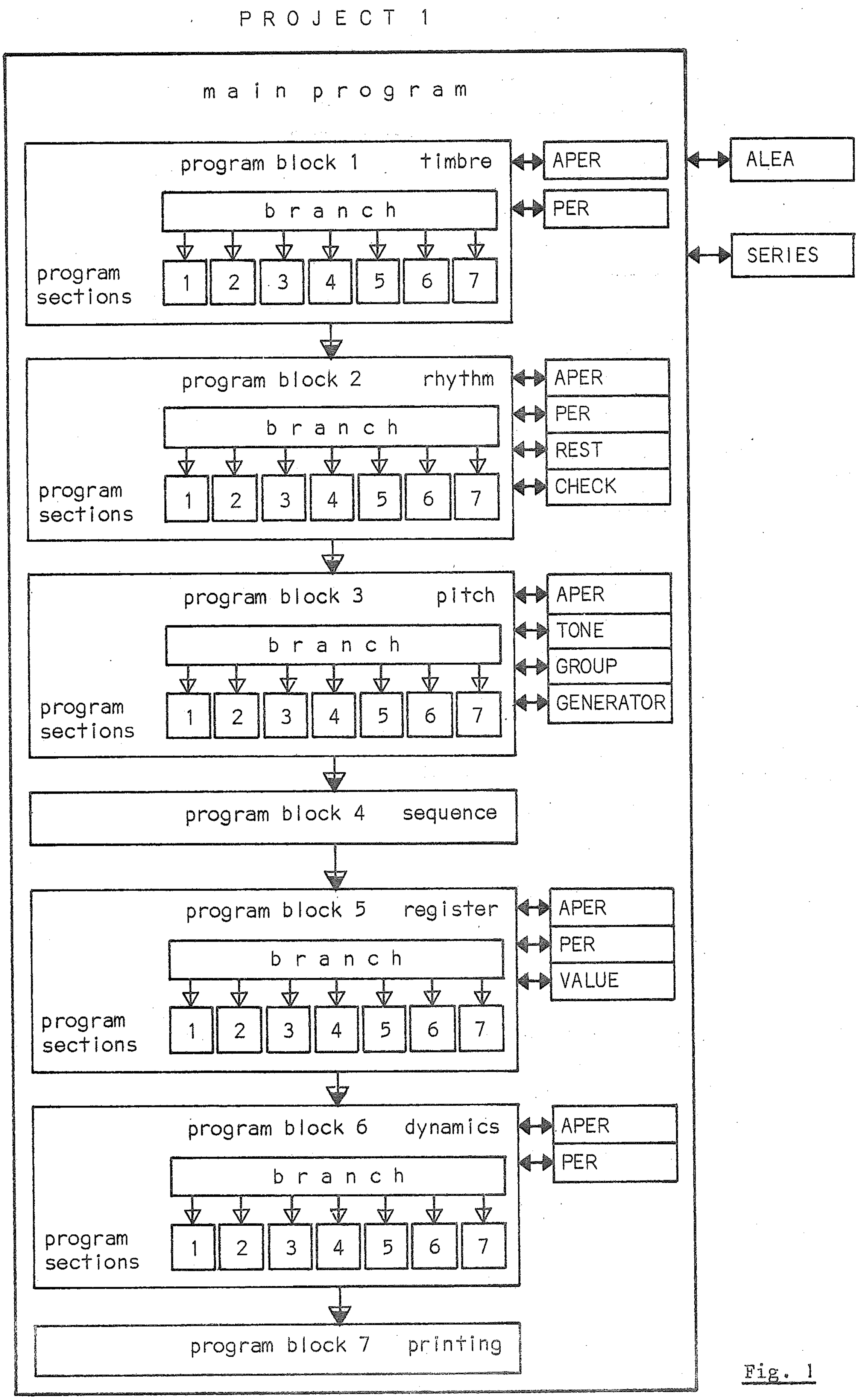

PROJECT 1
main program
program block 1 timbre
branch
program sections
1 2 3 4 5 6 7
APER
PER
ALEA
SERIES
program block 2 rhythm
branch
program sections
1 2 3 4 5 6 7
APER
PER
REST
CHECK
program block 3 pitch
branch
program sections
1 2 3 4 5 6 7
APER
TONE
GROUP
GENERATOR
program block 4 sequence
program block 5 register
branch
program sections
1 2 3 4 5 6 7
APER
PER
VALUE
program block 6 dynamics
branch
program sections
1 2 3 4 5 6 7
APER
PER
program block 7 printing

