Prefatory Remarks

*Formalized Music: Thought and Mathematics in Composition* by Iannis Xenakis is probably the best available source for the complete understanding of this composer's original theories, methods, and ideas about the interrelationship of music, philosophy, architecture, and other arts. Due to the high degree of technical and mathematical skill required to fully comprehend his treatise, Xenakis' reading public has necessarily been limited to a select few. The purpose of this brief introduction, therefore, is to provide a relatively non-technical explanation of the book's basic concepts as a guide for music students and others interested in Xenakis' theories. The interview with Xenakis which follows this introduction explores certain important points of his work in greater depth.

In the first chapter of *Formalized Music*, Xenakis shows how his composition, *Metastasis*, formed the basis for his design of the Philips Pavilion at the Brussels World's Fair in 1958, and discusses at length the use of calculus and probability theory in music. Since the use of calculus and probability theory in music involves rare, random events, he calls it "free stochastic music". More specifically, in generalizing Bernoulli's law of large numbers (e.g., the more one tosses a coin the closer will the heads/tails ratio approach 1) the Poisson process is defined, providing the probability of discrete events in a discrete interval of time. Applying the exponential formula (which is another function parent to the Gaussian distribution) yields the amount of time, or interval, between successive discrete events in a continuous interval (i.e., from zero until the first event). An "event" can be a cloud of sounds with a particular density in sounds/seconds.

Xenakis then demonstrates how a sound can be defined by a certain
number of “screens” (a grid defined by frequency and intensity), so that if a sound is sliced at a given instant \((t)\), a screen is generated. Each screen is then denoted by a symbol; a transition occurs in going from one screen to another, and a collection of transitions forms a transformation, represented by a table or matrix. Eventually a stochastic mechanism is derived in which alternative probabilities of various transformations (represented by a number between 0 and 1) replace the original probabilities of transition, indicated by 0 and 1. This sequence of transition, or the specific order of screens, is called a Markov chain.

Each Matrix of Transition Probabilities (MTP)—or stochastic matrix—governs the change of states in the pure mathematical sense, and can then be coupled with other matrices, e.g., frequency, intensity, etc. Also, from an MTP a state of stability can be calculated and a mean entropy defined, enabling the composer to identify the degree of ataxy (order or disorder) with a set of screens. In applying stochastic mechanisms, Xenakis uses matrices of transition probabilities for three characteristics of sound—frequency \((f)\), intensity \((g)\), and density \((d)\)—thereby decreasing the probability that the composition will rest in one particular state and increasing the probability that it will change states, allowing, therefore, for a higher degree of movement and variety in the composition. All three variables of the screen are then placed together, or interact, forming a new MTP, as a scheme or sequence of the partial mechanisms of screens. The system can now quickly arrive at a final state of equilibrium known as the stationary distribution, or proceed to disequilibrium with the imposed aid of perturbations \((P)\).

The mathematical theory of games as applied by Xenakis in two specific compositions, *Duel* and *Strategie*, is defined as a *two-person zero-sum game*, in which one player’s gain is equal to the other’s loss, so that the sum of the payoffs to all players (positive for winnings and negative for losses) is zero. Each game is developed through the use of qualitative matrices and linear programming—a method for determining unknowns so as to maximize or minimize a linear expression, subject to linear inequalities or constraints—and strict rules for the conductor. Although games are not new in music, their conceptualization, based on modern science, enables one to take advantage of some light-hearted diversion.

Realizing that the computer is a valuable instrument for composition because of its iterative facility, Xenakis sets up a flow chart in a sequential series of reiterated operations, following a scheme of minimum
constraints in composition, i.e., the ST program (FORTRAN IV). The first three steps in the ST program determine the length of a sequence, its density (number of sounds per second), and the composition of the orchestra, stochastically conceived, i.e. timbre classes and instruments (conditioned by density) for each pitch. Given the preceding general characteristics of the sequence, the computer is programmed to follow the next series of steps for each pitch that was calculated to be in the sequence an innate number of times. Steps four–six define the attack time, the specific instrument from the range of instruments made available for this sequence, and the pitch. Steps seven–nine determine whether a tone will be a glissando and what speed it will have, its duration in seconds, and its intensity. At step ten, we return to step four (attack time of the second pitch, etc.), continuing with each increment (of pitches) until the total number of pitches for the sequence is reached. Finally, if this number has not been reached, since the total number of sequences desired has been specified, the computer is programmed to go back to step one and determine the characteristics for the second sequence. This procedure continues until the total number of sequences indicated by the original input data is reached, thereby ending the program.

