PART IV Outline of a Concrete Music Theory

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1. TWENTY-FIVE INITIAL WORDS FOR A VOCABULARY

1. *Extract.* Any action producing a sound that is then recorded on a track of a disc or a tape is an extract. Extracts can therefore be either "live" sound recordings or sound recordings produced from preexisting recordings.
2. *Material classification of sound objects.* It is necessary to define a "material" classification of objects resulting from extraction before even submitting them to a technical or aesthetic analysis. This classification is based on the object's temporal duration and its center of interest, and it differentiates the sample, the fragment, and the element.
3. *Sample.* A sample is an extract of any duration (for example, from several seconds to a minute) that is not chosen for any well-defined center of interest.
4. *Fragment.* A fragment is a sound object of about one to several seconds in which a "center of interest" can be identified, providing it does not display development or repetition. If it displays these, the fragment should be limited to the portion that does not include any "redundancy."
5. *Elements.* If the analysis is taken even further, to the point of isolating one of the components of a sound object (a component that, furthermore, the ear can hear only with difficulty when it is isolated, and which in any case cannot be analyzed directly from sound), we say that the fragment has been broken down into elements. Examples of elements are an attack, a decay, and a piece from the continuation of a complex note.
6. *Musical classification of sound objects.* Once we have defined the "center of interest" that makes up the sound object, simply through limiting its duration, we must make a value judgment about its contents, whether it appears simpler or more complex. Thus we should be able to define the following: the monophony, the group, the cell, and the complex note.

7. *Monophony.* Cutting out in time does not allow us to separate out concomitant sounds. Only the ear can dissociate and separate these concomitant sounds into monophonic elements, which are then studied in themselves, through selective listening. Monophony in a superimposition of sounds is therefore the equivalent of a melody picked out by the ear from a polyphonic ensemble.
8. *Group.* A monophony of some length (a few seconds, or even some tens of seconds), studied for its repetitions or its inner development, is called a group.
9. *Cell.* By definition, a group is formed of either cells or complex notes. A cell is an ensemble with no repetition or development and does not have the definite characteristics of the complex note. Generally cells are dense complexes that develop rapidly (in rhythm, timbre, or tessitura) where even complex notes would be difficult to discern.
10. *Complex note.* Any element in a monophony that has a fairly clear beginning, continuation, and termination is called a complex note, by analogy with a musical note (which always has these simple characteristics).
11. *Large note.* A complex note can just as well be very short or quite long. A complex note is called a "large note" when its attack, continuation, or termination is sufficiently developed. If the development goes beyond a certain point, it will tend to become a group, and it will be possible to analyze its development in rhythm, timbre, and tessitura.
12. *Structures.* The totality of the material a composer chooses at the outset is given the name "structures." These may be cells or complex notes. They can also be ordinary notes, prepared or not, from unmediated, classical, exotic, or experimental instruments.
13. *Manipulations.* Any technique that changes structures before any attempt at composition is called a manipulation. Manipulations may be transmutations, transformations, or modulations.
14. *Transmutation.* Any manipulation that exerts its main effect on the matter of the structure without perceptibly altering its form is called a transmutation.
15. *Transformation.* Any manipulation that is intended to change the form of the structure rather than its matter is a transformation.

16. *Modulation.* If, without particularly aiming for a transmutation or a transformation, the intention is to selectively vary one of the parameters of a structure, or, more generally, if the intention is to develop the given sound in one of the three planes of reference of all areas of sound (tessituras, dynamic, and timbre), there will by definition be a modulation of the given sound, or the structure under consideration, in tessitura, dynamic, or timbre.

17. *Parameters that characterize a sound.* The parameters for variation of a sound can be understood either in the classical sense (there are three of them: pitch, intensity, and duration) or in the concrete sense (there are many more). It is preferable to use the concept of "plane of reference" rather than parameter. (See § II, III, and VIII.)

