INSTITUTE OF SONOLOGY

Royal Conservatoire The Hague

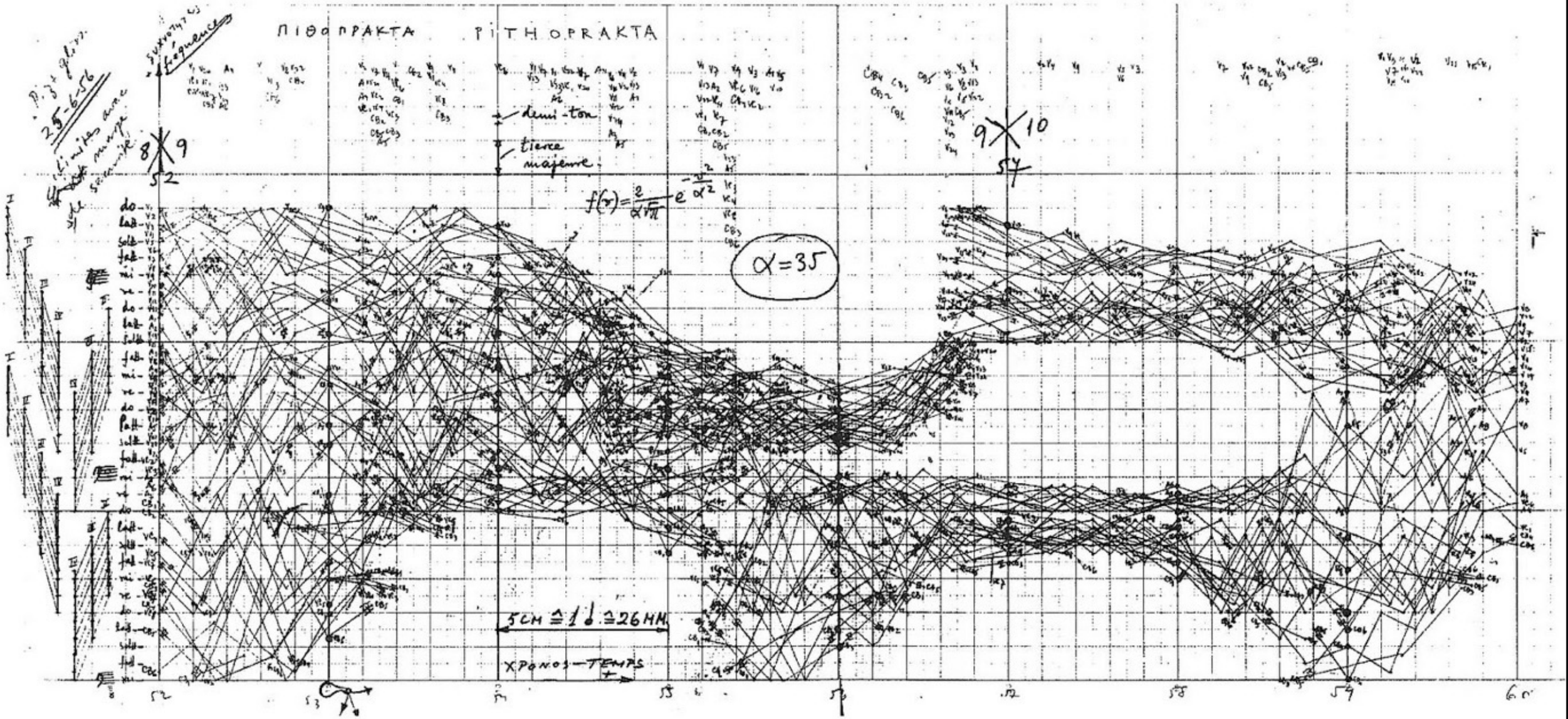
Xenakis

Composing with Algorithms

http://www.bjarni-gunnarsson.net

Pithoprakta (1955-56), mesures 52-59 : graphique de Xenakis

Source : Iannis Xenakis, *Musique. Architecture*, Tournai, Casterman, 1976, p. 167



"The main thing is: how to change. This is a matter of music, of knowledge, of the universe. Everywhere you feel the changes. The plants are changing, maybe not so fast as the human mind. They're changing slowly, as the particles do. Probably these particles are changing in the universe on a much larger scale of time. We know at least through astrophysics today that some of them are really mid-life, like the heavy ones. They did not exist at the beginning, and the lighter ones did not exist at the very beginning. So if even the matter itself is changing, everything is changing."

(Xenakis, 1986)

"In musical composition, construction must stem from originality which can be defined in extreme (perhaps inhuman) cases as the creation of new rules or laws, as far as possible; as far as possible meaning original, not yet known or even forseeable, construct laws therefore from nothing."

(Xenakis, 1992)

Xenakis

Worked for Le Corbusier's as an ***engineer*** and attended composition classes of Messiaen.

Composed instrumental pieces using ***stochastic laws*** and mathematics.

An important influence on the development of electronic and computer music.

