Chapter I

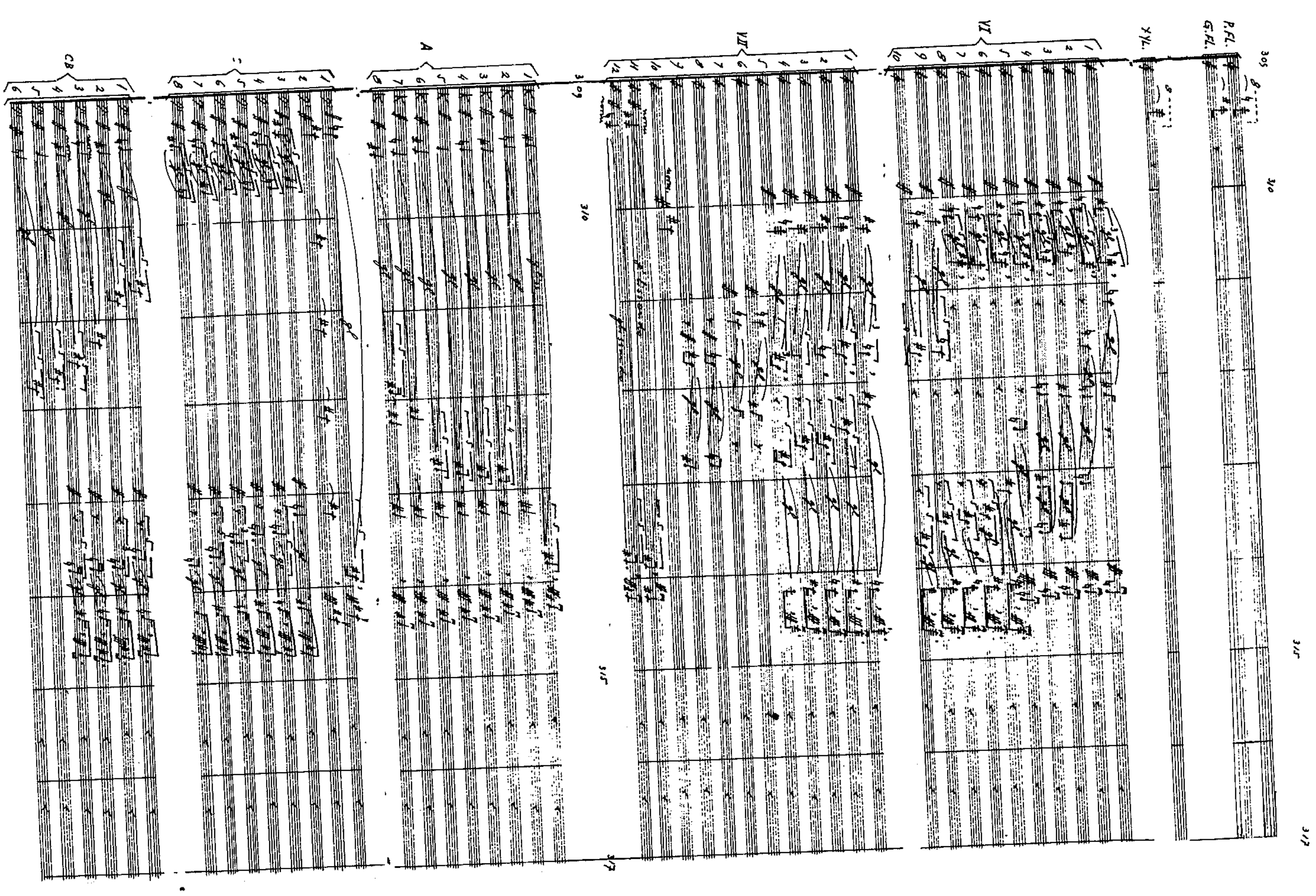
Free Stochastic Music

Art, and above all, music has a fundamental function, which is to catalyze the sublimation that it can bring about through all means of expression. It must aim through fixations which are landmarks to draw towards a total exaltation in which the individual mingles, losing his consciousness in a truth immediate, rare, enormous, and perfect. If a work of art succeeds in this undertaking even for a single moment, it attains its goal. This tremendous truth is not made of objects, emotions, or sensations; it is beyond these, as Beethoven's Seventh Symphony is beyond music. This is why art can lead to realms that religion still occupies for some people.