Fig. 1

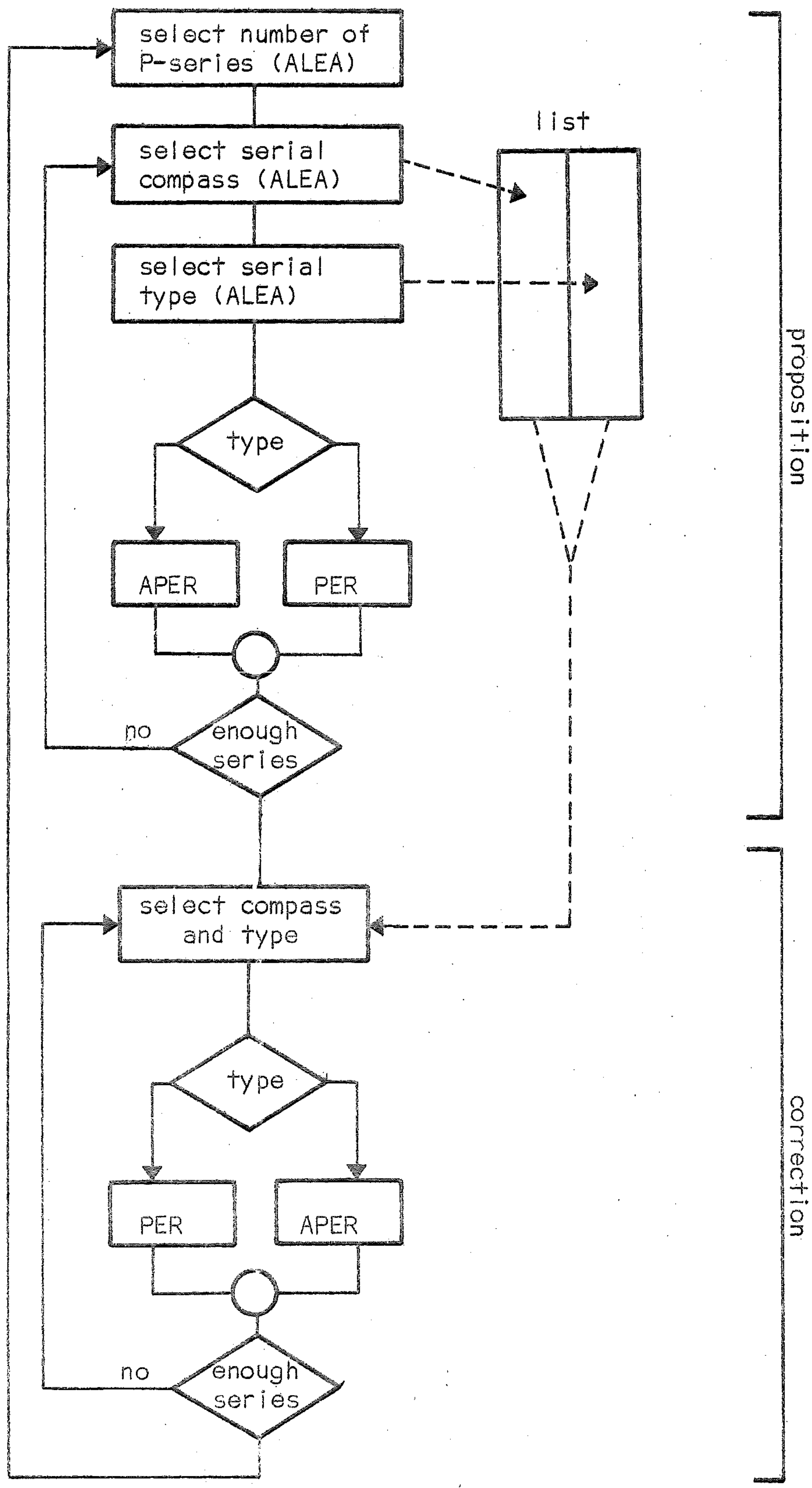

select number of P-series (ALEA)
select serial compass (ALEA)
select serial type (ALEA)
list
type
APER
PER
no
enough series
select compass and type
type
PER
APER
no
enough series
proposition
correction

Fig. 2

PETER STRUYCKEN : COMPUTER STRUCTURES 1969

Here follow three contributions on Peter Struycken's computer structures, which were made with the collaboration of the Institute of Sonology at Utrecht University.

Peter Struycken, born in 1939, studied at the Royal Academy of Arts in The Hague, and since 1964 has been teaching at the Academy of Art and Industrial Art in Arnhem. In 1968 he began experimenting with film and investigating the relationship between image and sound. In 1969 he was commissioned by the Prince Bernhard Fund to investigate at Utrecht State University the facilities that exist for an artist to work within the framework of a university, primarily in connection with the visualization of the results of scientific research. He participated in the electronic music and computer composition courses at the Institute of Sonology, thus encountering the selection programmes of PROJECT 2.

Apart from musical exercises with these programmes, he also attempted to generate graphic structures according to random principles. However, it soon became evident that musical programmes are essentially 'one-dimensional', since they only arrange data along the time axis. Two of the studio staff, Greta Vermeulen and Stan Tempelaars, then wrote special versions for him which permit the selection and permutation principles to be applied in two dimensions. One of these versions is described in the third contribution.

This was a welcome initiative for the Institute of Sonology to start gaining experience in a field that will become more important in the future: the visualization of acoustic events and the making audible of visible ones. We are convinced that structural relationships exist between acoustic and optical perception, and that an institute already active in the acoustic field ought also to place its facilities at the service of optical perception research. Although Struycken's work has not up to now had the intention of exemplifying these relationships, it might still mark the first beginnings, and also serve as documentation of the work done at the institute.

R. H. Fuchs

THE PERSON

In view of the logical and systematic character of Struycken's work since 1962, it is understandable that in his new paintings he has investigated the possibilities of the computer for his work. A question that arises here is to what extent this step was a natural or even a necessary one for him, and whether he expects something from the computer that could not be realized by conventional means. I feel that the question is relevant, especially as it is beginning to seem that a sort of magic is growing up around the use of computers by artists. In this magic circle the very word computer has a connotation of moving with the times. This connotation is extremely fashionable and has little to do with art. As a new and absolutely logical medium, however, the computer, just as all kinds of other technological and mechanical techniques and materials used nowadays by artists, seems to play a part in the attempts of individual artists to find alternatives to subjective and intuitive artistic processes such as 'old-fashioned' painting. Struycken, too, has been continually occupied in his work and writings with the establishment of a viewpoint with regard to intuitive, artistic processes; for him the computer surely also means the possibility of a logical and absolutely systematic process. In this the computer approaches his deepest aesthetic convictions.

But in art, a process is not justified merely by itself, but primarily by its result or effect. As far as these are concerned, the artistic use of computers is, understandably, still in its initial stages. In the exhibition "Cybernetic Serendipity" (London, Institute of Contemporary Arts) a preliminary attempt was made two years ago to make an inventory of the various applications of the computer in various branches of art. The exhibition was interesting because of its informative character. Apart from this, however, the results in the field of visual arts were strikingly conventional. It was definitively not always clear *why* a computer had been used, and if it had been really necessary to use it in view of the artist's intentions. The same really applies to most computer graphics of recent times. It concerns the manner *in which* the computer is, and can be used, and keeps circling around the personal inventiveness of the artist and around the possibilities of programming the inventions. This means that the artist must be able to analyze his plan and accomodate it in definite and logical components which are comprehensible for the logical structure of the computer's brain. It seems superfluous to say so, but the result emerging from a computer is just as conventional, trivial or revolutionary as was the artist's initial assignment to the computer.

The computer, then, is a *technical* aid. It can work out and realize programmes whose complexity and size would make it practically impossible for man to do so because, for example, it would take too much time. The technical invention increases the number of possible, artistic processes; and since the computer, just as any other technical means, has specific properties or will acquire them, it will be possible for new forms of expression to be born as a consequence, whilst existing forms will be able to be realized more effectively. (A comparison which I feel fits the case is the invention of oil paint, which made possible the precise, descriptive realism of painters such as Jan van Eyck: it was possible to paint in much greater detail with the supple oil paint than had previously been the case with the more brittle tempera, or paint with an egg-yolk base.) It cannot yet be said what the new forms of expression which will arise as a consequence of the use of computers in visual arts will look like. But the computer is, one might almost say naturally, a machine for the processing of extremely large amounts of data. And as Struycken's new paintings suggest to a certain degree, it will be possible to set the computer to work in visual art to arrange quantities.

The computer was a necessary tool for what Struycken wanted to realize in his recent work (from a practical view, it would not have been possible to make these paintings in this way without a computer). Since 1962 Struycken's paintings have been the result of systems of rules which were formulated by the artist beforehand. The rules concerned the behaviour and diverse appearance of the different visual aspects in any painting: surface, limits, colour-tone, brightness of the colour, saturation of the colour, material, texture, movement.

Each of Struycken's paintings is a planned organization of a quantity of various appearances of various visual aspects according to rules of behaviour which are definite, introduced and different for each picture, rules which it must be possible for the beholder to experience. This manner of working, which has led to magnificent results, gave (and gives) Struycken a feeling of a certain objectivity in the forming of his pictures. By objectivity I mean here that once the initial choice of a *principle* for the arrangement by rules has been made, each subsequent decision in the genetic process follows logically and automatically, thus no longer being a *choice*. By contrast, the 'normal' painter works in a much more subjective manner because, in the absence of a premeditated plan, each brush-stroke is actually a new choice every time from a larger number of possibilities. (This is in practice *somewhat* different of course, because the painter is always painting something: a landscape, say; and this provides him with a kind of plan.)

In his recent work, and this is what is new about it, Struycken has replaced construction according to rules by random structures. This, however, alters nothing in the ideological aims and points of departure of his painting, because nothing is altered in the visual aspects as such and in their possible appearances. In fact the visual aspects are not attached to the structure as such:

they are nothing more than Struycken's *analytical conception* of what a painting is - the visual aspects in any conceivable combination. This conception has remained the same in the recent paintings.