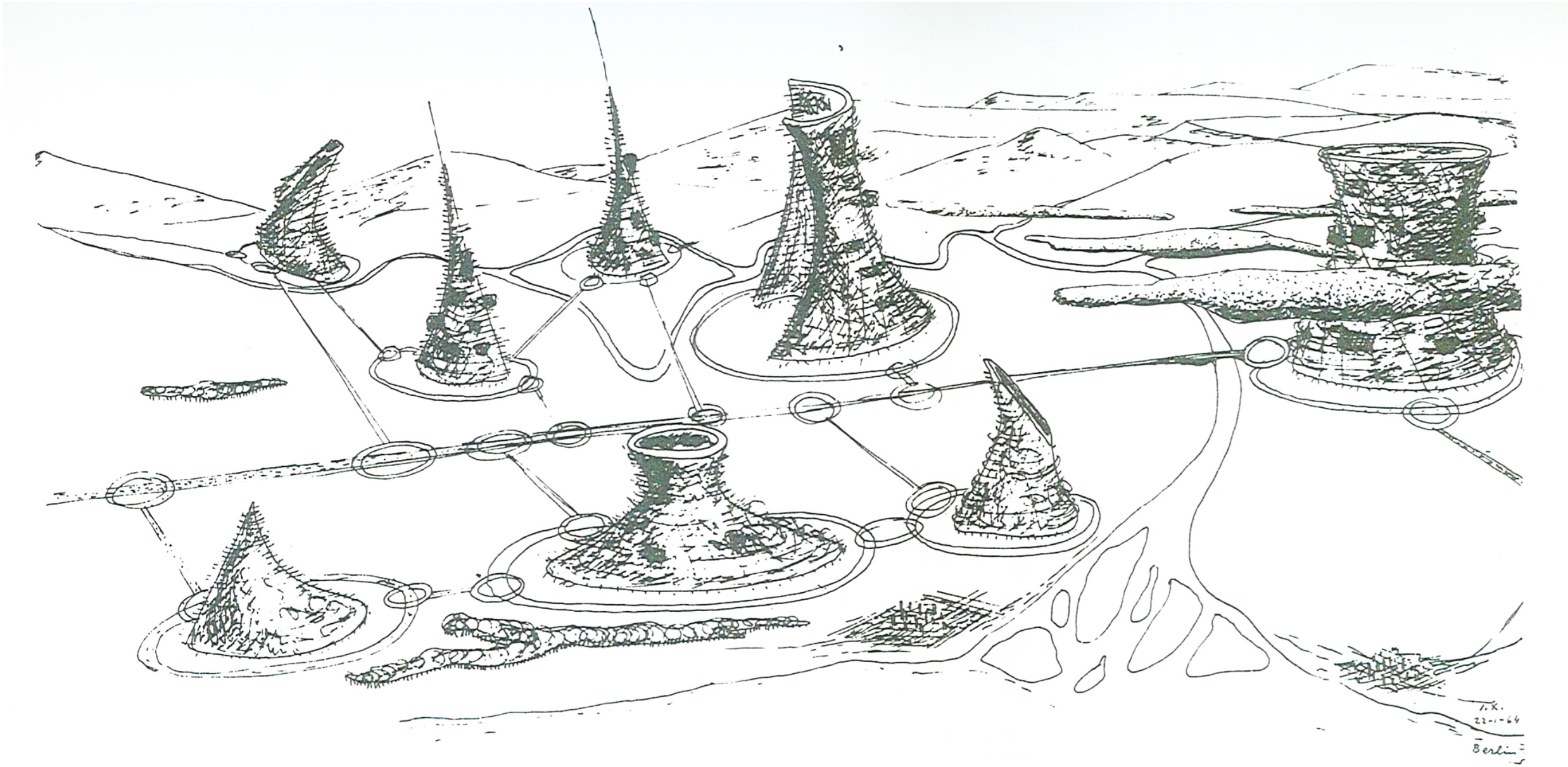
Xenakis

Pioneered ***granular*** and ***non-standard*** synthesis.

Developed computer programs for musical composition.

Catalogue of musical works contains more than 150 pieces.

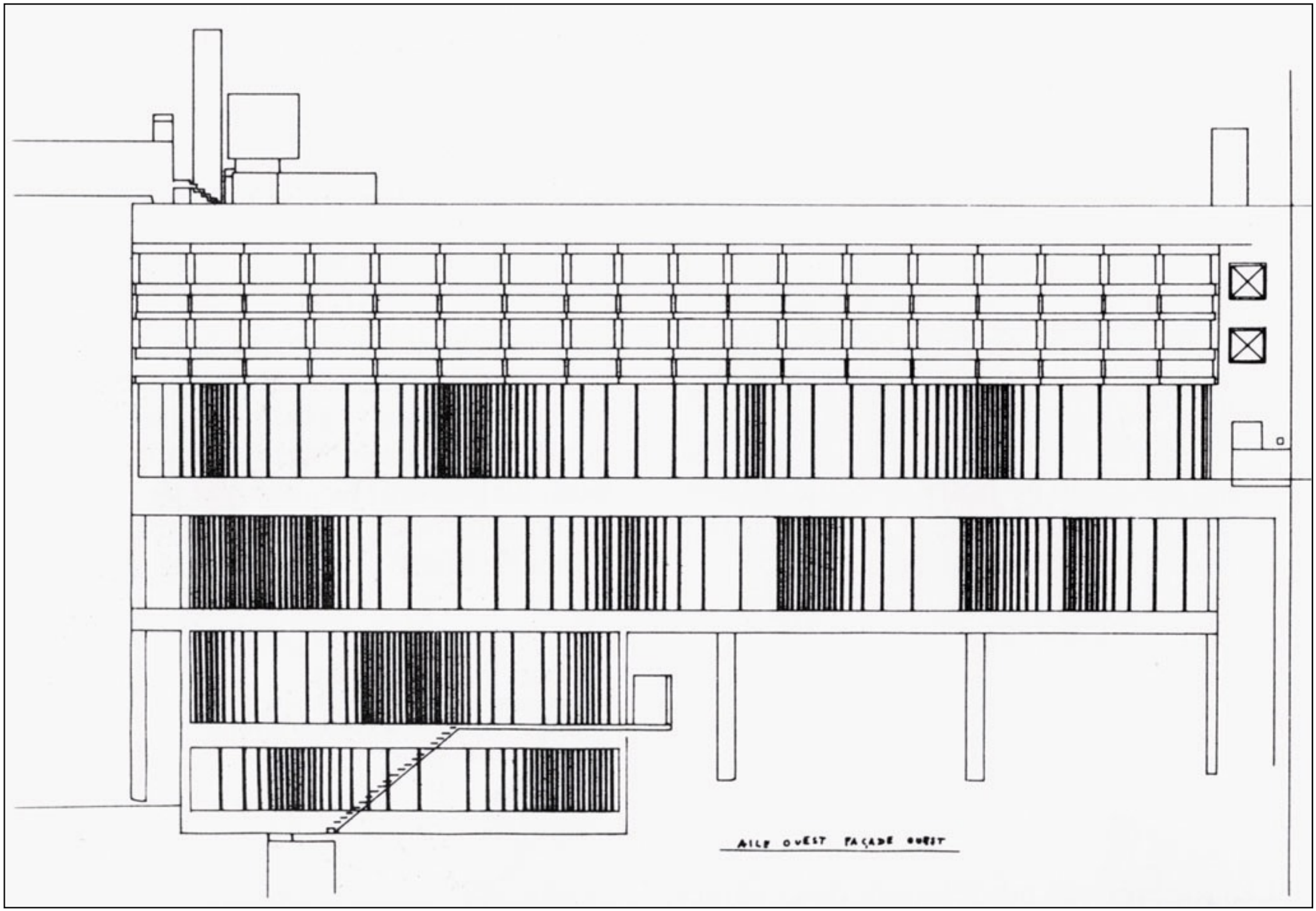
La Ville Cosmique



VILLES COSMIQUES

Groupe de villes cosmiques pouvant remplacer avantageusement l'océan des agglomérations répandues depuis Boston jusqu'à Washington en passant par New York et totalisant 25 millions d'habitants.

La Tourette



Metastaseis (1954)