But this transmutation of every-day artistic material which transforms trivial products into meta-art is a secret. The "possessed" reach it without knowing its "mechanisms." The others struggle in the ideological and technical mainstream of their epoch which constitutes the perishable "climate" and the stylistic fashion. Keeping our eyes fixed on this supreme meta-artistic goal, we shall attempt to define in a more modest manner the paths which can lead to it from our point of departure, which is the magma of contradictions in present music.

There exists a historical parallel between European music and the successive attempts to explain the world by reason. The music of antiquity, causal and deterministic, was already strongly influenced by the schools of Pythagoras and Plato. Plato insisted on the principle of causality, "for it is impossible for anything, to come into being without cause" (*Timaeus*). Strict causality lasted until the nineteenth century when it underwent a

The English translation of Chaps. I–VI is by Christopher A. Butchers.



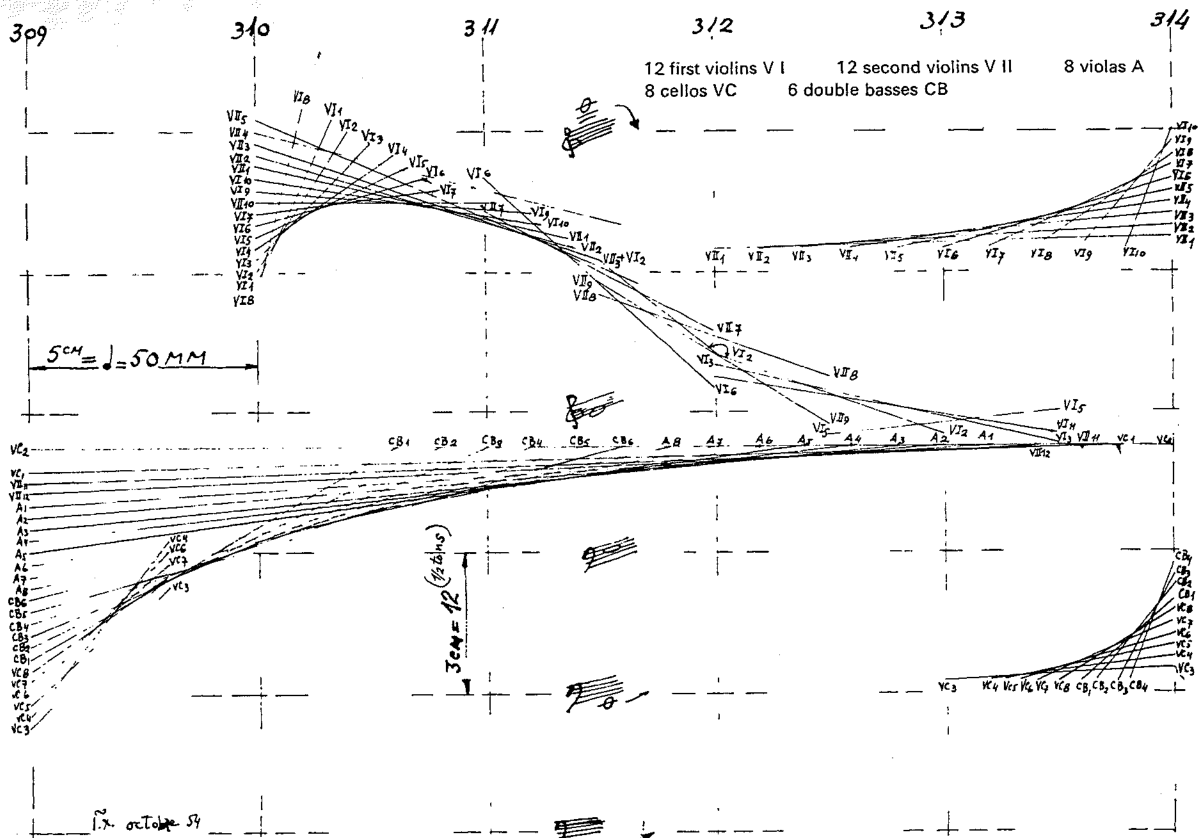


Fig. I–2. String Glissandi, Bars 309–14 of *Metastasis* brutal and fertile transformation as a result of statistical theories in physics. Since antiquity the concepts of chance (*tyche*), disorder (*ataxia*), and disorganization were considered as the opposite and negation of reason (*logos*), order (*taxis*), and organization (*systasis*). It is only recently that knowledge has been able to penetrate chance and has discovered how to separate its degrees—in other words to rationalize it progressively, without, however, succeeding in a definitive and total explanation of the problem of "pure chance."