Struycken took as a module the maximum number of black-and-white divisions in a square divided into four. These divisions were coded as follows: one square entirely white (00), four with one black field (11, 12, 13, 14), six with two black fields (four along the sides, two across the diagonals: 21, 22, 23, 24, 25, 26), four with three black fields (the inversion of the other row of four: 31, 32, 33, 34) and one entirely black (40). The random arrangement of these sixteen possibilities was worked out by a computer, guided by a few primary rules which were imparted before or during the programme, such as: the number of times that a certain possibility might occur, in which phase which possibility might only occur, etc. Within the framework of these rules the computer can always determine a choice from a series of alternatives, the artist being able to exert a certain extent of control over the appearance of the structure: more black, more white, more or less differentiation between black and white, and so on. A computer is necessary for this sort of arrangement because the number of possibilities of choice for a picture in which the module occurs, say, 484 times (22 high, 22 wide) was 484^{16}, at any rate if no restrictive rules were stated. But even restrictive rules would not be able to prevent the number of possibilities of choice in all cases from being absolutely extremely high.

With this kind of arrangement, however, the computer is also necessary for aesthetic reasons. Assuming that such a random structure could be organized 'by hand', it would probably be too monotonous to be visually exciting because all kinds of aesthetic preferences - and in the long run always the same ones - would play a part in each choice, which is of course not the case with a computer. The computer is probably the only thing capable of visualizing the *complexity* that is latent in the number 484^{16}. The obtained structure is now recognizable as this complexity, and

of programmes for arrangements which can be experienced; this is why he made the condition that it must be possible to perceive the system used in each painting. The increasing complexity of his pictures corresponds with the increasingly complicated architectural structures for which they are in a certain sense the programme. At a certain moment when a *group* of buildings had to be arranged with roads and parks between them, the number of components turned out to be so great and their possible contexts so complex that a random structure would have to be employed, because every conceivable system of rules would not be comprehensive enough to embrace and work with all the components. (For this, see Struycken's 'Over de mogelijkheden om in onze te bouwen omgeving voor wat betreft de visuele verschijning hiervan tot grotere samenhang en meer differentiatie te komen' - *The possibilities of achieving a closer context and more differentation in the environment we must build with respect to its visual appearance*) - published as Bulletin No. 10, December 10th 1969, by the Amsterdam galery Art & Project.) It is with this problem in mind that the computer structures were made. It is an extremely urgent problem: it has been calculated that in 35 years the ~~municipal~~ population of the Netherlands will have doubled, and that in this period just as much will have to be built as is already standing.

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Peter Struycken

THE PROBLEM

SYSTEM - AESTHETICS

Since 1969 I have had the opportunity of using the computer for planning pictures, thanks to the cooperation of the Institute of Sonology at Utrecht. This made it possible for me to use systems which were more complex than previously in order to make arrangements of the visual data - form and colour.

I have always been attracted to systematism as an indirect method of working because of the unconditional consequences connected with restrictions. Such consequences can lead to poverty of expression, the system becoming the end instead of the means, or they can lead to results which yield unsuspected aesthetic data.

The systems which I used were intended to produce a visual result leading to the interconnection of what can be called visual media. By visual media I mean the elementary quantities which in spite of the fact that they occur in combination, can be regulated separately.

In this report I shall confine myself to two visual media which are applied in the flat surface - form, colour, and their components.

1. FORM

(a) Limitation (the kind of surface, straight, curved).

(b) Surface (two-dimensional part of space, refers to size, big-small).

2. COLOUR

(a) Colour-tone (by which we recognize the type of colour, red, orange, yellow, green, etc.).

(b) Impression of brightness (the light-dark aspect of the colour).

(c) Impression of saturation (the strong-weak aspect of the colour).

New organisatorial principles were established for each of these aspects of visual media in each design, serially where at all possible, therefore predictable. Each design was also provided with a hierarchy fixing the order in which the visual media were made responsible for the transference of aesthetic information.

This resulted in structures in which the expression of the picture was sometimes determined by particular colour aspects, sometimes by form aspects and frequently by transitions from one to the other.

Working with the computer made it possible to extend the serial aspects which were employed by procedures guaranteeing a degree of chance that could be controlled accurately.

Predictability by means of series, where basically each successive step could be derived from the preceding one in such a way that only one possibility could be considered, was changed by the introduction of a degree of chance within whose margins successive stages were to occur, but where several solutions were possible.

I was very excited by the fact that a desired degree of unpredictability could be calculated with extraordinary precision, and applied and produced in as many variations as I wanted. It became necessary and possible to establish aesthetic criteria to which this extension of organization could apply.

I confine myself here to those criteria which have reference to formal relations, by which I mean relations which primarily give information about a certain condition of specimens of the same visual medium, one of the characteristics being brought into the foreground.

This might be exemplified by the relations between boundaries, between degrees of brightness, etc. I also mean the criteria which refer to relations between groups of various visual media, the relations, then, between boundaries, surfaces, shades of colour, degrees of brightness and saturation.

Characteristics of structures as a result of the behaviour of specimens of one and the same visual medium can be described as:

easy to survey	-	messy
mobile	-	still
closed	-	open
regular	-	irregular
many	-	few

Relations between groups of different visual media are usually described according to the most obvious medium in this relation - obvious in the sense of most noticeable; or the visual medium which the most demanding relation has in the specimens of the group, meaning that it has a special organization, causing a characteristic of the relevant visual medium to be demonstrated.

If we confine ourselves to situations in which both forms of relations are means and end, in contrast to situations where both forms and relations are used to communicate significances which are outside these formal relations - associations - we can then make these two types of relation responsible for communicating their own visual quality.

If we succeed in writing computer programmes which allow these two kinds of relation to be produced in a qualitatively satisfactory manner, the automatic consequence is that the logical system in which the programmed conditions are notated is also the one in which the visual quality is established. The establishing of visual quality in a logical system makes it possible for this quality to be accessible by means of this logical system too.

A subsequent stage in using the computer is of course to find out the extent to which alterations in a logical system provide the chance of exerting a favourable influence on the visual results.

It is of course possible to employ any system in planning pictures with or without the computer. But we can assume that the incredible consistency, accuracy and speed which enable complicated procedures with a great deal of calculation to be performed provide a perspective which is inconceivable without the use of the computer's qualities.

Stan Tempelaars

THE PROGRAMME

INTRODUCTION

The computer structures composed by Peter Struycken up to the present time consist of surfaces filled with black and white squares. This same structure is represented in the computer by an array with ones and zeros (1 = black, 0 = white), which are not independent of one another but coded in groups of 4, arranged in a square. There being 16 possibilities of filling a square divided into four in this way with ones and zeros, 16 code numbers (keys) are required.

Each key consists of two numbers, the first indicating how many ones there must be and the second one usually showing from which square the user must start writing the ones (clockwise). In this way the 'elementary structures' and their keys result (see fig. 1).

Fig. 2 shows four possible representations of a small computer structure,

(a) coded in keys,
(b) the keys converted to the corresponding 4-square elements,
(c) the output provided by the computer's line printer, a zero being represented by a space and a one by an asterisk, with a line between each 0 and 1,
(d) a version in black and white.

At first a structure was generated and then printed. It turned out later to be more advantageous to store all the structures in the memory, making it possible to combine structures, etc.

