Since the beginning of my composition of electronic music I have always been seeking for the technical means to produce phase-synchronized spectra with controlled phase-shifting of the individual partials. One learns ordinarily in the study of acoustics that the phase-alignment of the partials plays no audible role. However, that is true only to a very limited degree. Some results of phase-rotation which I achieved in an adventurously experimental manner in the Cologne studio were very encouraging toward making further investigation in this direction (for example, while simultaneously recording a spectrum on two parallel tape recorders, slowly pressing a finger down on the tape between the record and playback heads, and recording both outputs on a third tape recorder). By this means one can achieve wonderful spectral-“rotations,” in which all of the partials undergo phase-shifting among themselves.

The compositional availability of such phase-shifting in the Cologne Studio
for Electronic Music of WDR (Western German Broadcasting) in any case remained a permanent pipedream, like most of what I wanted to compose from 1952 (Etude, musique concrète, O.R.T.F., Paris) to 1976 (completion of the realization of Sirius at WDR), and could not realize because of technical limitations.

Since the opening of the studio for electronic music at IRCAM I have regularly been invited there for demonstrations of the equipment. From among the sound-examples of the demonstration tape made by Giuseppe Di Giugno (the designer of the synthétiseur 4X), I was fascinated by an example of the slow phase-rotation of an overtone spectrum of “over 700 phase-synchronized generators,” as he proudly explained.

At the first opportunity to find out whether I could realize a large project in the IRCAM studio, I concentrated on processes of phase-rotation with the use of the synthétiseur 4X.

The 4X has six “plaques” (“boards”—memory storage), and each “plaque” can be programmed for a maximum of 64 oscillators, when these are used with a sampling rate of 32,000 Hz (at which rate frequencies above 16,000 Hz are no longer available).

There are therefore $6 \times 64 = 384$ programmable oscillators. Each “plaque” is divisible into $32 + 32$ oscillators. If one wants to produce a continuous succession of spectra, then these “plaques” must be divided into two halves (with $3 \times 2$ outputs each, therefore six potentiometers), so that during the running of the program of one half, one can “load” the other half.

Depending on the complexity of the program, the “loading” sometimes takes rather a long time (in my program sometimes as much as six seconds). By doing this, the number of the simultaneously employable oscillators is automatically reduced by half—that is to say, by 192 ($3 \times 64$ or $6 \times 32$). The twelve outputs of the six “plaques” (each is divided in two) can be separately regulated during the work by means of $2 \times 6$ volume-controls on a mixing-table, and—if necessary—filtered.

These were the technical conditions known to me when, in May of 1983, I wrote the version of

Kathinka’s Chant

as

Lucifer’s Requiem

for

Flute and Electronic Music.

The work had appeared at the beginning of 1983 in a first version for flute and six percussionists—as the second scene of the opera Samstag aus Licht (Saturday
from Light). This form was premiered in a quasi-concert version in October 1983 at the Donaueschinger Musiktage by Kathinka Pasveer (flute) and the Kolberg Percussion Ensemble. On the 25th of May 1984 the stage premiere followed, under the auspices of the Teatro alla Scala at the Palazzo dello Sport, Milan, with Kathinka Pasveer and the Slagwerkgroep Den Haag (Stage Director: Luca Ronconi; Stage Design and Costumes: Gae Aulenti; Sound Director: K. Stockhausen).

**COMPOSITION AND REALIZATION**

In May of 1983 I first wrote for the electronic music to *Kathinka's Chant* a form scheme with explanations of the symbols. It contains the information for the theoretical programming. This I discussed with Marc Battier, a musical/technical colleague from IRCAM (Paris), with whom I wanted to collaborate.

In December 1983 and August 1984 I realized the electronic music in 2 × 7 days at IRCAM. Battier, using a PDP-11 computer, programmed the 4X according to my score.