After a time lag of several decades, atonal music broke up the tonal function and opened up a new path parallel to that of the physical sciences, but at the same time constricted by the virtually absolute determinism of serial music.

It is therefore not surprising that the presence or absence of the principle of causality, first in philosophy and then in the sciences, might influence musical composition. It caused it to follow paths that appeared to be divergent, but which, in fact, coalesced in probability theory and finally in polyvalent logic, which are kinds of generalization and enrichments of the principle of causality. The explanation of the world, and consequently of the sonic phenomena which surround us or which may be created, necessitated and profited from the enlargement of the principle of causality, the basis of which enlargement is formed by the law of large numbers. This law implies an asymptotic evolution towards a stable state, towards a kind of goal, of *stochos*, whence comes the adjective "stochastic."

But everything in pure determinism or in less pure indeterminism is subjected to the fundamental operational laws of logic, which were disentangled by mathematical thought under the title of general algebra. These laws operate on isolated states or on sets of elements with the aid of operations, the most primitive of which are the union, notated $\cup$, the intersection, notated $\cap$, and the negation. Equivalence, implication, and quantifications are elementary relations from which all current science can be constructed.

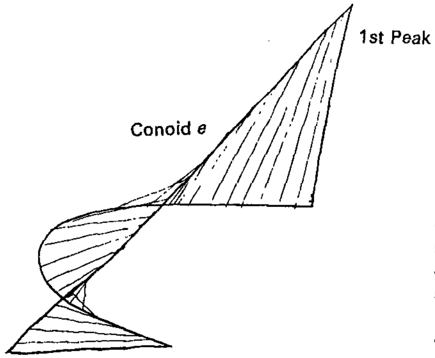
Music, then, may be defined as an organization of these elementary operations and relations between sonic entities or between functions of sonic entities. We understand the first-rate position which is occupied by set theory, not only for the construction of new works, but also for analysis and better comprehension of the works of the past. In the same way a stochastic construction or an investigation of history with the help of stochastics cannot be carried through without the help of logic—the queen of the sciences, and I would even venture to suggest, of the arts—or its mathematical form algebra. For everything that is said here on the subject

is also valid for all forms of art (painting, sculpture, architecture, films, etc.).

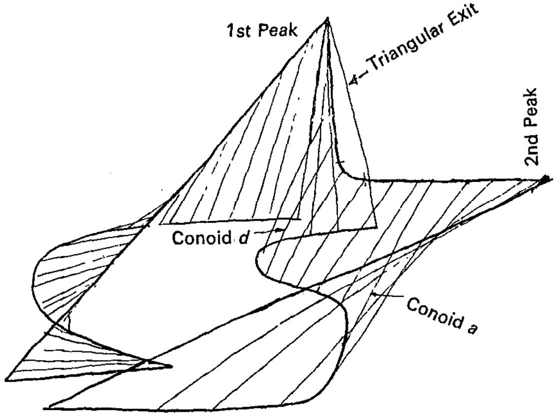
From this very general, fundamental point of view, from which we wish to examine and *make* music, primary time appears as a wax or clay on which operations and relations can be inscribed and engraved, first for the purposes of work, and then for communication with a third person. On this level, the asymmetric, noncommutative character of time is use (B after $A \neq A$ after B, i.e., lexicographic order). Commutative, metric time (symmetrical) is subjected to the same logical laws and can therefore also aid organizational speculations. What is remarkable is that these fundamental notions, which are necessary for construction, are found in man from his tenderest age, and it is fascinating to follow their evolution as Jean Piaget[1] has done.