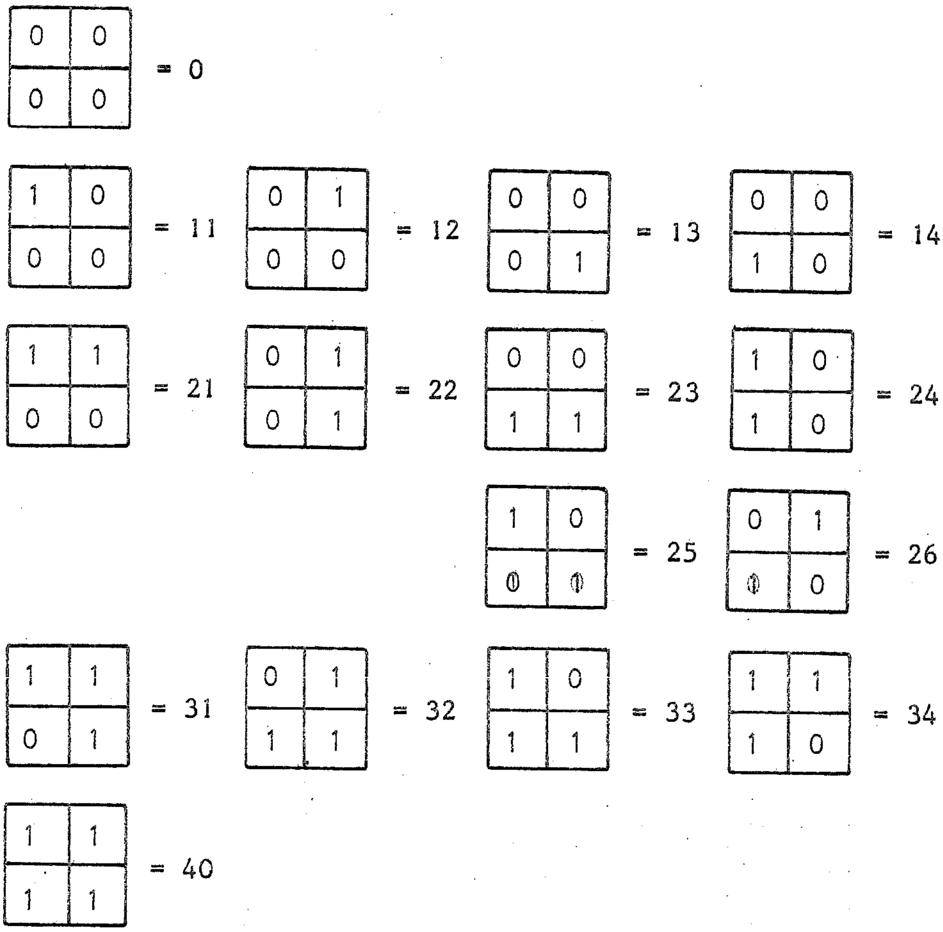
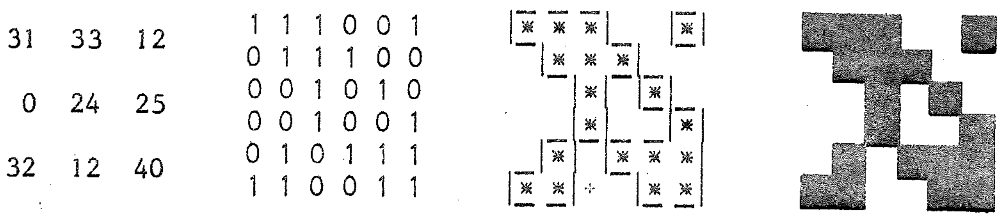


Fig. 1



(a) (b) (c) (d)

Fig. 2

The structures were stored in binary form. The advantage of this is that not much memory space is occupied and that logical treatments can be applied to the structures. For identification purposes the user provides each structure with a number. The procedure *fillin* is used to convert the key-code into binary code. If the number of the structure, the coordinates of the key (e.g. the coordinates of key 24 in fig. 2a are 2,2) and the value of the key are stated, this procedure places the zeros and ones in the correct place in the given structure. The advantage of working with a line printer instead of a plotter is that a large number of structures can be produced rapidly, the user then being able to make his selection.

If structures are to be combined, they must have the same dimensions. The user states at the very beginning how many structures he wishes to store at the same time, and their sizes (in fig. 2a the dimensions are: length 3 and width 3). He then has at his disposal a number of possibilities of generating and combining structures.

GENERATING A STRUCTURE

There are three procedures for doing this.

(a) In the first place structures can simply be read in. For this the procedure *copy* is used. The user must state the number of structures to be read and which numbers are to be given to these structures in succession; he must then register the structures line for line in the key-code.

(b) Structures can be generated in a manner similar to that of the ALEA selection principle in Koenig's PROJECT 1 programme, and as such, this procedure, which is called *aleakey* is its oldest component. The user can divide the structure up into sub-structures of arbitrary size (see fig. 3). There are then three possibilities of employing this procedure, indicated as gen0, gen1 and gen2.

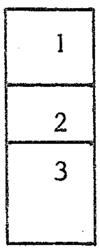


Fig. 3

gen0. For each sub-structure the user states a number of keys, each of which is provided with a significance factor, e.g. 1 - 21, 2 - 22, 5 - 24. The sub-structure is filled with the given 'elementary structures', which are selected at random, provided that the significance factors are taken into account. In the example above the chance of element 24 is five times greater than of element 21.

gen1. The point of departure is the same. The computer starts filling in the first line of each sub-structure according to the given keys. These data are no longer used for the second line; the computer uses the distribution in the same way in which it actually occurred in the first line and which will most probably deviate from the given distribution because of the limited number of elements. For the third line the distribution of the second one is used, and so on.

gen2. This is a variant of the previous principle. Only one set of keys is given this time, for the first sub-structure. This is filled in the same way as in gen0. For the second sub-structure the actual distribution in, say, the first three lines of sub-structure 1 is used as point of departure. This number of lines must be stated for each sub-structure. If this number is large, the actual distribution will barely deviate from the given distribution. Developments can thus be kept under control more easily than in gen1.

(c) The third possibility is provided by the procedure called *readvar*. The point of departure here is a model structure which has to be stated. This model is placed in the top left-hand corner of the structure to be filled. The rest of the space is filled with copies of this model, but variations may be introduced. This is because the model can be subdivided into parts which can be substituted in pairs at each copy. The user may state the probability of such a substitution. Which parts are substituted is decided at random.

COMBINING STRUCTURES

(a) Procedure *negation*. This can not really be called the combination of structures; this procedure makes a structure negative by replacing each one by a zero and vice versa.

(b) Procedure *combine*. This procedure provides five possibilities of combining structures. In the first four, combinations are made with the help of the logical operators ⊃ (implication), ≡ (equivalence), ∩ (AND), ∪ (OR). The corresponding squares of the structures to be combined (in AND or OR combinations there may be more than two of these) are compared. According to the contents of these squares, a one or a zero is placed in a new structure. See the table below. The two structures to be combined are indicated by a and b.

structure a	0	0	1	1
structure b	0	1	0	1
implication	1	1	0	1
equivalence	1	0	0	1
AND	0	0	0	1
OR	0	1	1	1

If the fifth possibility is used, another number must be given. If the number 4, for example, is selected, this means that at every fourth place in the new structure (counting from the top left-hand square) the corresponding square from structure b is taken over, structure a being copied for all the other places.