During the time spent in the studio there came about working notes containing the data for the particulars (chosen by ear) of the timbres and relative dynamics. Finally they were summarized in a four-page synchronization scheme with 2 × 6 tracks for copying from the 4X onto a 16-track tape. A supplemented form scheme with meter-level numbers is the result of the mix-down (August 21, 1984) in the auditorium “Espace de Projection” from the 16-track tape recorder to an eight-track tape recorder for the production of a performance master-copy. In this scheme I added the numbering (above each K) of the K 1 to K 6 sounds.

The realization was concluded on the 22nd of August, 1984.

The automatically generated tables for the sounds K1–K6 (*Tables d'ondes pour les K1–K6*) are dated the 20th of July 1983; all of the tables for the sounds rotatized in ellipses in the form scheme are dated the 14th of December 1983; the last version of the explanation of terms in the score (*Explication du nom des partitions*) and the score of the whole composition (*Partition*) are dated the 20th of August, 1984.

From the 9th to the 14th of May 1985 the world premiere and five further performances took place at IRCAM, with Kathinka Pasveer (flute) and a six-track projection of the electronic music.

The work lasts about 33 minutes.

The most essential aspect is the six-layered space-polyphony of controlled phase-rotations of harmonic spectra. A new orientation of musical logic in the realm of the harmonic stands out, which was not realizable with the technical means available up until now. Simultaneous phase-rotations of phase-
synchronous partial-groups of rich overtone-spectra (with completely determined fundamental tones and durations of each rotation, above all with very long durations and with certain intensity-relations of the partial-groups amongst themselves) can be of a beauty such as has never before been experienced. The changes of slow phase-rotations have such an intense temporal logic, that one can accurately follow quarter, third, and, above all, half-phases; and the coincidence of the maxima of all of the overtones (where a sharp explosion occurs at the point of phase synchronization) is perceived each time as a liberating new beginning.

I would like therefore to summarily describe the composition and the work of its realization.

Comments on the significance of the *requiem*-character, of the 24 stages, etc., of *Kathinka's Chant* are in the general forward to the score and will not be repeated here. I will describe only the technical aspect.

**Description of the Form Scheme (Example 1)**

1) *24 Grundtone-Segmente* (Fundamental-tone segments) of the *Lucifer formula* are distributed over the 24 stages 1 - 24 (see *Grundtone* and under them their *durations* [Dauern]).

Normal notes • signify periodic vibrations, slashed-through notes ◆ noise-bands.

2) In six layers, overtone-groups are reproduced over six loudspeakers (see the comments beneath the form scheme).

![Diagram]

3a) Where ❇ appears, a complete overtone-spectrum of the first to the 212th overtone was placed, with levels of the overtones inversely proportional to the frequency-intervals (fundamental-tone level 1000.000000 = maximum; second overtone level 500.000000; third overtone-level 333.333344, etc.), graphically depicted in my working notes (Example 2) as 212 ❇.

b) Moreover, at each ❇ there is an *electronically imitated instrumental sound* mixed in, phase-synchronous to the complete 212-overtone-spectrum. By this means six different sounds are employed, which I designate Kl-K6.

They had already been recorded for other programs, so then they were
EXAMPLE 1: FORM SCHEME
analysed and stored in memory, and there was nothing further to the selection.

Names of the instruments, recorded intensities and pitches are given in parentheses following the abbreviations:

\[
\begin{align*}
\text{K1} & = \text{PF, C1} & (\text{Pianoforte} & \quad f) \\
\text{K2} & = \text{VC, C2} & (\text{Violoncello} & \quad f) \\
\text{K3} & = \text{BC, C2} & (\text{Bass Clarinet} & \quad f) \\
\text{K4} & = \text{PF, F\#1} & (\text{Pianoforte} & \quad f) \\
\text{K5} & = \text{Tuba, F\#2} & (\text{Tuba} & \quad f) \\
\text{K6} & = \text{PF, C2} & (\text{Pianoforte} & \quad f)
\end{align*}
\]

These sounds were then generated on the fundamental tones which are given in the form scheme. I add as an example two pages of the frequency table for K1 (gpf L jub) (Example 3): in the left column run the numbers of the overtones (analysed on C1 = 32.7025 Hz); in the middle column is the level, which is referenced to a maximum of 1000.00000; in the third column the phase-shift is given, with reference to the third overtone = 0.00000.