Xenakis also attempts to describe sonic events through the use of two unique branches of pure mathematics: (a) set theory, i.e., Boolean algebra or the algebra of logic and (b) vector analysis. Vector analysis is used because it involves both a magnitude and a direction in space and can be considered simply as a directed line segment without any real physical significance. Set theory, on the other hand, can easily demonstrate the existence of a stochastic correspondence between the components of outside-time structures such as pitch, and the stochastically conceived moments of occurrence that have a structure in-time.

Finally, Xenakis has also evolved what may be called “the sieve theory” which is, first of all, an outside-time structure that allows any series, e.g., a scale or series of pitches, to be expressed mathematically in terms of logical functions. The introduction of an elementary displacement creates a sieve that allows only certain elements of the continuum—in this case, pitches—to pass through. This technique not only lends itself to “total order”, but is completely mechanizable, enabling widespread exploration in the future with the aid of computers and modern technology.

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MZ: In a critique on your book *Formalized Music*, one writer states: “The mathematics involved in the book seems often superfluous to the discussion.” I wonder what you think about that.

IX: I don’t know what he means by that. There are many possible explanations, either that he knows the mathematics too well so that it is not necessary to explain them, or that they are obviously not needed . . . they are not relevant to the music itself.

MZ: He also stated: “That probability theory can be used effectively to create music is thus a proven fact. That music not so composed can be properly understood as possessing only an atemporal combinatory content is less clear.”

IX: Yes, I think that he didn’t understand what I mean by atemporal, that is, outside-of-time structures. 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. I don’t think he understood that.

MZ: In his book, *Xenakis: The Man and His Music*, Mario Bois quotes you as saying: “I knew a great deal about ancient architecture . . . Le Corbusier, on the contrary, opened my eyes to a new kind of architecture. . . This was a most important revelation. . . Instead of boring myself with more calculations, I discovered points of common interest with music (which remained, in spite of all, my sole aim).” Could you explain what new kind of architecture you discovered to have common elements with music?

IX: I think there is a mistake in the translation, but I can tell you the following. In modern architecture there are materials like concrete, glass, steel, in comparison with the nineteenth century which used bricks, stone, and wood. The next important innovation of modern architecture was the simplification of geometric elements like planes, straight lines, and right angles. This was the cubic kind of architecture, introduced in the beginning of the twentieth century, in order to compensate for the lack of interest in the simplicity of design. Then new proportions were introduced—the game of proportions—utilizing light, especially the play of light, the
use of light, the type of light, and so on. The third problem was the function of the structure, its use. When you have a house, it must be as Le Corbusier used to say, a *machine habitée*, a machine to live in. That means that you have to standardize them. How many steps must you make from the kitchen, and so on.

**MZ:** It has to be functional.

**IX:** Yes, so that you don’t waste time. It’s an organic entity. The next thing is the macroscopic shaping of the building. I was disturbed by problems in music composition, and I was thinking about all these macrostructures, that is, the sound itself, the melodic patterns of sound material, which sound material. The architecture of these microstructures, that is, the composition itself on a larger scale, the use, the necessity, these were the problems that were plaguing me, so that a parallel search by Le Corbusier was for me very enlightening.

**MZ:** Could you go one step further and give an example of something specific that you learned from architecture that you could apply, or were those discoveries just general, basic concepts?

**IX:** No, this is a rather basic parallel. The other interesting thing was that the converse applied, that is, from my musical problems, I could design architecture.