18. *Planes of reference.* The most complex sound phenomenon that can be imagined or encountered in practice ultimately comprises three planes of reference that can fully define it:

    1. *melodic plane or plane of tessituras* (the development of the parameter or parameters of pitch in duration) (see § VII)
    2. *dynamic or formal plane* (the development of the parameters of intensity in duration) (see § V)
    3. *harmonic plane or plane of timbres* (the reciprocal relationship between the parameters of intensity and pitch indicating the development of spectra) (see § VI)

19. *Performance procedures.* Performance procedures are all the procedures that, starting with given structures, and after the use of appropriate manipulations, make possible the performance of the desired work. There are three of these procedures: preparation, montage, and mixing.

20. *Preparation.* Preparation techniques (necessarily limited to the use of classical or paraclassical musical structures, i.e., notes that are more or less complex) consist in the use of classical or exotic or modern musical instruments as sources of suitable sounds without being particular about using them in the traditional way. Thus a piano can be an almost indefinite source of sounds, going from noise to musical sound, from pure percussion to continuous sound.

21. *Montage.* Montage techniques consist of assembling sound objects by simple juxtaposition, and in particular by gluing fragments of tape recordings end to end.

22. *Mixing.* Montage procedures do not allow polyphonic superimposition. Mixing, on the contrary, consists of superimposing compatible monophonies and recording the result.
23. *Spatial music.* The name "spatial music" is given to any music that is concerned with the localization of sound objects in space when works are being projected to an audience.
24. *Static spatialization.* Any projection that presents any monophony as if it were coming from an easily locatable source is considered static spatialization. This type of spatialization will consequently have been anticipated at the stage of mixing on synchronized but separate tapes, which are projected individually through separate sound sources, real or virtual.
25. *Cinematic spatialization.* The name "cinematic spatialization" is given to any projection that makes sound objects move in space at the same time as they move through time. This effect will therefore have been anticipated when the work was first planned; it is realized before an audience by a conductor-operator responsible for cinematic spatialization, with the help of appropriate equipment (spatial music projector, French patent no. 605467).

II. REVIEW OF ACOUSTIC CONCEPTS: THE THREE DIMENSIONS OF PURE SOUND

A sound signal can always be reduced to the combination of an appropriate number of elementary simple, or *pure,* sounds, which physicists call sinusoidal sounds (fig. 24), which are themselves defined according to their amplitude and frequency. The ear is not directly responsive to these two measures, but, according to a fundamental law of psycho-physics, it is responsive to their logarithm. We shall call the logarithm of frequency *pure sound pitch* and it will be measured in octaves—or their submultiples, *savarts*—and we shall call the logarithm of amplitude *level,* which will be measured in *decibels.* Thus a sinusoidal sound will be defined by its level, its pitch, and its duration, for no signal is of course unlimited, and the idea of a simple or complex *note* rests on the concept of duration.

Level, pitch, duration are the three *dimensions* of sound represented, in figure 25, by a line that shows the evolution of pitch and level in relation

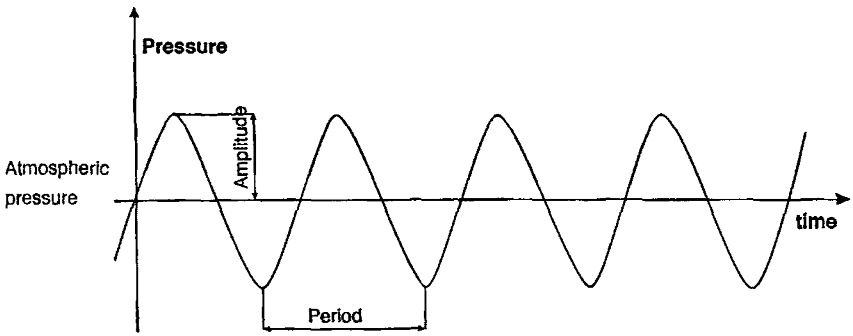


FIGURE 24. [Absolutely pure sound.]

to time: as the note has a finite duration, this line will have a corresponding length. Every complex note will be formed by combining these lines: as each one of the simple sounds evolves within the time under consideration, some of them dying out, others appearing, all the lines together will form a volume representing the evolution of the sound. As it is perfectly clear that a sound does not appear instantaneously but has a continuous development from its initiation right up to its decay, this volume will in general gradually increase from its basic plane and return to it after some length of time. It is this volume that represents the *complex note.*