After this short preamble on generalities we shall enter into the details of an approach to musical composition which I have developed over several years. I call it "stochastic," in honor of probability theory, which has served as a logical framework and as a method of resolving the conflicts and knots encountered.

The first task is to construct an abstraction from all inherited conventions and to exercise a fundamental critique of acts of thought and their materialization. What, in fact, does a musical composition offer strictly on the construction level? It offers a collection of sequences which it wishes to be causal. When, for simplification, the major scale implied its hierarchy of tonal functions—tonics, dominants, and subdominants—around which the other notes gravitated, it constructed, in a highly deterministic manner, linear processes, or melodies on the one hand, and simultaneous events, or chords, on the other. Then the serialists of the Vienna school, not having known how to master logically the indeterminism of atonality, returned to an organization which was extremely causal in the strictest sense, more abstract than that of tonality; however, this abstraction was their great contribution. Messiaen generalized this process and took a great step in systematizing the abstraction of all the variables of instrumental music. What is paradoxical is that he did this in the modal field. He created a multimodal music which immediately found imitators in serial music. At the outset Messiaen's abstract systematization found its most justifiable embodiment in a multiserial music. It is from here that the postwar neo-serialists have drawn their inspiration. They could now, following the Vienna school and Messiaen, with some occasional borrowing from Stravinsky and Debussy, walk on with ears shut and proclaim a truth greater than the others. Other movements were growing stronger; chief among them was the systematic exploration of sonic entities, new instruments, and "noises." Varèse was the

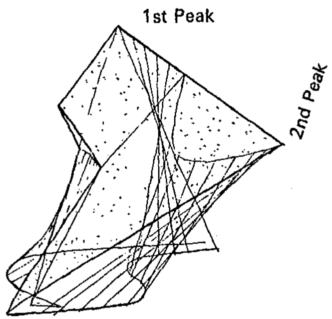


A. Ground profile of the *left half* of the "stomach." The intention was to build a shell, composed of as few ruled surfaces as possible, over the ground plan. A conoid (*e*) is constructed through the ground profile curve; this wall is bounded by two straight lines: the straight directrix (rising from the left extremity of the ground profile), and the outermost generatrix (passing through the right extremity of the ground profile). This *produces the first "peak" of the* pavilion.



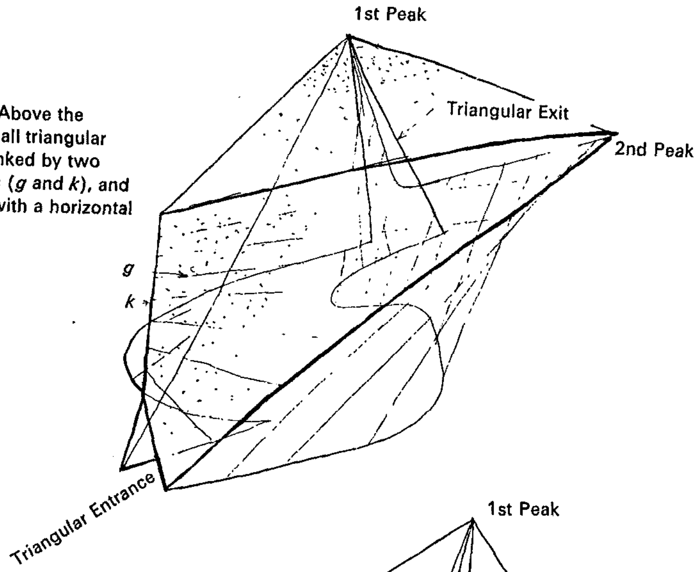
B. A ruled surface consisting of *two* conoids, *a* and *d*, is laid through the curve bounding the *right half* of the "stomach." *The straight directrix of d* passes through the first peak, and the outermost generatrix at this side forms a triangular exit with the generatrix of *e*. The straight directrix of *a* passes *through a second peak and is joined* by an arc to the directrix of *d*.

This basic form is the one used in the first design and was retained, with some modifications, in the final *structure. The main problem of the* design was to establish an aesthetic balance between the two peaks.