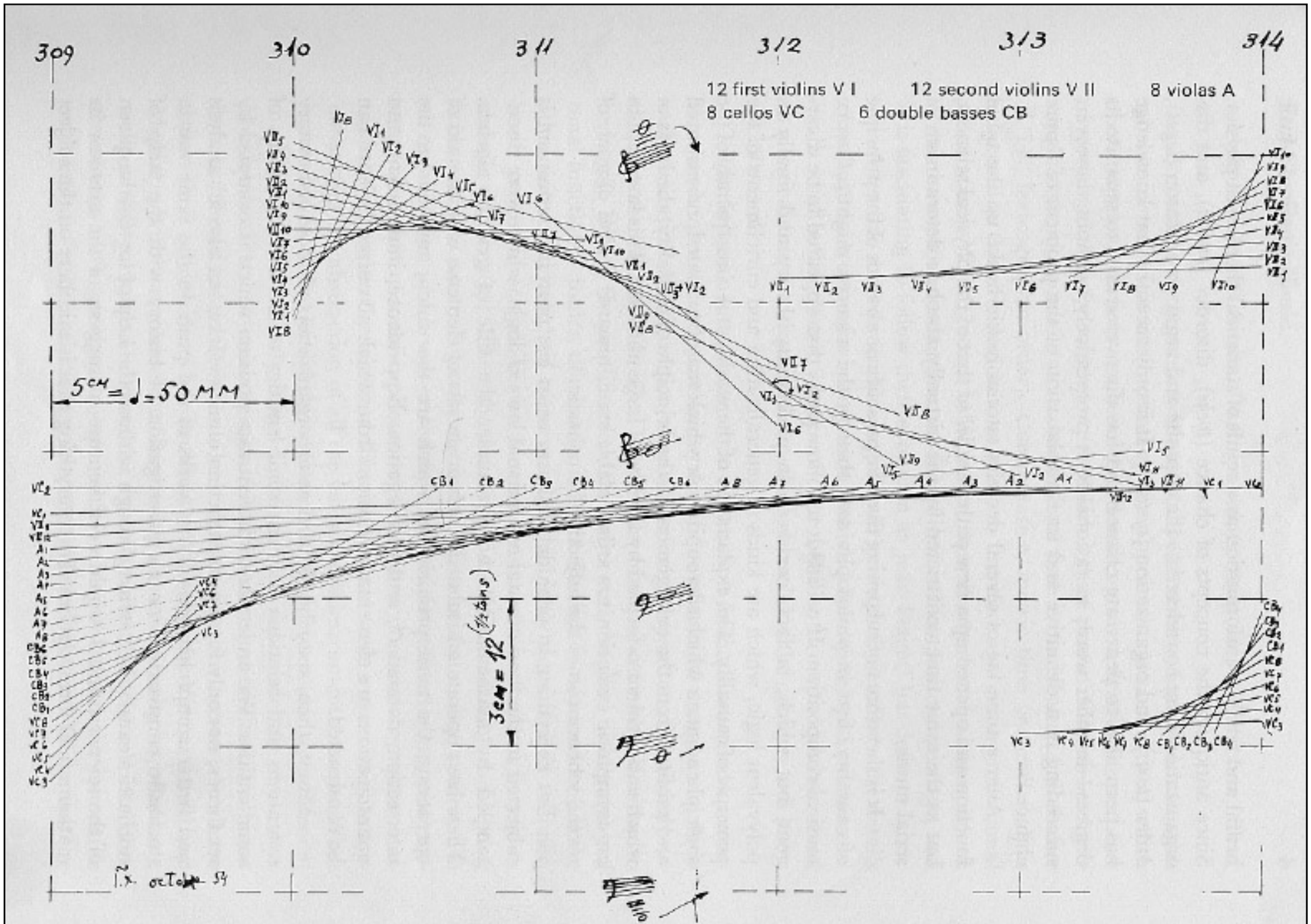


Fig. I–2. String Glissandi, Bars 309–14 of *Metastasis*

Metastaseis

Meta (*"after, beyond"*) ***-stasis*** ("*immobility*"), the relationship between movement, or change, and nondirectionality, or standstill.

For the audience at its 1955 premiere in Donaueschingen, it was as if they were hearing *"atomic music"* from *"the first traveller in space"*.

Introduced the notion of architectural or global sonorities, where ***massed glissandi,*** for example, create a sonic entity that can only be perceived as a whole and not as a product of smaller elements.

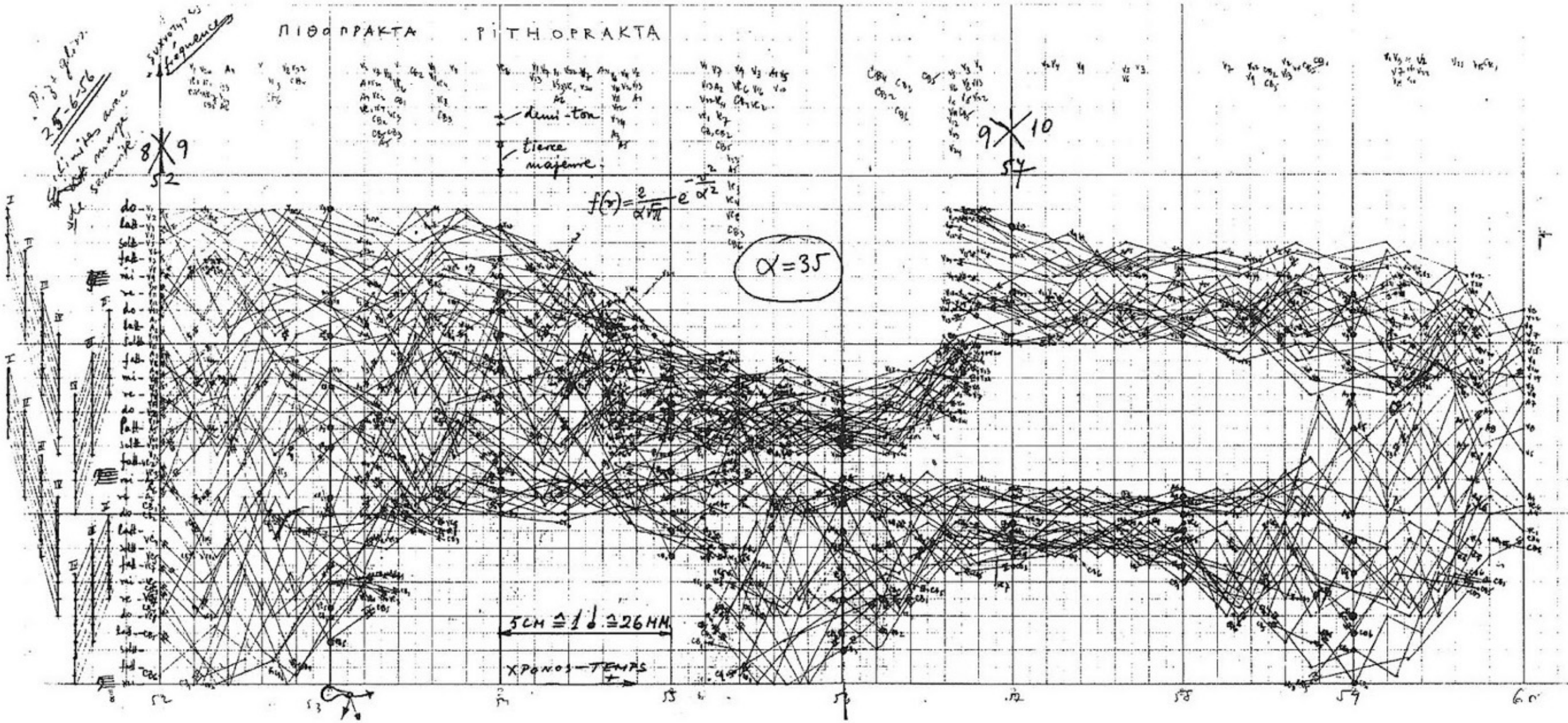
Led to a statistical conception of complex sonorities, resulting in what he would eventually call "***stochastic***" music.