Thus, a piano note retains a number of components defined by their frequency, and has a perceptibly constant relative proportion over its whole duration, but its overall level will constantly vary in relation to time, beginning with a rapid attack, then decaying very slowly. Figure 25 shows one of these notes with a constant timbre, and we shall call the time-related curve in level the *form* of the sound.[1] Let us on the contrary take the example of a noise such as the hissing of steam, starting suddenly: it will be characterized by the fact that it contains an almost limitless number of components, with levels that vary completely arbitrarily across the whole acoustic range. It is a *statistical* sound, which

1. There is equipment (the logarithmic recorder) that gives the form of the note straightaway.

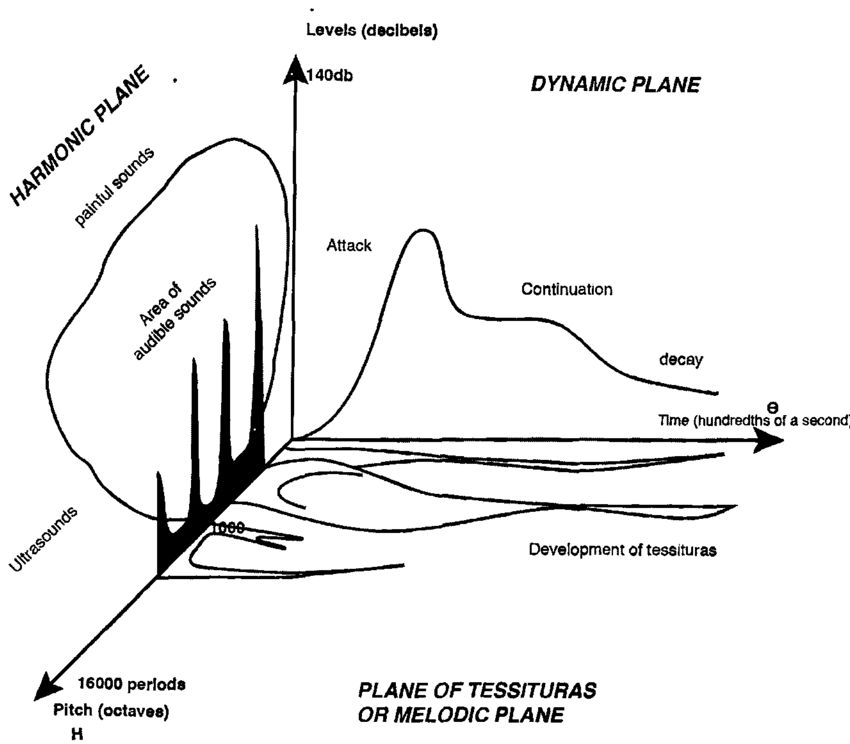


FIGURE 25. [Trihedron of reference.]

could go on indefinitely, but from its continuity we have cut an element of duration—here quite arbitrary—that we shall call a *complex note.* In this case it has a volume with a section that is very close to the whole acoustic sphere, the sphere of audible sounds, shown in figure 26 and remaining statistically constant throughout the duration under consideration. Through the use of technical procedures, it could be given a more or less rapid *beginning,* a *continuation* with a perceptibly constant level, and a very gradual *decay,* providing it with a form that is not so very far removed from the musical note that we used in our previous example. So the main difference between this noise and the note used previously is that the musical sound possessed an *order* evident in a continuity in the distribution of its components, which are perfectly