The succession of the sounds K1–K6 is entered in manuscript above each \( K \) in the supplemented form scheme (Example 4), thus in track 1 K1, K2, K3, K4, K5, K6, etc.

The intensity-proportion in each \( K \) between the overall level of the 212-spectrum and the overall level of the respective K1–K6 was determined by ear during the studio work. The 212-spectra are mostly very much softer. In several places I decided to overlay a K-sound on itself, both in phase and also aleatorically.

"Aleatorically" here means that the fundamental-tone frequency is defined as the middle frequency of a narrow frequency-band of 64 oscillators with aleatorically distributed frequency-intervals, and the bandwidth is determined by ear. So, for example, in Stage 1, track 1, the sound K1 is produced both in phase with the fundamental tone E\(_1\) = 41.20375 Hz, and also aleatorically, i.e. with 64 aleatorically distributed frequencies between 41 and 42 Hz.

4) The instruction that in the case of a number enclosed in an ellipse a sound should be produced with \( \text{all overtones over the noted fundamental-tone} \)
### Table d'onde pour les $k_1 - k_6$

<table>
<thead>
<tr>
<th>$k_1$</th>
<th>$k_2$</th>
<th>$k_3$</th>
<th>$k_4$</th>
<th>$k_5$</th>
<th>$k_6$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0000</td>
<td>1.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>0.0000</td>
<td>0.263</td>
<td>0.0405</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>0.0000</td>
<td>1.400</td>
<td>0.1111</td>
<td>0.0448</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>0.0000</td>
<td>0.400</td>
<td>0.1414</td>
<td>0.0414</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>0.0000</td>
<td>0.400</td>
<td>0.400</td>
<td>0.400</td>
<td>0.400</td>
<td>0.400</td>
</tr>
</tbody>
</table>

**EXAMPLE 3: TABLES FOR THE SOUNDS K1–K6 (EXCERPT)**

and from this spectrum the specified overtones should be stressed and all
the others suppressed (by ear), was altered in this way:

The numbered overtones in ellipses were phase-synchronously overlaid
with individual oscillators, and therefore not "filtered out." See the
Tables d'ondes, Page 1 (Example 5); in Stage 1, track IV, five oscillators
yield the low E (41.2 Hz) fundamental-tone with the maximum level of
1000.000000; the second overtone with a level of 500.000000; the third
overtone with a level of 333.333344, etc. In Stage 2, track 1, there are
eight oscillators, the first to eighth overtone with the given levels, in track
IV a further fifteen oscillators the 9th to 23rd overtone with the given lev-
els, etc.

5) In each of the Stages 1-24 and E2-E8 one phase-rotation of each over-
tone-frequency occurs, during the duration given in seconds, between an
"explosion" at the beginning (zero-crossing = synchronicity of all the
phases) up to the beginning of the next stage.
Example 5: Tables for all sounds in Ellipses (Excerpt)
So for example in Stage 1, track 1, for K1 the oscillators 1-64 are “loaded” with a low E (41.2 Hz), all with regulated phase. Each oscillator has a frequency difference of 0.0107527 Hz, which causes a cyclical phase-shift over 93 seconds (1/93 frequency-difference).

6) Noises (notated ♫) were produced in a similar way, with $3 \times 64$ aleatorically distributed frequencies in a narrow frequency band (bandwidth determined by ear).

7) “Witch laughter” is used in several places for coloration of silence. A thirteen-minute long monaural microphone-recording of witch laughter, made on the 18th of August 1984 in the IRCAM studio with Kathinka Pasveer as a laughing witch and Alain Jacquinot as sound-technician, was synchronized with itself in a five-fold time-delay on six tracks and mixed down to a two-channel stereo version on the 21st of August in the Espace de Projection.