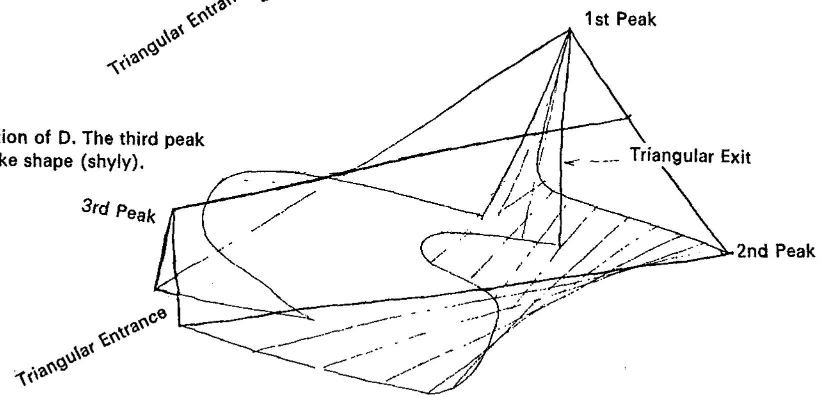


C. Attempt to close the space between *the two ruled surfaces of the first* design by flat surfaces (which might serve as projection walls).

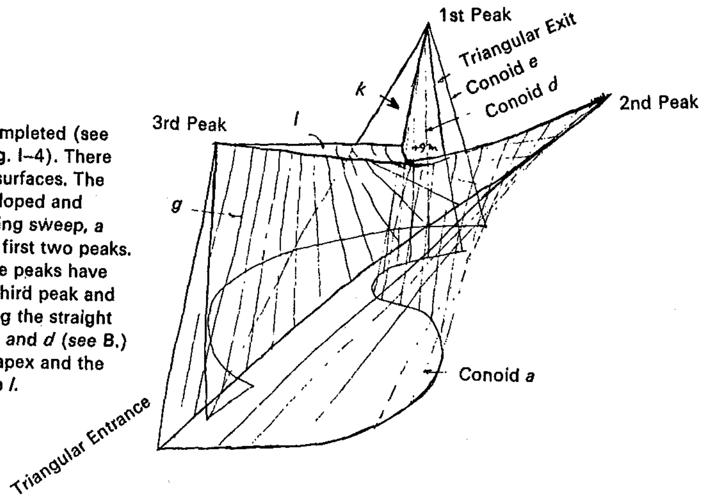
Fig. I–3. Stages in the Development of the First Design of the Philips Pavilion



D. Another attempt. Above the entrance channel a small triangular opening is formed, flanked by two hyperbolic paraboloids (*g* and *k*), and the whole is covered with a horizontal top surface.



E. Elaboration of D. The third peak begins to take shape (shyly).



F. The first design completed (see also the first model, Fig. I–4). There are no longer any flat surfaces. The *third peak is fully developed and* creates, with its opposing sweep, a counterbalance for the first two peaks. The heights of the three peaks have been established. The third peak and the small arc connecting the straight directrixes of conoids *a and d (see B.)* form, respectively, the apex and the base of a part of a cone *l*.

pioneer in this field, and electromagnetic music has been the beneficiary (electronic music being a branch of instrumental music). However, in electromagnetic music, problems of construction and of morphology were not faced conscientiously. Multiserial music, a fusion of the multimodality of Messiaen and the Viennese school, remained, nevertheless, at the heart of the fundamental problem of music.

But by 1954 it was already in the process of deflation, for the completely deterministic complexity of the operations of composition and of the works themselves produced an auditory and ideological nonsense. I described the inevitable conclusion in "The Crisis of Serial Music":

> Linear polyphony destroys itself by its very complexity; what one hears is in reality nothing but a mass of notes in various registers. The enormous complexity prevents the audience from following the intertwining of the lines and has as its macroscopic effect an irrational and fortuitous dispersion of sounds over the whole extent of the sonic spectrum. There is consequently a contradiction between the polyphonic linear system and the heard result, which is surface or mass. This contradiction inherent in polyphony will disappear when the independence of sounds is total. In fact, when linear combinations and their polyphonic superpositions no longer operate, what will count will be the statistical mean of isolated states and of transformations of sonic components at a given moment. The macroscopic effect can then be controlled by the mean of the movements of elements which we select. The result is the introduction of the notion of probability, which implies, in this particular case, combinatory calculus. Here, in a few words, is the possible escape route from the "linear category" in musical thought.[2]

This article served as a bridge to my introduction of mathematics in music. For if, thanks to complexity, the strict, deterministic causality which the neo-serialists postulated was lost, then it was necessary to replace it by a more general causality, by a probabilistic logic which would contain strict serial causality as a particular case. This is the function of stochastic science. "Stochastics" studies and formulates the law of large numbers, which has already been mentioned, the laws of rare events, the different aleatory procedures, etc. As a result of the impasse in serial music, as well as other causes, 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.