**MZ:** That was clear from the first chapter of your book.

**IX:** Yes, but directly from architecture into music, there is perhaps one factor. You see, musicians are taught in the schools to start with cells, that is, melodic patterns, a theme, essentially a melodic theme. All polyphonic music and all serial music is based on a string of notes. Then they expand it by inversions and other polyphonic harmonic, and orchestral manipulations. Now this is going from the detail to the large body, you see. In architecture, you must first take the large body into consideration and only then go to details; or both ways simultaneously. However, in addition to that, you always have to think of the land, the full range, the full dimension.

**MZ:** You must have a perspective of the total end result while you’re working in the details.

**IX:** Absolutely. That perhaps is one of the most important examples of what architecture gave to me, that is, how to think of music, not only from
the detail to the generality, but conversely from the general things, that is the architectural things, to the details.

MZ: You also stated: “What I'm aiming at is... to feel things, think them and express them; that's all.” Why did you choose a mathematical approach? In other words, if one of your aims is to feel things and express them, can you feel mathematics?

IX: I think it is possible to feel mathematics. Let's take a very simple example, the problem of proportion. When you have two intervals of time, a long and a short one, you may proportion them so that the long one may be double that of the short one. The proportion is something that you can feel. You have to feel proportions—in music, in architecture, in art—wherever you use them or manipulate them. You cannot imagine them. And the same is true for larger, more complex theories. Of course, there are things that you don't care to feel. For instance, the solution of the second degree equation.

MZ: A little further on in the same book, you talk about sensibility in music: “Sensibility has no longer any conventions by which to express itself. It expresses itself by other means, and it is sensible since it does so express itself; besides, traditional means of expression change very quickly, just as fashion does. What appears to me to be more important as regards music itself, at any rate in mine, is its abstract nature, its combinatory aspect, in the sense of the ratio of its proportions.” Could you elaborate on composing with or without sentiment?

IX: Yes. When the artist works, he may think that he is composing with sensibility because he is attracted by some ideas or by some other things. That might be the starting point sometimes, but in the course of the work, the things start “living” and he's fighting with these things all the time, changing them and being changed by them, so the starting point of his feelings becomes very remote. What remains finally can be expressed in a much more abstract way because it's the result of this thought. Even if you can't see the abstraction immediately—for instance, with Renaissance paintings and all of the best paintings of mankind which you try to understand before extracting from them proportional relationships or colors, shapes and the relationships of these shapes. Finally, it's a kind of music of proportions. This is what you finally understand through the ages, because you have lost the immediate sensibility of that time. It is for this reason that we can appreciate the Japanese or Chinese paintings of thousands of years ago... of the Greeks, the Egyptians, the Africans, which are all remote. What remains, in fact, are these much more abstract considera-
tions rather than the immediate magic of the thing itself. This is the mean-
ing of what I said.

MZ: A little further on, while talking about the use of computers, you
say: "This language of the machine is universal, but I admit that it de-
mands a knowledge that musicians do not ordinarily possess." Since the
mathematical character of this music has frightened musicians and made
the approach especially difficult, how can we get that knowledge?

IX: By training, by learning it as you learn everything that is needed.
There are many things that musicians practice now that are without any
useful value, and, surprisingly, many of the studies that they’re doing today
still derive from the past tradition. One must replace them with other,
much more important things.

MZ: Could you give an example of one of those things?

IX: Well, for instance, it is absolutely insane to ask a musician to sight-
sing with a high degree of accuracy because it takes up so much of his
time and he finds that he ultimately may be deformed musically, in the
sense that, if he just studies the tempered scale, he’s unable to hear quar-
ter tones, third tones, etc.

MZ: In other words, you’re saying that we are forcing ourselves to do
things that are not really natural.

IX: Not only are they not natural, they are restrictive because they are
only one of the possibilities. If you want many possibilities, then you can-
not deal too much with each one. It’s much more important to have a
wider knowledge of these things than to be highly specialized, because
you lose the natural aspect. Besides that, it’s not necessary to learn many
of these things . . . I remember in my classes when I was studying music,
they asked me to do all sorts of exercises with harmony and counterpoint
that were eighteenth century and were codified only by the scholars and
not by the musicians themselves. It’s absolutely nonsense . . . instead of
studying the music itself, or improvising or composing freely. People are
blind to today’s situation. And what is today’s environment? It’s science,
mathematics, and technology. You can hold out your arm and touch it.
If you don’t know how to use it, you are like a man without arms and legs.