**EXPLANATION OF TERMS IN THE SCORE**

(See Page 1, 2, 3 of KA 1.BAT [Example 6])

**EXPLANATION OF THE CODE FOR THE NAMES**

The first letter is a K, the second an A, B or C according to the following division:

A : Stages 1 to 6 ;
B : Stages 8 to 12 ;
C : Stages 14 to 24 (plus KE of the RELEASING OF THE SENSES).

Then follows a number, which designates the number of the track (from 1 to 6, which is given in the form scheme [Example I] with roman numerals). From this it follows: KA 1 designates Stages 1 to 6, track 1.

**EXPLANATION OF THE CODE FOR THE CONTROL OF THE 4X**

The sign $S!$ indicates the beginning of a line of commentary.

The addition SMMESSAGE/WAIT indicates a point of synchronization.

The symbol WT indicates the concept Wave Table, and that is the Frequency Table (table d'onde) of the selected spectrum or spectra for a sequence.
Kathinka’s Chant as Lucifer’s Requiem

Example 6: Score of the Electronic Music (Beginning)
KA1.BAT

$ Start S2
$MESSAGE/WAIT
$11
*0 5 0 2

$ Load WT of S3
.R WTPAST
*1
*DM1:VCC2
*S4
*2
*DM1:VCC2
*S4

$ Load frequencies of S3
.R BAM32
*1
*0
*4
*1 64. 41.2 .0167
*1
*4
*1 64. 41.2 .0167
*1
*4
*1 64. 41.2 .0167

$ Start S2
$MESSAGE/WAIT
$11
*0 2 3 5

$ Load WT of S4
.R WTPAST
*2
*DM1:S4V1
*S4
*4
*DM1:S4V1
*S4
*6
*DM1:S4V1
*S4

$ Load frequencies of S4
.R BAM32
*1
*0
*4
*1 64. 77.8 .04
*1
*4
*1 64. 77.8 .04
*3 64. 77.8 .04
*1
*0
*4
*1 64. 77.8 .04