(Harley)

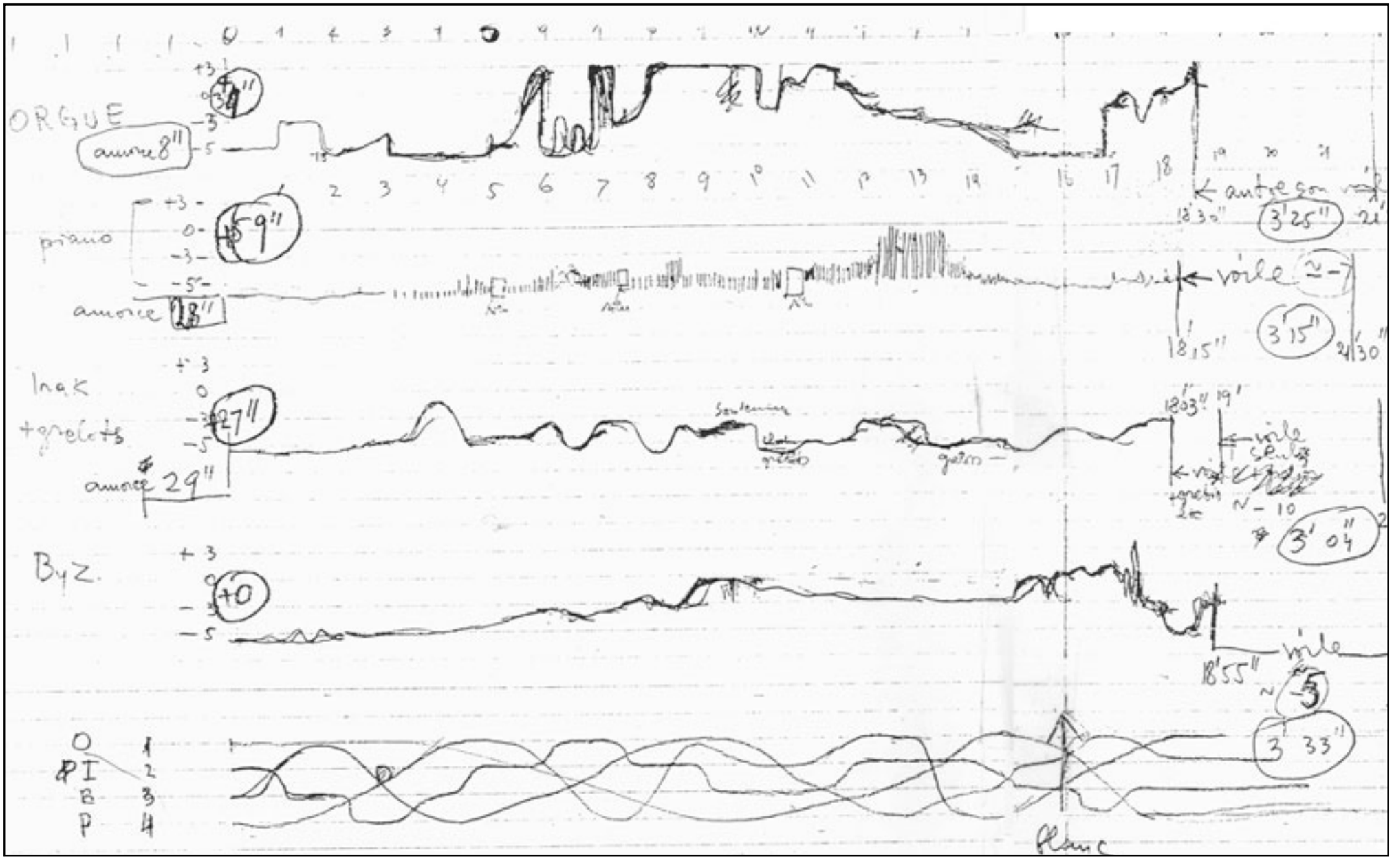
Pithoprakta (1956)

Pithoprakta (1955-56), mesures 52-59 : graphique de Xenakis

Source : Iannis Xenakis, *Musique. Architecture*, Tournai, Casterman, 1976, p. 167



Bohor (1962)



Bohor (1962)

"Xenakis's composition Bohor (1962) deploys the sounds of a Laotian mouth organ (slowed down greatly), small crotale bells, and hammerings on the inside of a piano to create a hypnotic and monumental sound mass. The last two minutes consist of sheets of broadband noise, which provoked a reaction at a Paris concert: "By the end of the piece, some were affected by the high sound level to the point of screaming; others were standing and cheering. "Seventy-five percent of the people loved it and twenty- five percent hated it," estimated the composer from his own private survey following the performance."

(Curtis Roads)

Achorripsis (1957)

Greek for *"jets of sound"*.

Consists of twenty-eight short sections, each one lasting for 15 seconds.

Seven ***sonic entities*** (Flute, Oboe, Strings Glissando, Percussion, String Pizzicato, Brass and Strings Arco) are used.

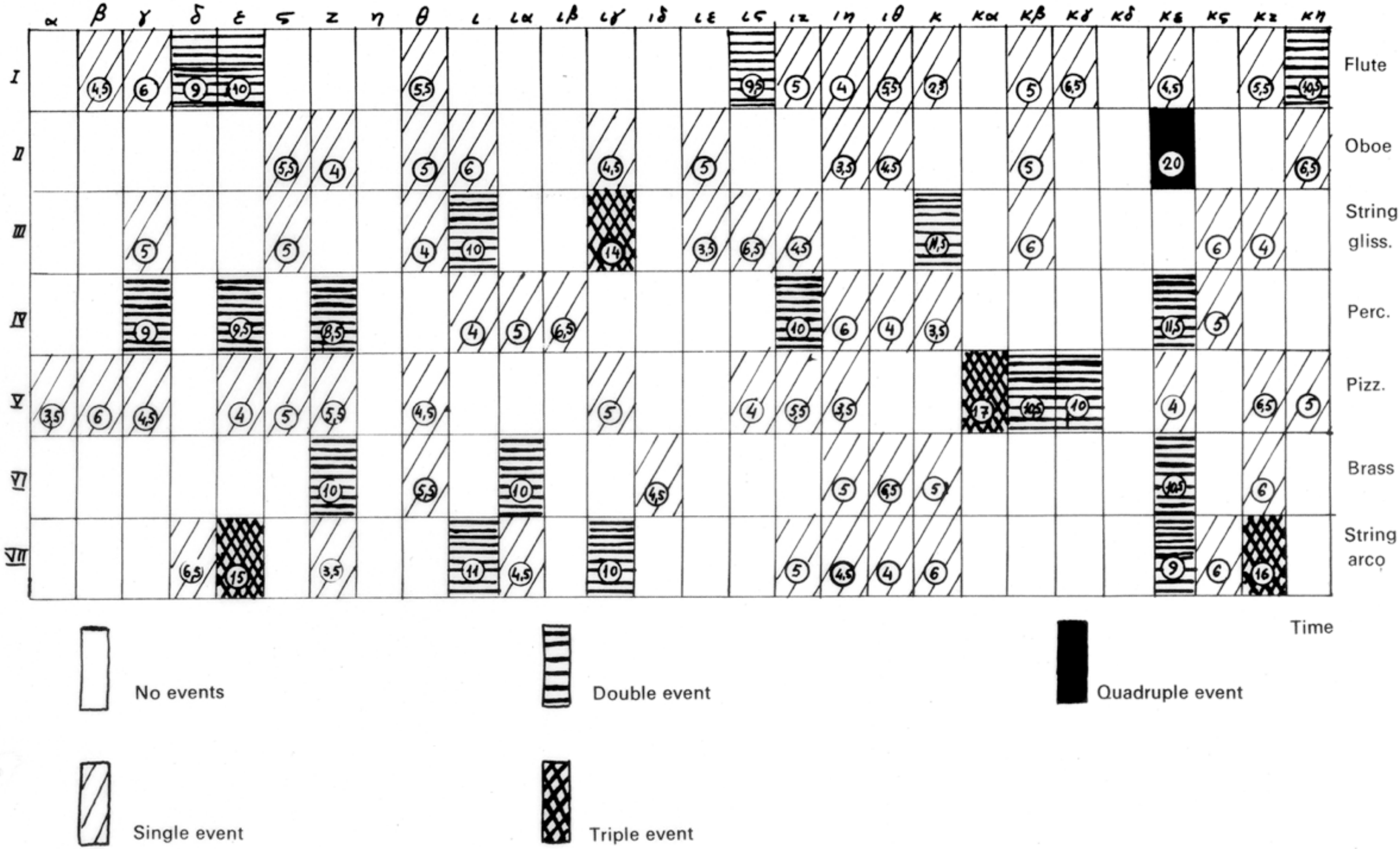
Achorripsis (1957)