But other paths also led to the same stochastic crossroads—first of all,

natural events such as the collision of hail or rain with hard surfaces, or the song of cicadas in a summer field. These sonic events are made out of thousands of isolated sounds; this multitude of sounds, seen as a totality, is a new sonic event. This mass event is articulated and forms a plastic mold of time, which itself follows aleatory and stochastic laws. If one then wishes to form a large mass of point-notes, such as string pizzicati, one must know these mathematical laws, which, in any case, are no more than a tight and concise expression of chain of logical reasoning. Everyone has observed the sonic phenomena of a political crowd of dozens or hundreds of thousands of people. The human river shouts a slogan in a uniform rhythm. Then another slogan springs from the head of the demonstration; it spreads towards the tail, replacing the first. A wave of transition thus passes from the head to the tail. The clamor fills the city, and the inhibiting force of voice and rhythm reaches a climax. It is an event of great power and beauty in its ferocity. Then the impact between the demonstrators and the enemy occurs. The perfect rhythm of the last slogan breaks up in a huge cluster of chaotic shouts, which also spreads to the tail. Imagine, in addition, the reports of dozens of machine guns and the whistle of bullets adding their punctuations to this total disorder. The crowd is then rapidly dispersed, and after sonic and visual hell follows a detonating calm, full of despair, dust, and death. The statistical laws of these events, separated from their political or moral context, are the same as those of the cicadas or the rain. They are the laws of the passage from complete order to total disorder in a continuous or explosive manner. They are stochastic laws.

Here we touch on one of the great problems that have haunted human intelligence since antiquity: continuous or discontinuous transformation. The sophisms of movement (e.g., Achilles and the tortoise) or of definition (e.g., baldness), especially the latter, are solved by statistical definition; that is to say, by stochastics. One may produce continuity with either continuous or discontinuous elements. A multitude of short glissandi on strings can give the impression of continuity, and so can a multitude of pizzicati. Passages from a discontinuous state to a continuous state are controllable with the aid of probability theory. For some time now I have been conducting these fascinating experiments in instrumental works; but the mathematical character of this music has frightened musicians and has made the approach especially difficult.

Here is another direction that converges on indeterminism. The study of the variation of rhythm poses the problem of knowing what the limit of total asymmetry is, and of the consequent complete disruption of causality among durations. The sounds of a Geiger counter in the proximity of a radioactive source give an impressive idea of this. Stochastics provides the necessary laws.

Before ending this short inspection tour of events rich in the new logic, which were closed to the understanding until recently, I would like to include a short parenthesis. If glissandi are long and sufficiently interlaced, we obtain sonic spaces of continuous evolution. It is possible to produce ruled surfaces by drawing the glissandi as straight lines. I performed this experiment with *Metastasis* (this work had its premiere in 1955 at Donaueschingen). Several years later, when the architect Le Corbusier, whose collaborator I was, asked me to suggest a design for the architecture of the Philips Pavilion in Brussels, my inspiration was pin-pointed by the experiment with *Metastasis*. Thus I believe that on this occasion music and architecture found an intimate connection.[3] Figs. I–1–5 indicate the causal chain of ideas which led me to formulate the architecture of the Philips Pavilion from the score of *Metastasis*.