$ Start S4
$MESSAGE/WAIT
$11

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EXAMPLE 6 CONT.
```
KA1.BAT

*3  5  0  2
$ Load frequencies of S3, 2nd half
$ MESSAGE/WAIT
  *3
  *2
  *1.  64  73.4  .04
  *1
  *4
  *3.  64  73.4  .04
  *1
  *5
  *4
  *1.  64  73.4  .04
$ Load WT of S5
 .R WTFAST
  *0
  *DM1:KS212
  *6
  *1
  *DM1:BCC2
  *6
  *2
  *DM1:S6V1
  *6

$ Load frequencies of S5
 .R BAM32
  *1
  *0
  *3
  *1.  64  51.5  53.  .02
  *1
  *2
  *4
  *1.  64  51.9  .04545
  *1
  *4
  *1.  64  51.9  .04545
$ Start S5
$ MESSAGE/WAIT
  *1
  *0  2  3  5
$ Load WT of S6
 .R WTFAST
  *3
  *DM1:S6V1
  *6
  *4
  *DM1:S6V1
  *6
  *6
  *DM1:S6V1
  *6
$ Load frequencies of S6
 .R BAM32

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```

EXAMPLE 6 CONT.
The comment (for example) $! \textbf{Load frequencies of S4 V1}$ indicates the action of loading the \textit{synthétiseur} with the frequencies of Stage 4, track I.

The comment $! \textbf{Load WT of S4 V1}$ indicates the action of loading the \textit{synthétiseur} with the Frequency Tables of Stage 4, track I.

\textbf{EXPLANATION OF THE CODE OF THE MODULES USED TO CONTROL THE 4X}

The modules are "called" by means of a number.
For example: *1 calls module 1. In this score modules with the numbers 1, 3, 4, 7, 9, 11, 17 and 18 are called.

\textbf{Module 1} serves for the calling of one of the 6 "plaques" of the 4X. Its syntax is:

*1 module 1  
*3 appel de la plaque 3 (call of "plaques" 3).

The following numbers are employed for the "plaques":

\begin{tabular}{|c|c|}
\hline
\textbf{plaque} & \textbf{number} \\
\hline
0 & 1 \\
1 & 2 \\
2 & 3 \\
3 & 4 \\
4 & 5 \\
5 & 6 \\
\hline
\end{tabular}

The syntax of module 3 is:

*3  
*1. 64. 41. 42.1 .02

This means: load oscillators 1–64 with a frequency-\textit{cluster} between 41 Hz and 42.1 Hz. The last parameter (.02) affects the manner of the frequency-distribution.

The syntax of module 4 is:

*4  
*1. 64. 41.2 .0107527

This means: load oscillators 1–64 with a cluster of frequencies on the low E (41.2 Hz), with regulated phase. Each oscillator has a frequency-difference of .0107527 Hz, which yields a phase-shift cycle of 98 seconds (see Stage 1, track I).
Module 7 serves to begin a stage with all oscillators in phase (percussive effect). Its syntax is:

*7
*0 2

"Plaques" 0, 1 and 2 are employed (0 2 means 0 1 2).

Module 9 serves to arrest a stage with all oscillators in phase. Its syntax is:

*9
*0 2

All the oscillators of "plaques" 0, 1 and 2 are switched into phase and arrested.

Module 11 combines modules 7 and 9. Its syntax is:

*11
*0 2 3 5

"Plaques" 0, 1 and 2 struck in phase.
"Plaques" 3, 4 and 5 are arrested (in phase).

Modules 17 and 18 serve for the production of glissandi. Module 17 for noise-glissandi, module 18 for glissandi of oscillators in phase.

The syntax of module 17 is:

*17
*1. 64. 42. 46. 53.5 0.1
*0 1. 2.
*1. 64.

In this example the glissando of Stage 17, track III, from 43.6Hz to 55Hz is indicated (see fundamental-tones F-A = rustling noise below the form scheme [Example 1]).

The syntax of the second line is the same as that of module 3.

Since 43.6 Hz as the middle frequency of a noise-band from 42–46 Hz and 55 Hz as the middle frequency of a noise-band from 53.5–57.5 were chosen, the values 42. 46. and 53.5 occur in the syntax.

The third line indicates that in module 17 the glissando occurs in "plaques" 0, 1 and 2.

The fourth line indicates that in this module the glissando involves all of the oscillators (oscillators 1–64).

The syntax of module 18 is:

*18
*1. 64. 46.248 58.27 .01333
*3. 4. 5.
*1. 64.
In this example the glissando from Stage 14, track I is indicated (falling glissando).

The glissando begins at 58.27 Hz (B-flat) and falls to 46.248 Hz (G-flat).
The third line indicates that the glissando occurs in "plaques" 3, 4 and 5.
The fourth line indicates that in this module the glissando involves all of the oscillators (oscillators 1–64).

(A glissando was realised by means of a slider-potentiometer on a mixing-table, which was connected to the controlling PDP-II computer.)

The final version of the score, written out by the computer on August 20, 1984, has 71 pages (KA1–6 18 pp., KB1–6 15 pp., KC1–6 33 pp., KE2–7 plus Ausung [Way out] 5 pp.).

Each part of this score begins with the following symbols:

Voix 1 = track I;

$JOB/RT II = JOB—beginning, RT II—operating system of DEC (manufacturer) PDP-II (= name of the computer);

.R WTFAST = loaded with Frequency Tables;

*DM 1:KS212 = DM1—"Disc 1," with which the 4X is fed (here: KS212 = K-spectrum with 212 overtones).

BAM34 = name of the program.

At the close of every section there is $EOJ (end of job).

SYNCHRONIZATION SCHEME (Example 7) AND SUPPLEMENTED FORM SCHEME (Example 4)