Five levels of ***density*** are generated according using a Poisson distribution.

Pitches, durations, successions, dynamics and glissando within a section are also calculated using ***probabilities***.

A ***probability matrix*** was used for the distribution of timbres and densities.

Achorripsis (1957)



Qualifications

Achorripsis (1957)

"Let us now imagine music composed with aid of matrix [of probabilities] (M). An observer who perceived the frequencies of events of the musical sample would deduce a distribution due to chance and following the laws of probability. Now the question is, when heard a number of times, will this music keep its surprise effect? Will it not change into a set of foreseeable phenomena through the existence of memory, despite the fact that the law of frequencies has been derived from the laws of chance?"

Achorripsis (1957)

"In fact, the data will appear aleatory only at the first hearing. Then, during successive rehearings the relations between the events of the sample ordained by "chance" will form a network, which will take on a definite meaning in the mind of the listener, and will initiate a special "logic," a newcohesion capable of satisfying his intellect as well as his aesthetic sense; that is, if the artist has acertain flair. "

(Xenakis)

Fundamental phases

1. Initial conceptions,

2. Definition of the sonic entities,

3. Definition of the transformations,

4. Microcomposition,

5. Sequential programming of 3. and 4.,

6. Implementation of calculations,

7. Final symbolic result,

8. Sonic realization.

Achorripsis

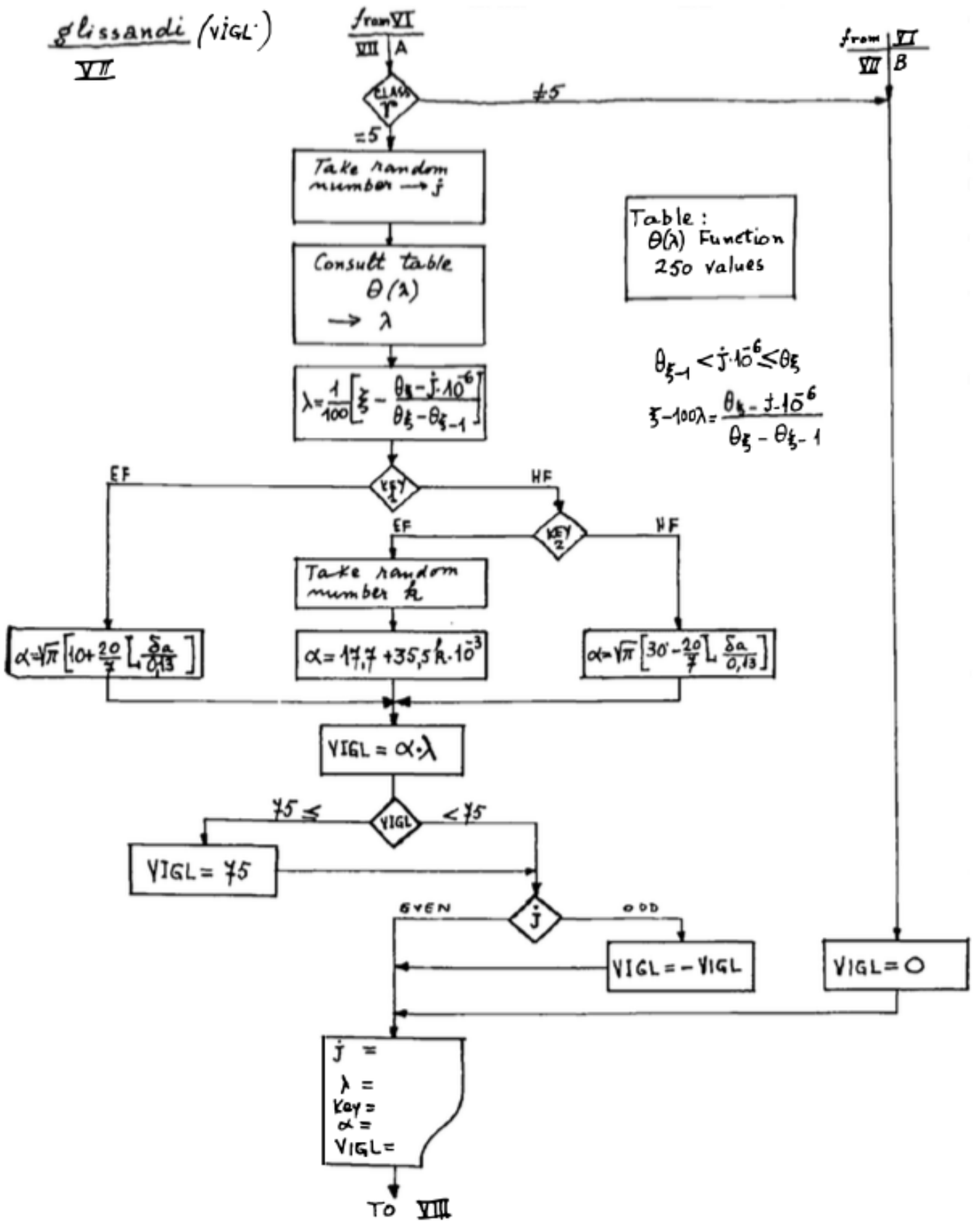


Fig. V–1. Excerpt from the First Flow Chart of *Achorripsis*

"A complex sound may be imagined as a multi-colored firework in which each point of light appears and instantaneously disappears against a black sky. But in this firework there would be such a quantity of points of light organized in such a way that their rapid and teeming succession would create forms and spirals, slowly unfolding, or conversely, brief explosions setting the whole sky aflame. A line of light would be created by a sufficiently large multitude of points appearing and disappearing instantaneously."

Formalized Music

ANALOGIQUE A ET B (1958-59)

Granular: "All sound is an integration of grains, of elementary sonic particles, of sonic quanta"

Analogique A, for orchestra and was composed using stochastical methods

Analogique B, hundreds of splices of tiny fragments of magnetic tape.

ANALOGIQUE A ET B (1958-59)

Markovian Stochastic Music, two chapters of Musiques Formelles are dedicated to the piece

One of Xenakis' most thoroughly formalized compositions.

Considered by many as a failure.