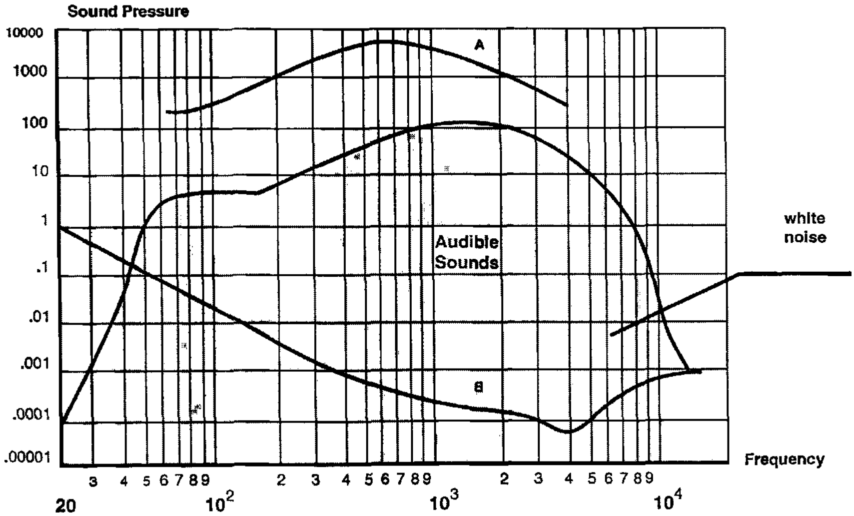


FIGURE 26. [Harmonic plane of a white noise.]

clearly defined. On the contrary, the noise of hissing steam has a huge number of components, in perfect disorder, and totally unpredictable. This is its essential characteristic, which, by analogy with optics, gives it the name *white noise.*

III. GENERALIZATION OF THESE CONCEPTS IN CONCRETE MUSIC: THE THREE PLANES OF REFERENCE OF COMPLEX SOUND

In reality, no pure sound exists, either in Nature or in human art. Sound is called musical, in the classical sense, when a "fundamental" predominates enough for the name of a note, in the tessitura, to be given to it. In addition, this note has fluctuations that make this attribution more or less precise. On the other hand, such a sound is much more complex than most musicians imagine: it comprises not only accumulations of harmonics (and the way they are superimposed is not always stable, but varies in relation to the duration of the note), but also a large element of "noise." Over and above the musical sound, which is the most apparent in the whole sound phenomenon, a note on the piano, the violin, a vocal sound contains elements of noise, i.e., fairly complex "transitory phenomena," which there is no point for musicians to define, since they are all implied in the words "violin," "piano," or "voice" and are inherent in the sound of the instrument and the way it is used. Duration itself, which theorists believe they can manipulate precisely, is no more than an illusion. It is an abstract duration, allotted to the note. In reality, the production of any note does not take place in duration, as manuscript paper would have it. Every note has a beginning, establishes itself, then stops, all this in a great fluctuation of intensity, which gives the sound a *form*. And so the classical musician, because he does not have the power to modify or use them as a means of expression, ignores *implicit* musical parameters contained in the musical note that is reduced roughly to the three dimensions of pure sound. If we wanted to be not only more rigorous but nearer to the reality of music, instead of the three variables or parameters of the physicists, plagiarized by music theory (duration, intensity, pitch), we should use the concept of *planes of reference*, which emphasizes the development of the note itself, in addition to notes in relation to one another.

In other words, it is through an effort of abstraction and simplification—useful, it is true, and adequate until now—that we can speak of the three dimensions of musical sound and the development of a melody, for example, in duration (rhythm), intensity (nuances), and pitch (tessitura), complicated by the fact of harmonics (timbre), which are nevertheless *given* once and for all, as are the secondary phenomena (attacks, touch, vibrato etc. . . .) implicit either in the given instrument or in the performer under consideration.

If, independently of melodic development, we concentrate our attention more on the note, i.e., a single note from this melody, we notice that the phenomenon is not so simple. It may be true that, to the physicist, every sound, and particularly musical sound, can be *analyzed* and broken down into pure sound components, but an analysis like this is a further effort of abstraction, but which, this time, wholly bypasses the sense of hearing and no longer belongs to music, but to acoustics.

If we wish to delve any further into the phenomenon of music, using acoustic data only as a scientific base, and most definitely not as an aesthetic criterion (this is of the utmost importance), the concept of a parameter of melodic musical development must be enriched with parameters that characterize the musical note; and, even if they have a rigorous scientific justification, these new concepts must be accessible to the direct experience of the musical ear.