Form scheme, frequency tables for all K-sounds; frequency tables for all sounds in ellipses, explanation of terms in the score and score have been commented upon.

After all of tracks I–VI had been completely realized, they had to be synchronized (see as an example synchronisation scheme [Example 7] for tracks I and II, Stages 14 and 15).

"Plaques" 1–3 were recorded through six amplitude-regulators 1–6, and "plaques" 4–6 were recorded through six further amplitude regulators 7–12 onto a 16-track tape recorder with a click-track registering seconds of time. I regulated by this means the levels (notated down during the studio work) for the sound-components, in several places four-handed with Marc Battier. The recording was attended to by the sound-technician Alain Jacquinot.

Tracks I–VI were successively copied onto a 16-track tape recorder and synchronized with the aid of the click-track. Several segments had to be repeated
several times, in order that the explosions at the beginning of the stages be precisely synchronized.

In order to perfectly realize such a synchronization process, it would be necessary to have six 4X’s simultaneously at one’s disposal.

As has already been mentioned, as the conclusion of the synchronization work, the 16-track tape was projected over six loudspeakers distributed in a circle in the Espace de Projection and with a level-balance—determined by repeated hearings of each segment A, B, C and Entlassung—of the six tracks, copied onto an eight-track tape. The technical collaborators were Daniel Ragun and Alain Jacquinot.

The supplemented form scheme (Example 4) contains the level-values of this balancing. Where there is no number, the sound in question was copied from the 16-track tape to the eight-track tape without alteration (0 dB); —— are crescendi, ———— decrescendi.

In connection with this production a two-track copy was produced for the studying of the flute part—with a panorama-distribution of the six tracks from left to right. It turned out that a reduction to only two channels had as a consequence an unusually strong impairment of the musical effect. One should therefore unconditionally reproduce the six-track composition over six loudspeakers arranged in a hexagon around the audience. The flute is to be amplified over a transmitter and two loudspeakers each on towers to the left and right of the stage. For a secure synchronization of the flute-playing with the tape a softer stereo-mixdown of the six tracks can be projected into the hall over these loudspeakers through six panorama-regulators, in addition to the six-channel rendition.

During a performance, the amplitudes of the six-track tape with the electronic music and the two-track tape with the witch laughter must be regulated from the middle of the hall by a sound-projectionist.

**Comments on the Score-Example (Example 8)**

Page 3 is reproduced as an example from the score of the version for flute and electronic music of Kathinka’s Chant as Lucifer’s Requiem.

At the beginning of each new stage the tracks in which the sound occurs is indicated by roman numerals. The six types of □-sounds are marked with K1–K6. Right before the track in which the fundamental and first overtones occur (see ◊ ), the pitch of the fundamental is notated, marked with an arrow; the note with a staccato-dot is the concluding explosion of the preceding fundamental-tone.

The ordinal numbers of the overtones appear in the ellipses ◊ (thus in Stage § : track II the 1st–9th overtone, track III the 10th–36th, track IV the
EXAMPLE 8: SCORE EXAMPLE
37th–82nd, track V the 83rd–118th, track VI the 119th–136th, and track I the 137th–192nd).

The diagram to the right, next to the overtone-numbers shows with dots, from which speakers the sound comes: \[
\begin{array}{ccc}
\text{V} & \text{III} \\
\text{V} & \text{II} \\
\text{VI} & \text{I}
\end{array}
\]. A dot in a small rectangle indicates a \( \text{E} \)-sound.

CONCLUDING NOTE

The version of Kathinka's 'Chant as Lucifer's Requiem' for flute and electronic music has—through the above-described phase-rotations of harmonic spectra and the associated explosions of imaginary giant gongs at the null-points of the phase-cycles—bestowed upon the Requiem a heretofore unknown spaciousness, solemnity, austere beauty of the gliding harmonic transitions through all consonance/dissonance gradations, a traceable polyphonic multilayeredness and purposefulness of the partial processes—as a magic world around the solitary voice of the flute.

December 15, 1984

—translated by Jerome Kohl

NOTES

1. All pitches here refer to a tuning-A of 440 Hz (and not 442 Hz, as I originally intended because of the tuning of the flute).