MZ: In program notes for your concerts, you cite Poisson’s law and sev-
eral algebraic equations. When asked your reason for doing this, you said:
“If the listener doesn’t understand any of it, it is first of all useful to show
him to himself as ignorant. To be unwilling to know them is... uncivilized." Isn't that attitude self-defeating in its arrogance? Doesn't that create more obstacles to the understanding and acceptance of your music? And doesn't it really depend on your perspective, meaning the listeners' perspective? In other words, background becomes extremely important—cultural, social and intellectual environment. You can't expect people with a limited background to be able to accept it.

IX: Yes, that's true. But today, for instance, they have started teaching probability theory in high school. And this will become a generalized practice in a few years, I'm sure. It was not an arrogant thing that I did, but perhaps the way I said it was a little crude. But it's better to know the reasons behind something than ignore them. So with my ignorance, either I want to get rid of it by learning, or I assume the ignorance and say I don't care. It leaves you with the responsibility. Twenty years ago when I was studying and searching out the tools I needed for my music, it was very difficult to learn probability theory because it was so specialized. But very rapidly, especially with information theory, cybernetics, the new technology, and the use of probabilities in so many other fields, the knowledge of probability theory became rather widespread. Now probability theory is commonly taught in colleges and universities which is fine but this is not yet true in the high schools. But it will come to that.

MZ: Could you briefly elaborate on why probability theory is more serious than merely tossing coins?

IX: Tossing coins is a machine, a natural machine, when it works of course. But probability theory deals with all sorts of machines which are more or less abstract, machines which can create a random base.

MZ: Isn't it also true that the tossing of coins is only one small part of probability theory, and that you are more involved with the overall problems posed by it?

IX: Yes, that is what I meant. It's just one detail, maybe important, but it's just a detail.

MZ: Are "degree of ataxy" and "entropy" terms which are interchangeable, or is there a clear distinction between the two?

IX: No, ataxy describes the degree of order, orderliness, or disorder. Entropy measures the rate of ataxy. They are linked together, but they are not equivalent. This means that when ataxy—in the sense of something
which is not proper, which is in disorder—increases, the entropy also increases. This is why there is a link and sometimes confusion.

MZ: Could you briefly describe Fourier synthesis, the failure of this theory, and the eventual freeing of computers and digital-to-analog converters to define what you have termed their “true position”?

IX: Fourier’s synthesis was an attempt to describe any curve of sound pressure that hits our ear and that we hear most of the time as a sound except when the vibrations are very low or very dense. The Fourier series enables you to analyze any such curve or variation of the sound and of the sound pressure on your ear into a series of additions of elementary periodical wave forms which can be described by a mathematical trigonometric function: cosine or sine. This process was generalized even in the case of impulses, where each impulse can be expanded into a series, the Fourier series, which is trigonometric, in addition to trigonometric wave forms or variations of pressure that are smooth. But it’s very difficult to reproduce or synthesize these forms even with a computer, because it is first of all theoretical and requires a lot of computer time. It becomes much more complicated when you go into simple noise type sounds—which applies to most of the instruments in today’s music and to electroacoustic music. Perhaps the best way to escape from that is to take another path. The path I propose in the last chapter of my book, Formalized Music, is, I think, original. It has to be worked out and proved and dealt with. It’s not a ready-made thing, but just a proposal for a new approach to the concept of music. Let’s put it this way: with Fourier analysis you try to explain or to create very complicated things by an accumulation of very simple elements like the periodic sound waves; what I propose is to start with a very complicated pattern (for example, Brownian movements) and to try to simplify it.

MZ: Can a sonic scheme defined by a “vector-matrix” representing a compositional attitude, that is, stochastic behavior having a unity of a superior order, run the risk of becoming as rigorously structural as serial music tends to be today?