Finally the user can state which structures he wishes to see in print, after which he can stop, or start a new series of structures, perhaps with other dimensions.

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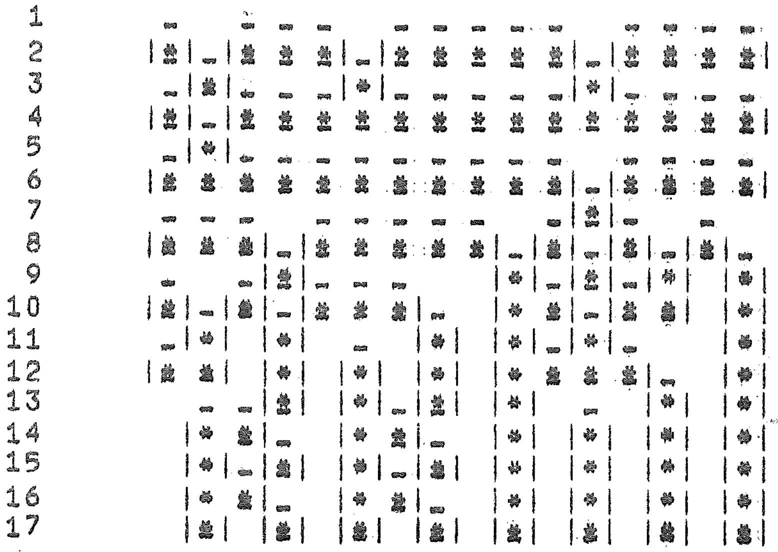
STRUKTUUR NR. 1



3-21
1-25

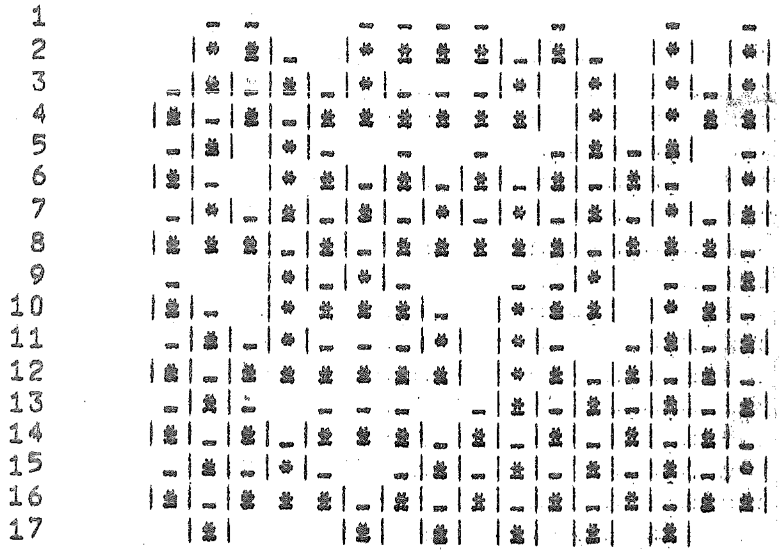
1-21
1-22
2-25

3-22
1-25

aleakey

gennul

STRUKTUUR NR. 11

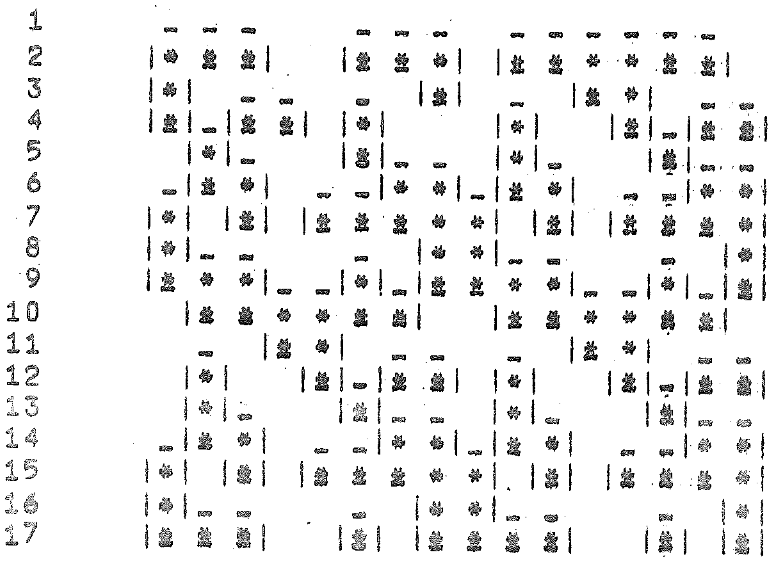


1-21
1-22
2-25

aleakey

gentwee

STRUKTUUR NR. 16



readvar

model:

34	11	12	31
25	21	22	0
26	24	23	40
33	14	13	22

M. L. Eaton

BIO-POTENTIALS AS CONTROL DATA FOR SPONTANEOUS MUSIC

The impetus for this paper comes from three sources. First, a realization of the important role of the "theorist" as a planner of possible and advantageous musical techniques. Second, the possibility of using electronic sound generation control equipment in conjunction with biological potentials. Third, certain problems which are inherent in all improvised music. These three general areas contribute to the character and outlook of current ORCUS research in "Bio-Music".

The idea of employing bio-potentials as a source of musical material was first discussed in detail in August, 1961. Interest in development of "bio-music" systems was aroused by two specific problems; first there was the fact that in improvisation the musicians are quite limited by the necessity for predetermined material, and the second, that the improvisor, even when improvising alone, is severely limited and guided by the physical restrictions imposed by his body and by the mechanical nature of all conventional musical instruments.

By 1963, the concept of using bio-potentials for musical purposes had developed from one of direct conversion of signals into sound to a more sophisticated approach of data acquisition and manipulation to derive signals suitable for driving electronic sound generation equipment. In these systems the feedback loop consists of bio-sensors which, after signal processing, generate an audio output that is fed back through the ear and brain to the bio-sensors. This basic feed-back loop is the starting point for a large number of "bio-music" systems. The primary difference between systems are in the nature of the data processing which occurs between the bio-sensors and the audio output, and the type or types of bio-potentials employed.

The idea of employing bio-potentials for musical purposes is not as new as might be supposed. Around the turn of the century, the U.S. Patent Office received an application concerning a proposed device which would allow the musician to manipulate the keys of a player piano by attaching wires to his head. This was before the discovery of "brain waves" and at the time constituted a rather far-fetched scheme. The applicant did not specify in any detail what method was to be used to obtain signals which would be useful for the purpose of generating player piano music. The application was rejected.

The idea of converting bio-potentials into sound is not a completely new idea. Several researchers have developed devices during the past 25 years for converting brain waves into sound, especially J.A. Bates, C.A. Beevers and R. Furth, and Bozenikov and Soroko. However, none of this research was connected with music; it was for electro-encephalographic (EEG) analysis purposes. The sounds produced by these devices is singularly uninteresting, at least from a musical point of view. Nevertheless the devices do constitute the first practical circuits for converting "brain waves" into sound.