Xenakis - Analogique A + B (1958-59)

ST Pieces

Possible realizations of a particular ***compositional model***.

The ST (Stochastic Music) program generated data in text format which Xenakis later ***transcribed*** to musical notation.

ST ***parameters***: attack time, instrument class, instrument, pitch, duration, dynamics, and glissandi.

ST Pieces

ST/10-1 080262. ST stands for "stochastics," "10" for instrumental groups, "1" for version and the last digits for the realization date.

Density was important, and defined as the average number of events (note onsets) within a section.

IBM 7090

ST Pieces

Quantization of attack times produces a rhythmic structure with a subdivision of a half note into 3, 4, 5, and 6 parts.

A piece contains a number of sequences or movements where the durations of the movements are independent.

Each ***section*** has a fixed mean density with a lower limit at 0.11 onsets per second and the upper limit around 50 sounds per second.

ST Pieces

Instruments divided into classes of timbres based on different ***articulations in playing***, i.e., pizzicato, col legno, tremolo, and glissando.

Pitch was expressed as a floating-point number between 0 and 85. ***Duration*** was also expressed as a fractional number, and ***dynamics*** were represented by integers on a scale of 0–60.

ST Algorithm

1. The work consists of a succession of sequences or movements each ai seconds long.

2. Definition of the mean density of the sounds during ai.

3. Composition Q of the orchestra (from r classes of timbres) during sequence ai.

4. Definition of the moment of occurrence of the sound N within the sequence ai.

5. Attribution to the above sound of an instrument belonging to orchestra Q.

ST Algorithm

6. Attribution of a pitch as a function of the instrument.

7. Attribution of a glissando speed if class r is characterized as a glissando.

8. Attribution of a duration x to the sounds emitted.

9. Attribution of dynamic forms to the sounds emitted.

10. The same operations are begun again for each sound of the cluster N ai.

11. Recalculations of the same sort are made for the other sequences.

Interpretation

Xenakis ***changed, edited, arranged***, and ***inserted*** material into the literal results of the program.

Nouritza Matossian: "*he used seventy-five per cent computer material, composing the remainder himself.*"

Did not see the pieces as test pieces but the rather that the program was a ***generator*** of musical material.

One ***run*** of the program could result in several pieces.

"Freed from tedious calculations the composer is able to devote himself to the general problems that the new musical form poses and to explore the nooks and crannies of this form while modifying the values of the input data. For example, he may test all instrumental combinations from soloists to chamber orchestras, to large orchestras. With the aid of electronic computers the composer becomes a sort of pilot: he presses the buttons, introduces coordinates, and supervises the controls of a cosmic vessel sailing in the space of sound, across sonic constellations and galaxies that he could formerly glimpse only as a distant dream."

(Xenakis)

Xenakis - Atrées (ST/10, 3-060962), 1956-62

Outside-time

"A given pitch-scale is an outside-time architecture, for no horizontal or vertical combination of its elements can alter it. The event itself, that is, its actual occurrence, belongs to the temporal category. Finally, a melody or a chord on a given scale is produced by relating the outside-time category to the temporal category. Both are realizations in-time of outside-time constructions."

"What will count will be the abstract relations within the event or between several events, and the logical operations which may be imposed on them"

(Xenakis)

Outside-time

"For instance, the scale of white keys on the piano has a structure of intervals; this structure is an outside-of-time structure.Now you can produce good or bad music, of course, but it's interesting to see that this white key structure is something independent of the melody, or the tonality, or modal music, or serial music, and so on.That's very important."

"Serial music is a typical in-time structure.The relationship of the notes in the twelve-tone scale is one of the simplest outside-of-time structures because you are repeating exactly the same chromatic interval creating the twelve tones. […] So any serial string of notes is something which is in-time, not outside-of-time."

(Xenakis)

"In architecture, what is more important than the material itself? Like the Taj Mahal – which was made with marble and things like that, very expensive material – I don't think it's a very important architectural piece. There are other things that are done with cheaper materials. They are much more interesting. Why? Because in architecture [it] is the problem of shapes, of proportions and the sizes, of course. These are features, kind of abstract, much more than the material itself. And if the proportions are OK, then this enlightens the materials; they become much more important, interesting. If not, then you might add gold or whatever and fail anyway. In music, I think it's the same thing; it's the same problem."

(Xenakis)

Issues

Stochos / Goal

Causality / Logic

Determinism / Indeterminism

Speed / Movement

Gravity / Time

(Gerard Pape)

Xenakis

CCMIX interview (min 3.08)

Composing Sound

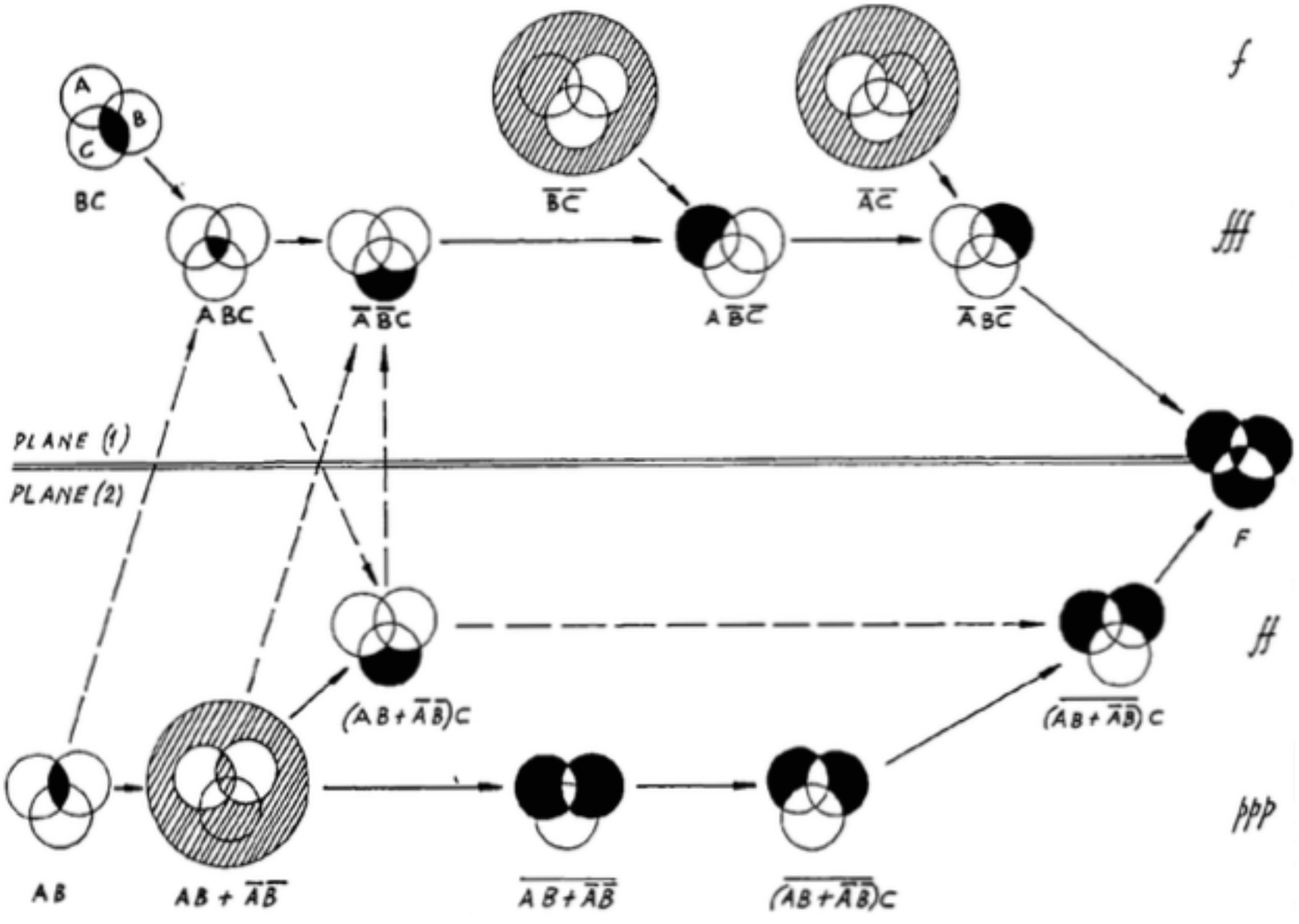
Sound is not treated as the starting point of composition, but as its ***outcome***.