IX: No, if you use probability functions, or distributions, or laws—that is, a stochastic approach—then you have unexpected results each time, but only in the detail. On the larger scale, you have an identity of form, that is, you have created a kind of family of possible, mutual works, pieces. For instance, you can translate this identity of form into a problem containing input data and compute it, which enables you to change the output, but the program is the same, that is, the skeleton is the same.
MZ: You use the ST program for more than one composition. Doesn't that limit you? In other words, are you saying that there is no end to the kind of program you could set up and that each program gives you many possibilities so that there is no end to the possibilities?

IX: Yes, that's true of the last question.

MZ: Do you think that using this approach allows for greater possibilities than, for example, resorting to serialism? After all, we've gone a far way from 12-tone music to serialism today. We have progressed considerably over the years.

IX: If the serialists use probability theory, then they have approached the position that I took against serial music twenty years ago. If the serialists expand by using the other domains especially stochastic domains, that it, use probability or dice throwing or things like that, then they are not in the orthodox realm of serial music.

MZ: I want to go back for a minute to the idea of the structure. Once you set up the program, can you vary that program or would that involve changing the entire program? What I think one wants is freedom, not to be confined. Can you really do that?

IX: Oh yes, one can do that. The difficulty is to do something that is really interesting enough. It's much more difficult and important to produce a family of music, rather than individual musical pieces which could be interesting. It is like inventing new forms, say, new fugues. Your freedom will only be limited by the macroform of the fugue.

MZ: There's another consideration that comes in here and that's the possibility of the music becoming predictable. Is this a problem that can arise, and that one has to strive to avoid?

IX: First of all, predictability is something very relative. When you hear music that you don't know, it seems to you that everything is the same. Therefore, you can predict what will happen. But, in fact, you don't predict, for it's something not very clear in your mind. After several repeated auditions, you start knowing the piece better. Then you are absorbed by things that you recognize and things that seem to be unexpected. So locally the composition can be unpredictable when you consider the details that you have not seen before. Can we say that predictability is something which condemns the quality of the music? I think such a suggestion is absolutely wrong. That is, no music would stand simple white noise.
MZ: If by a repeated hearing of a composition you can understand it better in the sense you described, isn't it also true that the more you hear something the less predictable it becomes because you have already heard it?

IX: Certainly, yes. The interest of the music is not linked to unpredictability. That's a false presumption that stems from the absolute variation of the Viennese school and that tendency. When you start with 12-tone music, even by the standards of today's serialists, it is a finite thing. Whenever you use finite stuff, you are in the predictable domain. So unpredictability is very relative, and it's a kind of forced sophism.

MZ: Could you briefly summarize your sieve theory and elaborate on whether one can gain a better understanding of serialism through it, as an identifiable example of an outside-of-time category; in other words, can one use a serial combination of notes as you would a major or minor scale?

IX: 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. When you take these notes which are outside-of-time and, so to speak, put them in a bag or pick them up in a certain order, you are doing a time ordering, you are putting them in-time. So any serial string of notes is something which is in-time, not outside-of-time. That's very important. It's the same thing that happens in classical tonal or any other music when you use the whole gamut of the scale—let's say the white keys. It's a time choice, you see. You pick up elements which are outside-of-time and you say, I'll put them in this time order. This is where tonal music and serial music are so closely related, in spite of the theoreticians who would like to say that no, serial music has brought something new. That's not true, tonal and serial music are very close. While serial music, by ordering all twelve tones without priority (just the order), has lost much of the wealth of tonal music and has replaced it by manipulations of this in-time structure, tonal music is richer because its structure is much more outside-of-time. When you take the white keys, let's say the major scale, you have differences, which means it's more complicated than the twelve-tone series which is always the same repetition. The melodic pattern operates in exactly the same way in both cases. The difference is that in serial music you take all twelve notes, while in the case of tonal music, you make choices—you don't need to use all seven notes.

MZ: In other words, you're saying that the possibilities are much greater in the major-minor system.
IX: In the outside-of-time structure, yes. So serial music compensated by all sorts of polyphonic manipulations that tonal music did not need because it was enriched by harmonic things, and so on.