So, essentially, we must turn to the concept of *duration* and identify an external, or overall, duration that characterizes the note in the classical sense, such as its basic length, in relation to other notes in the melody, and its internal duration, where the passage of time is seen as the only possible indicator of the development of the note within itself.

It may appear surprising that such an important approach has not already been adopted by musicians, and that the need was only felt with the advent of concrete music. Even more, there can be no other explanation for the confusion felt by musicians, of concrete music or not, faced with the first experiments in concrete music than the lack of familiarity and aesthetic experience in this matter. If, for example, we imagine musical notes that resemble notes of a piano, violin, or voice, but in which the proportion of musical sound to noise is gradually inverted, we may easily think that classical music theory is losing its rights and is incapable of providing certainly values, and even an adequate vocabulary to characterize the new phenomena. These, already present in ordinary music, now become prominent.

In addition, wanting to make immediate aesthetic value judgments about the new music when one is incapable of defining, or even naming, the various occurrences of such phenomena is putting the cart before the horse, and wanting to write harmony before even having learned the theory of music. Hence the importance of the new concepts outlined here.

In particular the question "What instruments is this piece played on?" no longer has any meaning. The essential question is to be able to replace the word "instrument," which is widespread and convenient, and also an easy point of reference, with a sound-classification system, or sound characterology, which would enable sounds to be classified into families. Prior to, or together with, a theory, the characterology of sounds appears as the generalization of the concepts of instrument making.

There then arises the question of finding out where a characterology like this will come from. For a long time, musicians engaged with concrete music, wanting to avoid confusing acoustics and music, have attempted to do without the "trihedron of reference," which completely strips down every sound, however complex it may be, through three "projections" onto "planes of reference." Experience showed that it was practically impossible to do without these graphic representations, taken from acoustics. The combinations of sounds developed by the experiments of concrete music are indeed so multiform that a classification by comparison with a few basic types, defined empirically, has shown itself to be impossible.

So musicians have had to take on some of the concepts of acoustics, represented in Cartesian coordinates, on a three-plane projection of the cluster of curves, or even of volume, representing even the most complex sound phenomenon in a three-dimensional space. So the three classical parameters of pure sound into which musical sound was assimilated (duration, intensity, pitch) will be replaced by formal *characteristics,* distributed over three planes of reference by curves representing the development of the note, complex or otherwise. In other words, the classical parameters are considered to be stuck, at least in the broadest sense: the note in question has, generally speaking, a pitch, a duration, an intensity. If it is complex, it can have a whole "package" of pitches, an intensity that varies greatly in the course of its development, and a timbre that can be extremely complicated due to the interaction of fundamentals and harmonics modulated in various ways.

In conclusion, three numbers, representing values of the conventional musical note that are in general simple and arithmetical, are replaced by the three graphic representations of figure 25, representing the development—or, more precisely, the configuration—of the note itself. In some respects this method will give the molecular structure of the musical element.

IV. INDIVIDUAL STUDY OF THE THREE PLANES ENABLING THE COMPLEX NOTE TO BE REPRESENTED

From the definition that we have just given of the three dimensions of the complex note—level, pitch, and duration—we can, by adopting the methods of representation used in geometry, discern three *projections* obtained by combining the three preceding dimensions in pairs. Studying each of these projections will give us a way of understanding the note. We shall use the following terms:

- plane *of forms* or *dynamic* plane for the plane of development levels in relation to time
- plane *of spectra* or *harmonic* plane for the level-pitch plane
- plane *of tessituras* or *melodic* plane for the plane of variations of pitch in relation to time

V. DYNAMIC PLANE

The simplest of them, and the most scantily used in classical music, is the plane of levels in relation to durations or the dynamic plane. The curve representing the projection of the complex note in this plane, which we have called the form of the sound, generally begins at 0, if a complex note with an inner unity in the sense defined above has been isolated, for example by extraction from a closed groove or a tape loop. The note appears, then decays, the level returns to 0, and, generally speaking, we can discern three essential sections in its form:

- the *attack*, the onset of the note, often very abrupt in traditional instrument making (plucked strings, percussions, syllables)[2]
- the *continuation* of the note, during which it retains a perceptibly constant average level, despite some characteristic fluctuations (slow increase or decrease, vibrato, etc.)