There are many bio-potentials which can be used for musical purposes. Some of them generate enough information to be used with a relatively small amount of processing while others are of a more auxiliary character. The electrical signals generated by the heart are, for example, quite easily detected over the entire body and can be used as a source of information. Heart rate and waveform are affected enough by auditory experiences to make this source usable. Generally, however, these changes are not great enough to allow the EKG to serve as the sole source of information.

The psycho-galvanic skin reflex, due primarily to changes in skin resistance during emotional stress can also serve as an auxiliary source. But, since these signals vary quite slowly and predictably they must be used in conjunction with other bio-potential sources. The signals generated by involuntary muscular contraction can also be used; facial areas are particularly subject to this type of activity. These signals are quite large compared to most other bio-potentials and are for this reason quite easy to employ. The placement of the sensors is of course a determining factor in the nature of the signals which can be detected.

One of the easiest sources to employ and one which is more indicative of mental activity concerning shape and form is the movement of the eyes within their orbits. When the eyes are stationary a steady potential is generated between a pair of electrodes attached equidistant from them. However, eye movement produces a change in the ionic concentration of the eye fluids thus generating a changing electrical potential. The use of eye movement potentials is quite simple since normal eye movement generates signals in excess of 100 mv.

The source of bio-potentials which holds the greatest interest and the greatest challenge, however, is the cerebral cortex. It is primarily to this source that the present author has directed his attention. The discovery in 1929 by Hans Berger of the alpha rhythm, a basic rhythmic brain signal, produced a renewed interest in the dream of "think-work"; of mental remote-control. However, the problem of correlating electro-encephalographic (EEG) data with observable behavior has proved to be extremely slow and frustrating over the past forty years. Many postulates and thousands of experiments have failed to produce any widely accepted central theory of correlative interpretation.

There are, though, two important advances in cerebral research which have occurred during this century that have given researchers cause for some optimism. The first of these is the determination of functional cortical areas within the brain. It is now quite clear that certain areas of the brain control specific types of behavior and physical action. For example, the parietal area controls fine hand and finger movements; the temporal lobes are associated with memory functions. The contributions of Bremer, Von Bonin, McCulloch and especially of Penfield and Rasmussen of the Montreal Neurological Clinic are quite important. These researches serve as important sources of information in EEG research.

The second important advance is the discovery of spontaneous electrical signals of cortical origin. The first of these (the alpha rhythm mentioned above) has proved to be extremely important in electro-encephalographic research. A large portion of the EEG literature is devoted to it since it is the most dominant cortical signal. It can be detected over a large portion of the skull, is relatively easy to identify and maintains certain stable characteristics during the entire adult life of an individual. It is generally agreed that the alpha rhythm becomes the dominant brain rhythm by the age of five; has a frequency of 12-12 Hz dependant on mental activity; that its amplitude and harmonic content often vary greatly with mental activity and that is has the greatest amplitude in the vicinity of the occipital lobe. The following quotation from Electroencephalography by Hill and Parr (page 220) indicates its importance:

> "The slight changes in frequency which do seem to occur are usually closely related to the degree of alertness of the subject; mental activity with the eyes shut may produce a transient acceleration by 0.5 Hz or so, and in subjects in whom the rhythm persists with the eyes open visual scanning

of a significant pattern has the same effect. The form of the individual waves, and accordingly their harmonic content as displayed in the analysis, also show fluctuations with attentiveness; a rhythm which has been diminished by attention usually has a more spikey or monophasic appearance and the second harmonic content is proportionately higher"...

"Summarising this selection of data, we have a complex rhythmic activity, closely associated functionally and anatomically with visual perception and integration, and particularly with the appreciation and imagination of form and pattern.

It remains to speculate on the possible functional properties of alpha activity as a type of the spontaneous resting rhythms. It should be recalled that the alpha rhythm is only one of a number, perhaps a very large number, of similar phenomena."

The alpha rhythm is by no means the only signal originating in the brain nor are all cortical potentials rhythmic in nature. The work of Lion, Winter, Levin and of Jan Trabka on non-rhythmic brain signals (see bibliography) are especially important in this connection. Research into the nature of non-rhythmic cortical activity has increased considerably in the past ten years. Since the signals are transient the parameters of amplitude, frequency and harmonic content are more difficult to study.

Whether a bio-music system employs transient or rhythmic brain signals as system input data, the parameters of amplitude, frequency and harmonic content can be used as basic information which after processing can be used to drive any desired type of sound generating equipment. Let us consider a quite simple EEG music system. This circuitry, although not sophisticated enough for serious music composition, will serve to illustrate all of the important principles of EEG music systems.

NOTES:

1. Diode D1 prevents positive pulses from the clock from feeding back to the 3 Bit and 5 Bit counter inputs.

2. All Logic gates shown are "AND" gates.

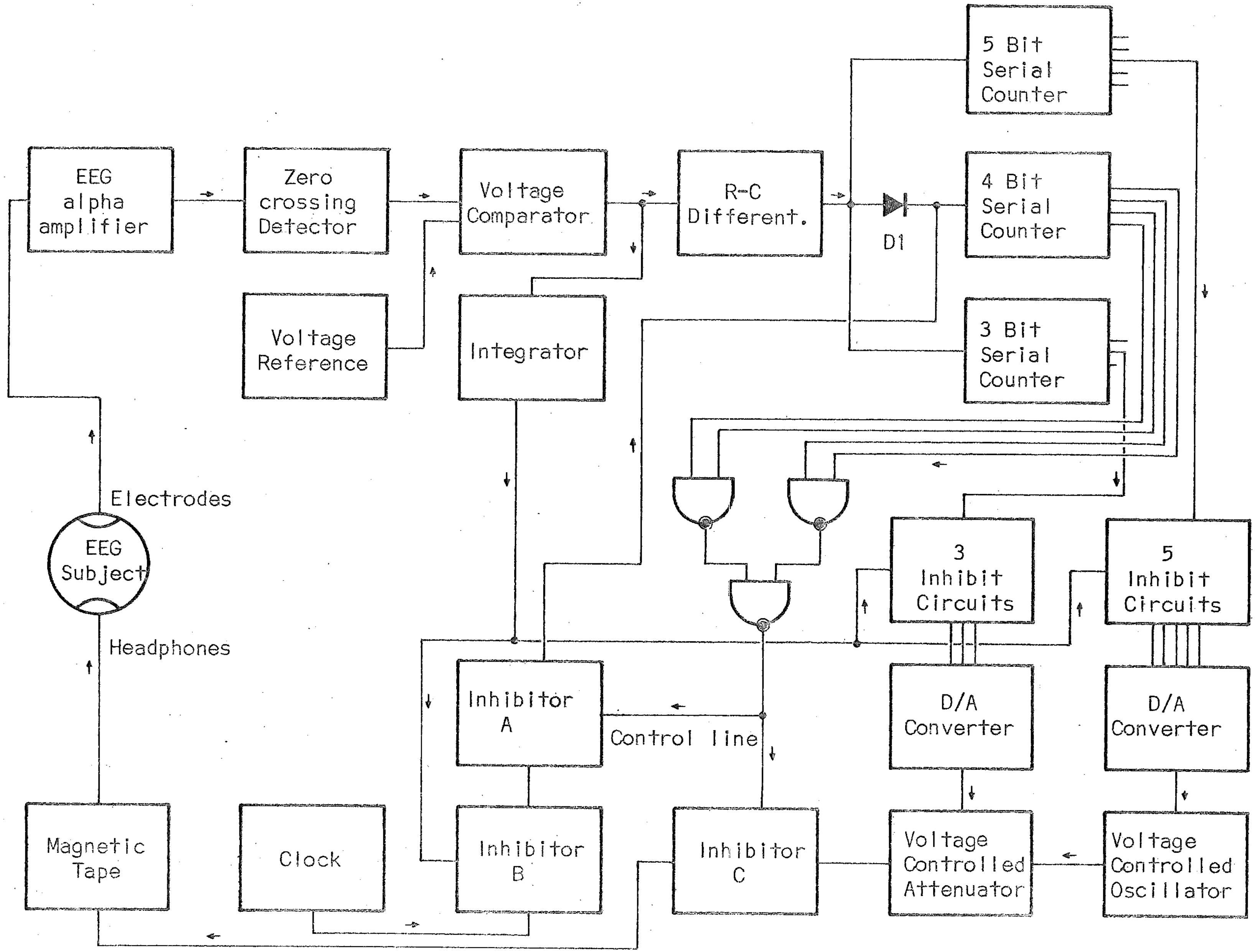
3. All Inhibition Circuits are of the "Reverse Bias" type. That is, they pass signals present at their inputs only when the control line signal is zero.