MZ: Could you elaborate on your sieve theory?

IX: Well, the sieve theory can be applied not only to pitch but also to any other structure like time, intensity, the degree of order or disorder, density, and other characteristics of sound. A sieve structure is nothing more than the basic axiomatics starting with the sensations, as described more fully in footnote number 14 of *Formalized Music*. This gives you the formal construction starting from the sensations of a simple sieve, which is the equivalent of the chromatic well-tempered scale. You have an element that you repeat indefinitely and you thus create the elements of your set, your complete range. Now the next step is a problem of choosing points. In a straight line you have a continuity of points; in the sieve we don’t. You start from the other end, that is, discontinuity. You can create continuity because in the sieves you hit the natural number first, then you hit the rational numbers, and finally you can also deal with the irrational numbers. In this way, from the sensations, you can obtain a kind of reconstruction of all number theory, until you arrive at continuity. But you don’t need that in music. What the sieve theory enables you to do is to choose in a totally ordered set, or to structure the elements of the set. By comparison, this is what happens in the major scale, the white key scale, or any other more or less complicated scale. This ordered set depends on an elementary displacement; it could be a quarter tone, or a comma, or anything you want. This process represents a very general way of structuring an ordered set. Even the time, for instance, can be designed this way because it is an ordered set.

MZ: In other words, you’re trying to define your own structure as raw material to work with. What does a totally ordered structure mean?

IX: It means that, given three elements of one set, you are able to put one of them in between the other two. This is the best definition. Whenever you can do this with all the elements of the set, then this set, you can say, is an ordered set. It has a totally ordered structure because you can arrange all the elements into a room full of the other elements. You can say that the set is higher in pitch, or later in time, or use some comparative adjective: bigger, larger, smaller. When you deal with such a set, you have to do some structuring, otherwise you are as restricted as the serialists,

1 See Appendix II, pp. 102–103, below.
because they have just one set, the structure itself, I mean the chromatic structure itself.

MZ: However, serialism has gone beyond just the ordering of twelve tones. Some are using a more combinatorial approach which possesses an inner structure within the order of the twelve tones.

IX: When this combinatory element is used, it is in-time, not in the structure itself, because they have all of the twelve tones.

MZ: And you're talking about a specific structure outside-of-time?

IX: Yes. If you take a sieve, that is, a specific choice of pitches, of notes, then this sieve behaves like a scale and you pick notes out of this scale. Therefore, all the notes that you pick are related to each other according to the sieve that you have originated yourself. Then you can do all sorts of combinations with those notes, in-time.

MZ: Then you can do it in conjunction with other things that have their own structure.

IX: Absolutely. You can put all these things into correspondence. You then end up with a denumerable infinity, that is, you can count or put them into correspondence with all natural numbers. For instance, the set of rational numbers is denumerable because you can put them into correspondence, one-to-one, with the natural numbers; you can classify them. You cannot do that with irrational numbers.

MZ: Pierre Boulez discusses at length in his book, *Boulez on Music Today*, an index of distribution, of “space”, as a dimension of sound which is fully capable of being explored through total serialism. Aren’t you both really talking about the same thing, that is, in terms of “space”? In other words, he’s talking about serializing three-dimensional space. Also, is there a place in the future, realistically speaking, where serialists—even including Milton Babbitt’s all-combinatorial set approach—can come to terms, to meet or converge with probability in order to broaden its base?

IX: First of all, serialism does not deal at all with the outside-of-time structure of its sets. I think that represents a failure because just using one set they are less rich than those having a free choice of structure. Secondly, I have not read the book, but if this is a precise interpretation—that is, if the space has three dimensions which are pitch, time, and intensity—then what you have suggested is now true. I have used the three-dimensional
space approach also—but it is one way of thinking, which is not the only one.

MZ: And you also think it's narrow.