"Xenakis often composed with graphs, at least until the end of the 1970s. Many of the sonorities, with which he was the first to experiment and which make his music so original, have been conceived thanks to graphs."

Defines three important Xenakian "sonorities"

1. Masses of short sounds
2. Glissandi
3. Sustained sounds

Symbolic Music



Screens

Fig. II–14

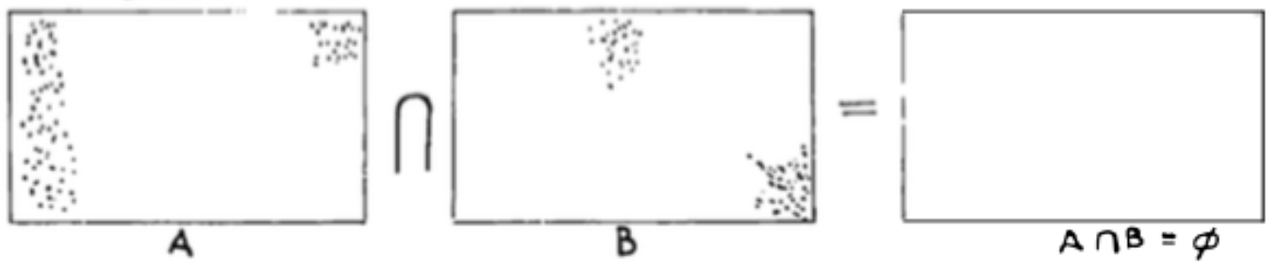


Fig. II–15

Fig. II–16

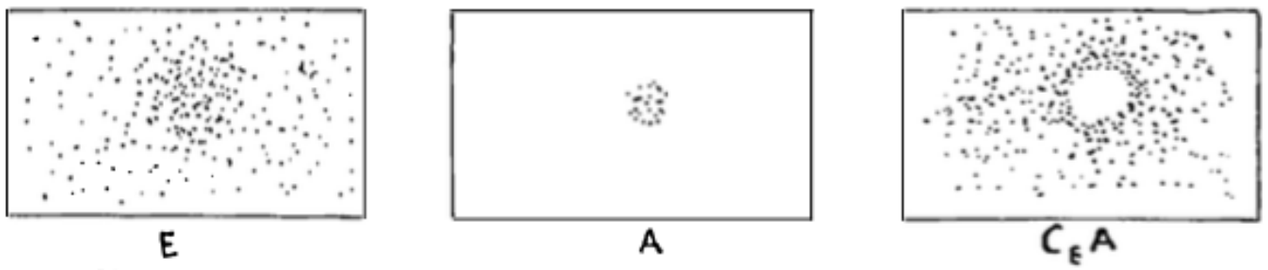


Fig. II–17

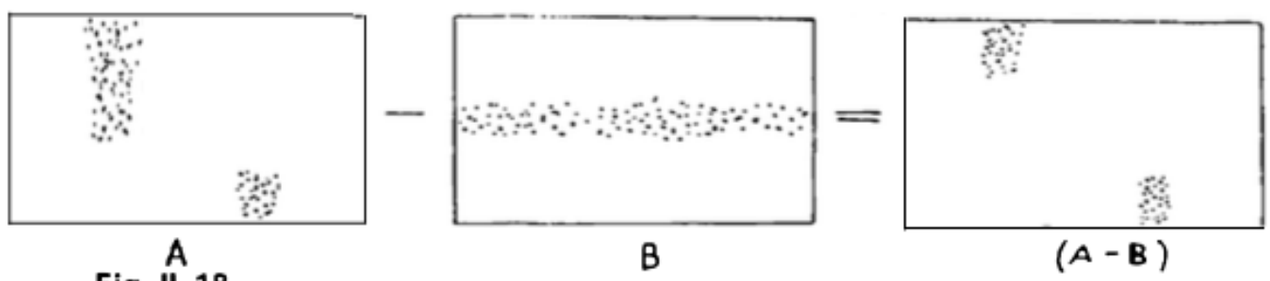


Fig. II–18

Brownian Motion

Brownian motion, a mathematical model originally developed to describe random movement of particles suspended in gas or liquids.

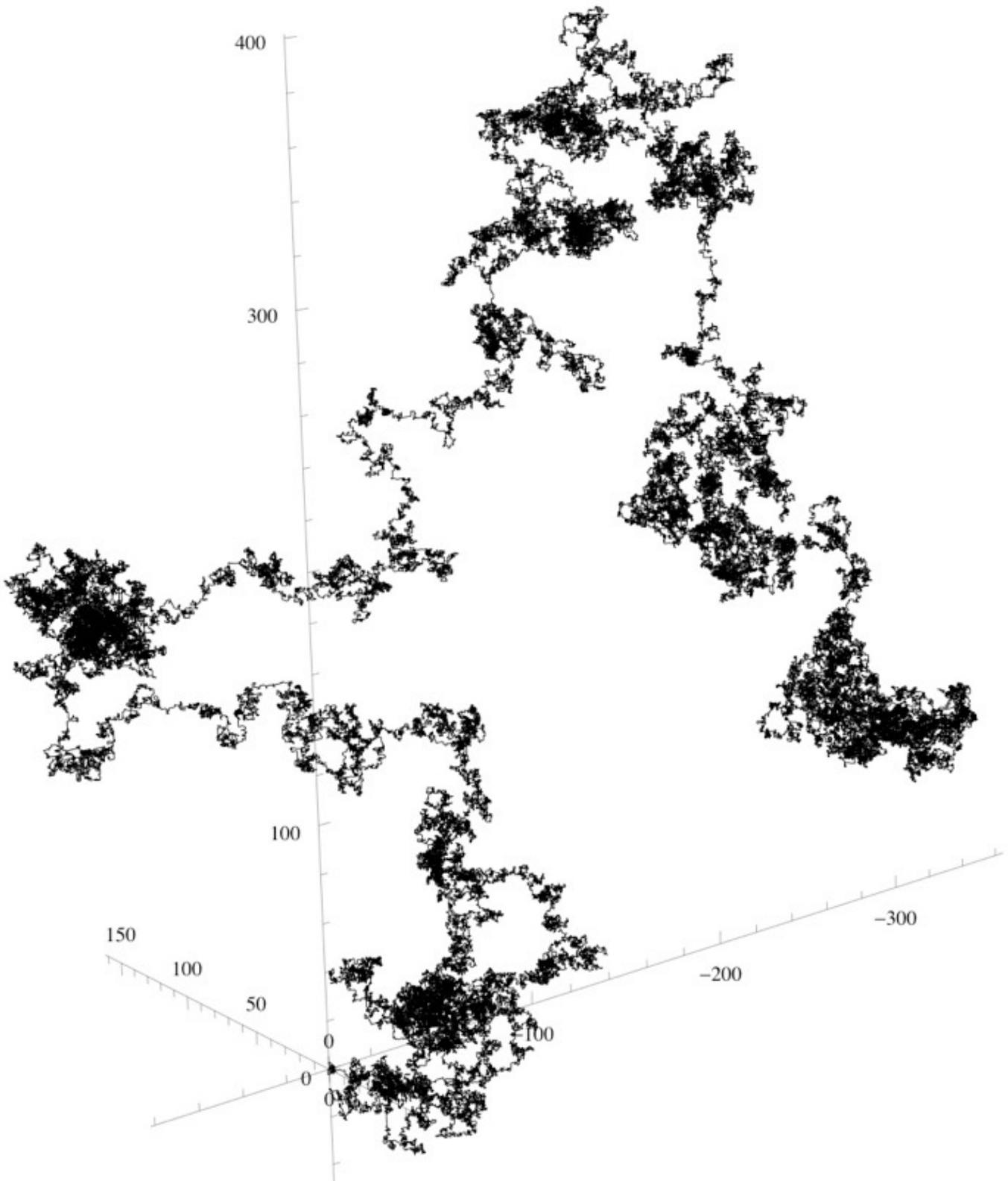
Inspired Xenakis as a generating concept in Pithoprakta.