4. The Voltage Controlled Oscillator has a one octave range within the audio spectrum. The five bit counter has 32 possible output combinations, each of which generates a unique analog output signal value from the associated D/A Converter. Thus there are 32 distinct sine wave frequencies which can be generated over the one octave range of the oscillator.

5. There are 16 possible output combinations from the 4 Bit Counter which controls the duration of the audio signal. Thus there are 16 possible durations; the range of these durations, however, is a function of the clock speed. Each clock pulse represents 1/16 of the maximum possible duration time.

6. The EEG amplifier amplifies the Alpha Rhythm of the brain which is approximately 10 Hz to 12 Hz dependant upon mental activity and whose amplitude ranges from less than 1 μv to approximately 50 μv, the amplitude also being dependant upon mental activity. The "mental activity" which varies the parameters of the Alpha rhythm is primarily "concentration" or "attention" to external stimuli or to mental effort of an abstract nature. In most subjects, concentration brings about an increase in Alpha frequency and a decrease in alpha amplitude.

7. The Zero Crossing Detector operates as follows:
The output changes state each time the input waveform passes through zero. These are rectangular pulses of positive or



A BASIC ELECTROENCEPHALOGRAPHIC COMPOSITION SYSTEM negative polarity and their amplitude is directly proportional to input amplitude up to a certain level and are of constant amplitude for input amplitudes greater than this level.

8. The Voltage Comparator operates as below:
For voltage amplitudes greater than the amplitude of the Voltage Reference a positive output voltage step is generated; for input amplitudes less than the Voltage Reference no output occurs. The circuit does not respond to negative inputs. The amplitude of the output is constant for all inputs greater than the Voltage Reference. In the system shown the Voltage Reference amplitude is less than the constant amplitude level of the Zero Crossing Detector.

9. The R-C Differentiator serves to provide pulse waveforms for the counter inputs.

10. The purpose of the "Integrator" is to obtain a positive DC voltage from the voltage comparator output for Inhibition circuits B,3, and 5 during EEG pulse trains.

OPERATION

Suppose that due to the EEG Source (the composer) being in a quiescent state, the Alpha Rhythm amplitude increases. These Alpha signals will be squared by the Zero Crossing Detector and fed to the input of the Voltage Comparator. If the amplitude of these signals from the Zero Detector is greater than the amplitude of the Voltage Reference, a positive pulse will occur at the output of the Voltage Comparator for each positive pulse present at its input.

Due to the action of the Integrator, these positive rectangular pulses will be an essentially direct positive voltage as described above. This positive direct voltage will prevent Inhibit Circuit B from passing the clock pulses at its input and will prevent the 3 Inhibit Circuits and the 5 Inhibit Circuits from passing signals present at their inputs.

The positive pulses at the output of the Voltage Comparator are fed for storage into the 3 Bit and 4 Bit and 5 Bit counters.

When the output of the Voltage Comparator falls to zero due to increased mental activity and its resultant decrease in Alpha amplitude long enough for the output of the Low Pass Filter to fall to zero, the events described below occur:

(A) Inhibit Circuit B begins to pass the clock pulses present at its input. Since, there is no signal present on the control line of Inhibit Circuit A it also passes the clock pulses which begin changing the state of the 4 Bit counter, from the state that it is in. (This state was inserted into the counter by the prior pulses from the Voltage Comparator output.) The situation where the control line to Inhibit Circuit A is not zero will be discussed below.

(B) The 3 Inhibit Circuits and the 5 Inhibit Circuits pass their counter states to their respective D/A Converters.

(C) Since the output of the "AND" circuits is assumed to be zero there is no signal present on Inhibit C control line and it passes the audio signal which is present at its input. The amplitude and frequency of this signal is controlled by the analog signal present at the Voltage Controlled Attenuator and the Voltage Controlled Oscillator.

(D) The clock changes the state of the 4 Bit Counter until all flip-flop outputs are in the logical "1" state. Under this condition the three "AND" gates produce an output which inhibits the oscillator signal present at the input of Inhibit Circuit C and which also prevents further clock pulses from reaching the 4 Bit counter since Inhibit circuit A will no longer pass the signals.

(E) The system remains quiescent until the EEG signal becomes large enough to initiate another series of rectangular pulses from the Voltage Comparator.

In the event that a series of pulses should begin at the Voltage Comparator output <u>before</u> the oscillator sound ends due to an output from the three "AND" circuits, the oscillator will be prevented from reaching the Magnetic Tape Input as soon as the Voltage Comparator output becomes positive, since the 3 Inhibit Circuits and the 5 Inhibit Circuits will be prevented from passing their input signals.

Above, it was assumed that the 4 Bit counter was not in the 1111-state when the series of rectangular pulses at the Voltage Comparator output ended. In the event that the counter is in the 1111-state, initially no audio sound will reach the Magnetic Tape Input since Inhibit Circuit C will not pass the Oscillator signal. The system will remain quiescent until the 4 Bit Counter contains another state due to new pulses arriving from the Voltage Comparator.

Due to the arithmetical ratio of the number of flip-flops in the 3, 4, and 5 Bit counters, the situation where a given duration, amplitude, or frequency would always result in the same value each time for the other two parameters is avoided.

The system desribed is based on the ability of the composer to direct or to avoid directing his attention to the sound being generated. The sounds generated are found "interesting" or "not interesting" to the composer and partial control over their reaching their full duration remains with the composer. Obviously the composer does not wield full objective control over the system by specifying, consciously or willfully, the frequency, amplitude and duration of the desired audio signal. This is not the point of the system; it is rather to provide the composer with a direct and semi-automatic method of composition which is intimately related to his mental activity in both an objective and subjective sense while allowing him to retain some measure of "real-time" control over the course of the composition.

Through the use of a digital memory, the present system can be extended to provide successions of sounds based upon analyses of prior counter states. This would provide longer intervals for the composer to "consider" the course of the composition.