IX: Yes, because while it may be rich in its own way, it is still only one approach. For instance, you can deny the fact that one sound is made of pitch, intensity, and duration. There are sounds which have no pitch, or have so many pitches that you are lost in them, or sounds which do not have one intensity, but are so varying that it's impossible to give them an account, a description. This has to do with Fourier analysis, you see. This is probably why Boulez says musical space is three-dimensional. But this is the most elementary approach to space which is not the most central issue. It's an interesting approach which has been used by many people, by me as well, but I think it's not the only one. There are other problems concerning the inner structure and their characteristics. Some characteristics can perhaps be sieved through the approach of topology, which is not space anymore, but properties of continuity and discontinuity, of connectedness, and so on. Now as for what you said about combinatorial serialism, I think that when you deal with combinatorial problems in very small quantities, then you can play games with them. But if you have large combinatorial numbers, then your attention, your capacity to deal with them, is gone. You can only deal with large combinatorial numbers in a statistical way, that is, by introducing probabilities. Probability theory is based on a combinatorial analysis, only it's much larger. Combinatorial analysis is a tool of probability theory. But you have to deal with it and also the problems of determinism, or irregularity, that is, of periodicity, and so on.

MZ: In your book you state that your basic aim is to: “Attain the greatest possible asymmetry (in the etymological sense) and the minimum of constraints, causalities and rules.” Is this still true today, and in what ways or areas have you expanded this idea?

IX: No, this corresponds to only a few of the chapters. For instance, in the section on symbolic music which deals with the use of sets, combinations of sets, and so on, then of course it's evident that you don't have too much dissymmetry or asymmetry. And besides that, symmetry is not defined by the name in itself. Total dissymmetry is a question of organization, and the answer to it is that it could be, up to a point, an infinite asymmetry or dissymmetry, and the way to get to it is by the use of probability theories. But there is much to be done to the part which is not totally unrelated, that is, the part which is more or less well-organized, and the part which uses renewals or periodicity. That means that you repeat
the same operations. There are many things that can be done; in my book I discuss several techniques, for instance group theory for *Nomos alpha* or *Nomos gamma*—for cello or large orchestra—which is based on something which is repetitive, but the diversity comes from the confrontation of different types of repetitions.

**MZ**: Are there any compositions that you have recently published or written that you are particularly proud of or that explore new territory? In other words, I would like to know what you have done since the writing of *Formalized Music* and where the potential lies today and in the future. Where can you take this material?

**IX**: Essentially there are two directions. One lies in instrumental music; by taking into consideration a kind of generalization of the melodic pattern of the melody and the manipulations that are possible, you create bushes or tree arborescences of melodic patterns. That is, you don't have one little pattern, but a complex of melodic patterns that are not melodies in the old sense, but which are in continuous change. Therefore what you have is a kind of bush of such melodic patterns which are intermingled. Now this bush or arborescence of melodic patterns can be considered as an object, and you can treat it by logic, outside-of-time or in-time, by expanding it or by moving or rotating it as an object in itself. This produces a new type of generalization because it can happen with serial music or tonal music, and, even more importantly, because the rotations are continuous, you don't have just one melodic line, but something which is much more complex.

**MZ**: Could it be described as a shape in continuum?

**IX**: Yes, a form which can be changed. In order to change it constantly, you have to define it first, because the change is in-time already. That is, you have to propose something, like a bush, and then you can modify it with all these transformations. You can also effect more complicated transformations by using the complex numbers, which I have done also. So this is one main direction and there are several representative works.

**MZ**: Can you name them?

**IX**: The first work with arborescences, that is, with tree-like shapes, is *Evryali* for piano, which was performed in Tully Hall. There is one for piano and orchestra, *Erikhton*, and there is another one for large orchestra, which was conducted by Solti last year, called *Noomena*. Finally, an organ piece, *Gmeeoorh*, which was commissioned by the organ festival at
Hartford, Connecticut. Another possible direction is the topological approach to shapes in music, to structures on a larger scale, that is, how to use them, and how to conduct them. Essentially this approach is for instrumental music because it's much easier to deal with and much more economical. When you have to deal with computers, in micro-scales, it's very expensive, difficult, and time consuming. Dealing with computers represents the third direction—the work that I'm doing with computers (to continue the last chapter of my book) is the exploration of this micro-synthesis with probability, that is the inverse direction of the traditional sound synthesis with D/A converters. In PERSPECTIVES a criticism appeared in connection with this last chapter of my book, the essence of which was that when a university did an energy spectrum of a sound, produced the way I indicated, they found that the energy corresponds to the energy of the white sound, which is correct, of course. But the point is that when you have different white sounds made out of different probability distributions, then these white sounds are different among themselves. And so you have a kind of music which is not the colored sound, but is sound which is noise-like—the zero degree approach of what I am proposing, that is, the use of many complicated manipulations of equations and so on. Even in this case you have noises which are put together in such a way that each takes its personality from the probability distribution and in this sense it's a very interesting experiment.