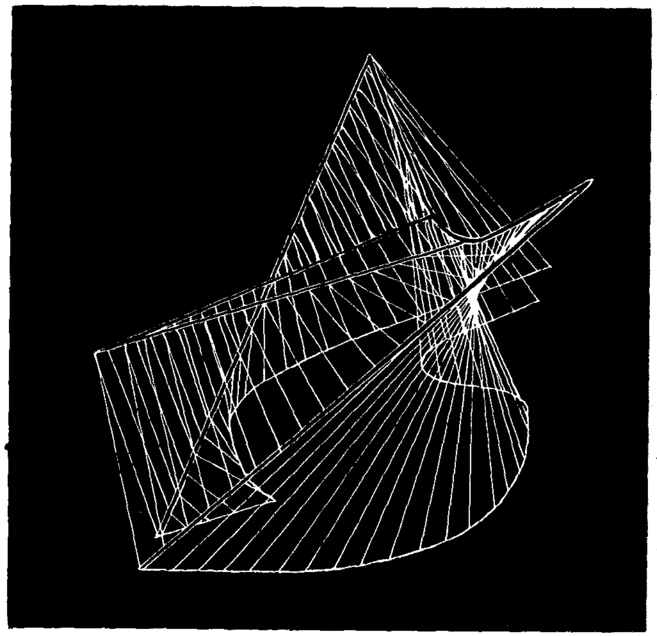


Fig. I–4. First Model of Philips Pavilion

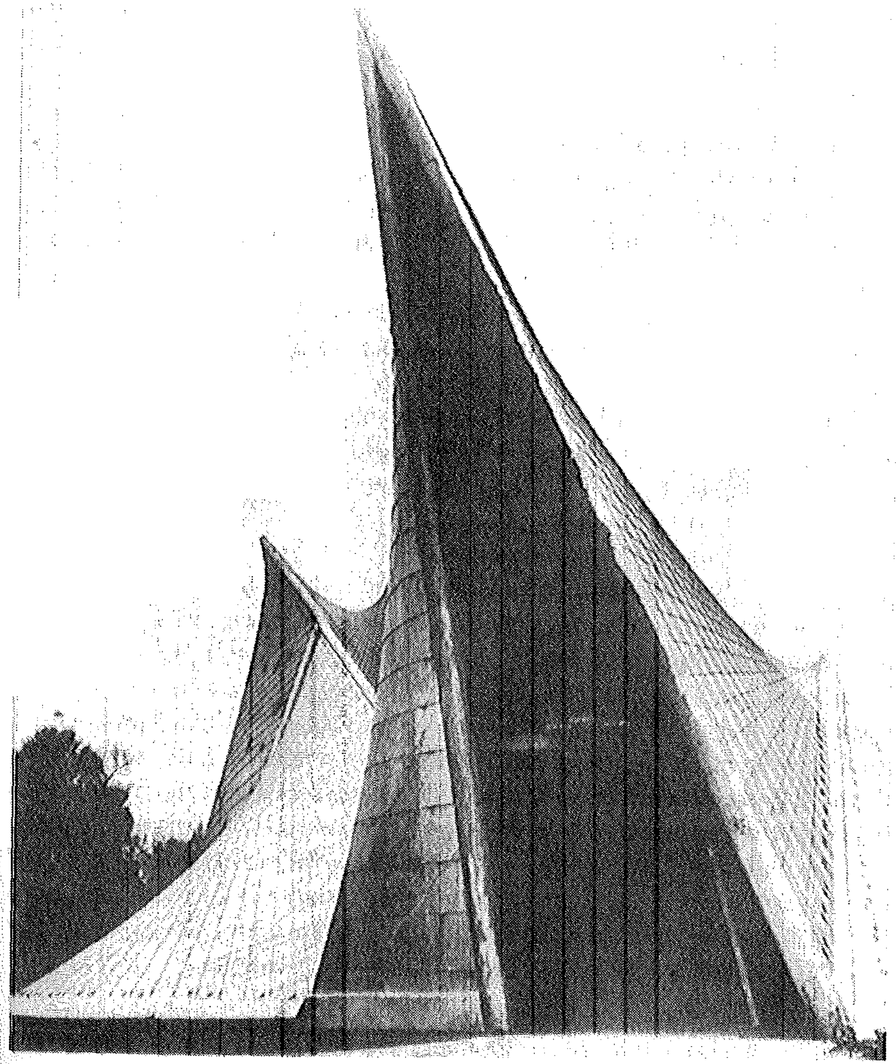


Fig. I–5. Philips Pavilion, Brussels World's Fair, 1958