The basic elements of any EEG music system are: (1) The signals generated by the cerebral cortex and the rest of the brain. (2) Circuitry to process this raw data into appropriate digital information. (3) Memory and decision circuitry to store and direct this data. (4) Sound generation equipment. (5) The human ear and brain which complete the feedback loop. It is evident that a plethora of difficult philosophical problems arise in choosing the nature of the feedback loop elements. Many of the same philosophical problems found in conventional electronic music confront the theorist in "electroencephalomusic"; but there are, in addition to these, several new difficulties. Questions also arise concerning the nature of "spontaneous music". As an approach to these problems, then, let us consider the following. The developments of any given age are a function of the relationship between the creative thought of the artist and the technical means which are available to him. These two facets of artistic production are intimately linked together. Only rarely does the artist find the technical means available to him adequate for the expression of his artistic ideas. This problem is generally ignored by musicologists and by theorists; it is generally accepted that the limits imposed by given instrumentation correspond to the limitations that the composer would place upon himself from aesthetic or philosophical considerations.

Probably the most significant decision in the history of music was the choice of "pre-conceived" over "spontaneous music". The necessity for the decision arose due to a severe disparity between creative thought and technical means. Technical capabilities of that age provided the composer with various instruments but with no method for combining their sounds except by "pre-conceiving" the music through some type of musical notation. The choice of pre-meditated instead of spontaneous music came about very simply and naturally; spontaneous music evolved into "improvised" music. Busoni in his prophetic book <u>The Essence of</u>

Music and Other Writings stated that "Improvisation would stand nearest the true essence of art if it lay within human capacities to master its promptings" (page 100). The use of bio-potentials and electronic circuitry provides the technical means to create a sophisticated spontaneous music.

Many problems in "electroencephalomusic" which appear at first to be serious are in fact quite illusory. The most important of these is the role of the "will" of the composer in producing sounds. Jazz musicians are often asked how they can think of the right notes so fast. Of course, any one who has ever improvised realizes the absurdity of the question; the player "guides" the course of the playing, he isn't thinking of each individual note. Furthermore, most will agree that even in the composition of written music the role of the "will" is usually small. Nevertheless, the fact that it is often impossible for the composer of "electroencephalomusic" to "will" a specific sound is disconcerting to some. (It is possible to construct EEG music systems in which the composer can "will" specific sounds.) The success of any sophisticated EEG music system, though, depends on the ability of the composer to guide the course of the composition by initiating, subconsciously, changes in the cortical signals which are producing the sounds; the degree of attention is frequently used to regulate the complexity of the flow of events. Of course, the type and complexity of feedback loop circuitry are also quite important in determining the final audio output.

The nature of the feedback loop circuitry can be such that each bit of cortical information is immediately processed into sound material or the cortical information can assume the role of selecting predetermined and stored sound sequences. In the first case extreme, any cortical signals containing sufficient information to initiate sound would do so immediately. In the second case extreme, cortical signal data would be stored for a duration dependant upon some cortical signal parameters and would then produce a predetermined sound sequence. This sound sequence would constitute the composition. In practice the decision and memory circuitry never closely approach either of these extremes.

The next problem which confronts the theorist is the significance and nature of various cortical potentials. Within the confines of the present introduction a complete survey of various theories of cortical function is, of course, impossible. However, the function of the various areas of the cerebral cortex, as mentioned previously, is well established. It must be realized that detailed information on the exact site from which a signal emanates is difficult to determine even when the surface of the cortex is exposed, and quite impossible under normal conditions. Furthermore, the correlation between behavior and recorded data remains in a relatively primitive state. However, in using cortical potentials for musical purposes, behavior correlates are of little concern; the same is true in conventional music. The EEG signals can be treated as raw data which can be processed to produce any desired system characteristics. The measure of the control by the feedback loop is the effect of the audio output on the EEG signal compared statistically with the change in EEG parameters with no audio feedback.

The last problem which should be mentioned is that of the role of the composer in employing "electroencephalomusical" systems. It will be quickly realized that in EEG music systems the mental activity of the composer is "automatically" becoming sound; and that the perception of this sound is "automatically" changing his mental activity. This represents an ideal situation from the point of view of the creator of "spontaneous" music but it creates a problem rarely considered in "pre-conceived" music; the effect of cogitation upon the final musical product. In "spontaneous music" the mental effort is the composition. The process of exclusion becomes a portion of the composition. Thus the EEG composition unfolds in "real time". The mental methods themselves become important in determining the aural output; and the composer soon discovers that the discipline involved in EEG music is a discipline of mental states.

The importance of mental states is shown quite simply by consideration of the elementary EEG music system described earlier which employed the alpha rhythm as the prime source of data. In this system a lack of attention to the audio output will completely attenuate the sound whereas intense concentration on the sound being produced will result in positive feedback producing an increase in duration, frequency and amplitude limited only by controls built into the system.

The subject of the control of mental states and of the immediacy of EEG compositions raises important philosophical and religious questions which cannot be dealt with in this paper. It should, however, be mentioned that the inclusion of bibliographic references to research on mental states induced by drugs does not necessarily imply that present research supports these methods as effective techniques for realizing EEG compositions.

The above material represents a minimal outline of the more important facets of "electroencephalomusic" systems. Present systems and designs, experiments now in progress and the events of the next decade will indicate that "bio-music" represents a highly significant development; the centuries old dream of a musical system capable of intimate fulfillment of the composer's ideas will be realized.

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	-	Newsreel, Sunday	(4 - 13'31)
	Wim Franken	Poèmes de voyage	(4 - 29'02)
	Erhard Grosskopf	Dialectics for flute, viola, trombone and 4 sound tracks	(4 - 10'30)
	Günther Hempel	Polyphonie für 3 Vokalisten, Sinusgeneratoren, Ringmodulatoren, Kurzwellenempfänger und Tonband	(2 - 15'50)
	Werner Kaegi	Hydrophonie I	(4 - 16'30)
	Gottfried Michael Koenig	Funktion Blau	(4 - 6'00)
	-	Funktion Indigo	(4 - 12'38)
	-	Funktion Violett	(4 - 19'55)
	-	Funktion Grau	(4 - 10'15)
	Tera de Marez Oyens	Photophonie	(2 - 14'00)
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	Luctor Ponse	Radiophonie Ia	(4 - 6'01)
	-	Radiophonie Ib	(4 - 3'04)
	-	Radiophonie II	(4 - 28'15)
	-	Radiophonie III	(4 - 15'15)
	Rainer Riehn	Chants de Maldoror (revised version)	(4 - 26'26)
	Wybren Veeman	Impuls	(4 - 6'40)
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The following item was received after assembly of this issue:

The 1969 Annual of the Institute of Psychoacoustics and Electronic Music at Ghent University has just appeared. It contains the following contributions:

Prof. Josef Rufer:	Technische Aspekte der Polyfonie in der 1. Hälfte des 20. Jahrhunderts. (with a number of unpublished documents left by Arnold Schoenberg.)
Dr. Andres Briner:	Hindemiths Ludus Tonalis.
Henri Pousseur:	La Polyphonie en Question.
Herman Sabbe:	De Polyfonie: Grenzen van een Begripsextensie. (with an extensive summary in English.)
Volker Nösselt:	Die Zeitstrukturverarbeitung akustischer Schwingungsverläufe durch das Audioperzeptionssystem.

This annual can be obtained from the above-named institute, Muinkkaai 42, 9000 GHENT, Belgium.