MZ: Can you apply these theories to more than one medium?

IX: Oh yes, absolutely. For instance, one year ago we ended a spectacle at the Museum of Cluny in Paris with laser beams and electronic flashes—about 600 electronic flashes and three laser beams; they each had all sorts of configurations with mirrors interspaced, and each one of the flashes was operated individually, independently from the others, and all this was determined by a light score. This light score program was produced onto a tape of binary commands or instructions that was then read from a tape drive which dispatched all the commands to all these things. So it was a completely automated spectacle, even in so far as the movement of the sound in the space. There were twelve loudspeakers, an eight-track tape recorder, and the composition lasted about 24 minutes. In the future it will be movable, that is, even more complex than at Cluny, with lasers, electronic flashes and sound, and it will be able to be reproduced in France, or abroad . . . or even in the States, if there is any demand for it.

May 1975
Paris, France

Appendix I
A Selected Bibliography Recommended by I. Xenakis


Appendix II

Footnote from *Formalized Music*, page 267:

14. The following is a new axiomatization of the sieves, more natural than the one in Chaps. VI and VII.

**Basic Assumptions.** 1. The sensations create *discrete* characteristics, values, stops (pitches, instants, intensities, ...), which can be represented as points. 2. Sensations plus comparisons of them create *differences* between the above characteristics or points, which can be described as the movement, the displacement, or the step from one discrete characteristic to another, from one point to another. 3. We are able to repeat, iterate, concatenate the above steps. 4. There are two orientations in the iterations—more iterations, fewer iterations.

**Formalization.** Sets. The basic assumptions above engender three fundamental sets: $\Omega, \Delta, E$, respectively. From the first assumption characteristics will belong to various specific domains $\Omega$. From the second, displacements or steps in a specific domain $\Omega$ will belong to set $\Delta$, which is independent of $\Omega$. From the third, concatenations or iterations of elements of $\Delta$ form a
set $E$. The two orientations in the fourth assumption can be represented by $+$ and $-$. 

Product Sets. a. $\Omega \times \Delta \ni \Omega$ (a pitch-point combined with a displacement produces a pitch-point). b. $\Delta \times E \subseteq \Delta$ (a displacement combined with an iteration or a concatenation produces a displacement). We can easily identify $E$ as the set $N$ of natural numbers plus zero. Moreover, the fourth basic assumption leads directly to the definition of the set of integers $\mathbb{Z}$ from $E$.

We have thus bypassed the direct use of Peano axiomatics (introduced in Chaps. VI and VII) in order to generate an *Equally Tempered Chromatic Gamut* (defined as an ETCHG sieve). Indeed it is sufficient to choose any displacement $\text{ELD}$ belonging to set $\Delta$ and form the product $\{\text{ELD}\} \times \mathbb{Z}$. Set $\Delta$ (set of melodic intervals, e.g.), on the other hand, has a group structure.
Iannis Xenakis (Ιάννης Ξενάκης, 1922–2001) was a Greek-French composer, music theorist, and architect-engineer. Studied engineering in Athens; upon graduation, he joined the studio of Le Corbusier in Paris, and worked with him on architectural projects for 12 years, most importantly the Sainte Marie de La Tourette, on which the two architects collaborated, and the Philips Pavilion at Expo 58, which Xenakis designed alone. It was not until he was nearly 30 that he undertook serious musical studies.