Brownian Motion

Brownian motion is often modeled with the drunken walk or ***random walk*** analogy. Imagine a drunkard walking in a city, resulting in a series of steps, each of which goes in a random direction.

Xenakis used random walks pieces such as Cendrées, Jonchaies, Tetras, N'Shima and Mikka. It was also used for stochastic sound synthesis in pieces such as La Légende d'Eer, S.709 and Gendy3.

Random Walk



Xenakis - Mikka, (1971)

Stochastic Functions

Stochastics

"... I originated in 1954 a music constructed from the principle of indeterminism; two years later I named it 'Stochastic Music.' The laws of the calculus of probabilities entered composition through musical necessity."

"*These laws ... are veritable diamonds of contemporary thought.They govern the laws of the advent of being and becoming. However, it must be well understood that they are not an end in themselves, but marvelous tools of construction and logical lifelines.*"

(Xenakis)

Stochastics

Probabilities to control the movements of elements where the composer invents schemes and explore the limits of different distributions.

'Stochastics' studies and formulates the law of large numbers, the laws of rare events, the different aleatory procedures, etc.

Probabilities in Composition

1. *"We can control continuous transformations of large sets of granular and/or continuous sounds.*
2. *A transformation may be explosive when deviations from the mean suddenly become exceptional.*
3. *We can likewise confront highly improbably events with average events.*
4. *Very rarified sonic atmospheres may be fashioned and controlled with the aid of formulae such as Poisson's. Thus, even music for a solo instrument can be composed with stochastic methods."*

(Xenakis)

Stochastic Music

"In fact, the data will appear aleatory only at the first hearing. Then, during successive rehearings the relations between the events of the sample ordained by 'chance' will form a network, which will take on a definite meaning in the mind of the listener, and will initiate a special 'logic,' a new cohesion capable of satisfying his intellect as well as his aesthetic sense, that is, if the artist has a certain flair."

(Xenakis)

Stochastic Music

"But other paths also led to the same stochastic crossroads: natural events such as the collision of hail or rain with hard surfaces the song of cicadas in a summer field a political crowd of dozens or hundreds of thousands of people...It is an event of great power and beauty in its ferocity. Then the impact between the demonstrators and the enemy occurs. ...Imagine, in addition, the reports of dozens of machine guns and the whistle of bullets adding their punctuations to the total disorder. The crowd is then rapidly dispersed, and after sonic and visual hell follows a detonating calm, full of despair, dust, and death."

(Xenakis)

Exercises

```
(
NF(\iop, {|freq=78, mul=1.0, add=0.0|
    var noise = LFNoise1.ar(0.001).range(freq, freq + (freq * 0.1));
    var osc = SinOsc.ar([noise, noise * 1.04, noise * 1.02, noise * 1.08],0,0.2);
    var out = DFM1.ar(osc,freq*4,SinOsc.kr(0.01).range(0.92,1.05),1,0,0.005,0.7);
    HPF.ar(out, 40)
}).play;
)

(
NF(\dsc, {|freq = 1080|
    HPF.ar(
        BBandStop.ar(Saw.ar(LFNoise1.ar([19,12]).range(freq,freq*2), 0.2).excess(
        SinOsc.ar( [freq + 6, freq + 4, freq + 2, freq + 8])),
        LFNoise1.ar([12,14,10]).range(100,900),
        SinOsc.ar(20).range(9,11)
    ), 80)
    ;
}).play;
)
```

```
var <>pindex, <>cindex;

initialize {
    if(pindex.isNil, { pindex = 1000 });
    if(cindex.isNil, { cindex = 2000 });
}

clearProcessSlots {
    pindex = 1000;
    (this.pindex - 1000).do{|i| this[this.pindex+i] = nil; }
}

clearOrInit {|clear=true|
    if(clear == true, { this.clearProcessSlots() }, { this.initialize() });
}

transform {|process, index|
    if(index.isNil && pindex.isNil, {
        this.initialize();
    });

    pindex = pindex + 1;
    this[pindex] = \filter -> process;
}

control {|process, index|
    var i = index;

    if(i.isNil, {
        this.initialize();
        cindex = cindex + 1;
        i = cindex;
    });

    this[i] = \pset -> process;
}
```

```
(
NF(\depfm, {|freqMin=5, freqMax=20, mul=20, add=80, rate=0.5, modFreq=2100, index=0.3, amp=0.2|
    var trig, seq, freq;
    trig = Dust.kr(rate);
    seq = Diwhite(freqMin, freqMax, inf).midicps;
    freq = Demand.kr(trig, 0, seq);
    HPF.ar(PMOsc.ar(LFCub.kr([freq, freq/2, freq/3, freq/4], 0, mul, add),
    LFNoise1.ar(0.3).range(modFreq,modFreq*2), index) * amp, 50)
}).play;
)
```

Exercises

1. Implement a stochastic process that uses a different distribution for amplitude, frequency and duration of events.

2. Implement a stochastic process where the high and low limits of a distribution change in time. They should start by being very wide (far apart) but narrow as the process unfolds.

3. Implement a stochastic process where sequences of different distributions are used.

4. Implement a rhythmic sequence where a Markov chain is used for duration values.

Exercises

5. Implement a sequence of Pbinds where each uses a brownain motion (Pbrown) for controlling pitches in different ways. These Pbinds should then be sequences in time using Pspawner.