2. We deliberately group together within the term "instrument making" all the technical resources of musical instruments, including the human voice, which is a very important instrument.

- the *decay,* the tail end of the note, the beginning of which is difficult to discern because it is not very different from the continuation but which in traditional instrument making is standardized due to the properties of resonating instruments, which give a very slow decay (mute, reverberation)

Concrete music, which is no longer limited by instrumental conditions such as these, will consistently use absolutely random note forms, and we shall give some examples of these, gradually moving away from the sounds of traditional music by relaxing the restrictive rules that arose from the nature of the instruments that limited it.

Attack of the Note

Thus, in the field of attacks, instrument making offered little more than three distinct modes:

a) *Plectrum*—or *plucked*—attack, in which a string was displaced from its initial position, then abruptly released. This is the steepest attack that can be found: the sound comes in immediately at its maximum level.

b) *Percussive* attack (piano): here a hammer hits a string, which vibrates after the time taken for the impulse to spread along the whole string. This attack is less violent than the preceding one, and it is also different from it mainly because the timbre produced is modified.

c) *Aeolian* attack (reed or violin bow), in which a string is made to vibrate very gradually, without any sort of discontinuity, for example by blowing a current of air across telegraph wire, or gradually making a violin string vibrate with a rosined bow. This is the same type of attack, even more gradual, as is made by the reeds of woodwind instruments (organ, harmonium).

Figure 27 a, b, c represents the form of the sound in these three basic examples.

Concrete music will liberate itself from these modes of attack, which we shall call *natural,* and replace them with more complex modes. Figure 27 d, e, f gives some examples of *artificial* modes of attack that we

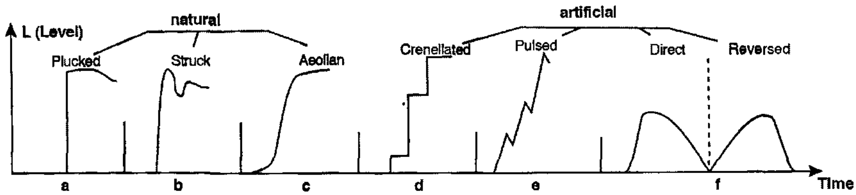


FIGURE 27. [Examples of natural or artificial attacks.]

shall be able to create, and which will supplement the previous ones. Better still, the techniques of concrete music will enable us to dissociate the characteristics of attack and timbre in familiar sounds.

Because of its practical importance we would draw attention to the mode of attack by *inversion* (27f), in which the forms of decay of the note are used systematically as the mode of attack: these forms are very progressive, for the decay of a natural sound is always a very slow phenomenon, and this is what gives music played backward its particular character. By simply adjusting the speed of decay, which can vary between several tenths of a second and several seconds, the whole character of the note will be changed without the general law of attack being altered. This single example shows how rich the contribution of concrete techniques can be in providing new notes or pseudoinstruments.

Finally, concrete music will use *impacts*, i.e., notes that in theory are reduced to *attacks*, with no prolongation of the decay through natural or artificial resonance.

Body of the Note

Here again, the physical rules that determine the functioning of traditional instruments have given only an extremely limited number of combinations: the simplest, of course, is the perfect consistency of the sound level (horizontal form), which seems as if it will go on indefinitely. Such is the case with a laboratory oscillator, for example. It is impossible to attain this indefinite consistency with an instrument controlled by a performer (violin, human voice). The hand trembles, the breath varies. Also, a device of the performer is a *vibrato,* which is generally an undulation of amplitude of about 10 to 15 percent, with five to eight undulations per second, and is used by all violinists and singers to conceal the inevitable fluctuations of their sound level. In this way it has gained acceptance in music and is perceived by the listener as an intrinsic characteristic of the note. Finally, the most apparent characteristic of the body of a note in theory is that it has a clearly defined level that the composer has become accustomed to marking on his score with symbols:

ppp pp p mf f ff fff

corresponding, according to Stokowski, to the following numerical values:

+20 decibels + 40db + 50db + 60db + 75db + 85db + 95db

Overall, the characteristics of the bodies we have just enumerated are very poor, and the simplest devices of concrete music technology will increase them considerably. For example, systematically increasing vibrato, which is impossible in traditionally made instruments because it would lead to unacceptable fluctuations in the pitch of notes, will give rise to so-called *pulsed* sounds, as in figure 28a. This concept will be generalized by also giving the name "pulsation" to every note obtained by rapid (usually artificial) repetition of the same impulse.

We use the term:

artificial, because it cannot be found in normal instruments, for the sound process with a very clear lowest point in the middle of the body of the note, followed by a rapid increase (fig. 28b).

For example, we shall use the term:

crenellated for the process with a sequence of independent resonances, where it can be seen that very large numbers of combinations can be made from these. This is a sequence of irregular maxima and minima (fig. 28d).

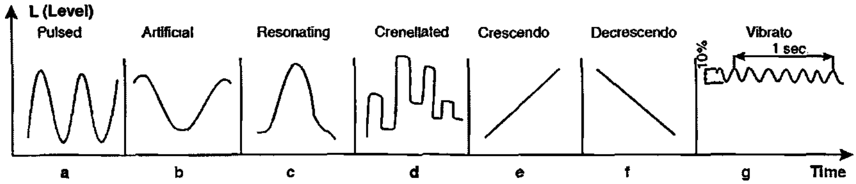


FIGURE 28. [Example of the allure of the body of a note.]

We shall use the term:

resonant for a sound characterized by a single increase in level in the middle of the body of the note (fig. 28c). This resonance can also be equalized artificially with the potentiometer.

rubbed, the process with a sustained action (reed or bow, for example) that gives an intermediary effect between the crenellation and the resonance (fig. 28g).

Finally, many complex notes will not have any definite shape; we shall simply describe their *crescendo* or *decrescendo* development (fig. 28e and f).

Decay of the Note

The decay of sound elements can be much better described in its form than its duration, for if it is quite easy to determine the instant when a sound completely disappears (when it is lost in background noise), it is still quite tricky to define the beginning of the decay, which is generally combined with the body of the note itself. In traditional instruments (violin, piano, voice, etc. . . .), it is a convention to call *period of decay* the moment when the note is no longer sustained, i.e., when energy is no longer being given to the vibrating body. So it gradually expends the energy it contained, as much through sound wave radiation as through inner agitation, and the general laws of acoustics lead to a gradual decline in accordance with a so-called *exponential* law, for which we will use the general term *reverberation,* and which will have a very variable duration—from several tenths of a second to several seconds. This term

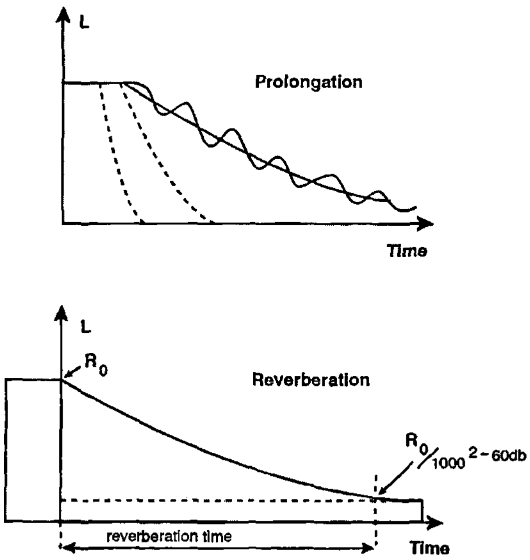


FIGURE 29. [Example of prolongation by natural or artificial reverberation.]

"reverberation" comes from the fact that most sound sources, after they have stopped vibrating themselves, radiate in the concert hall, which maintains the sound for a time, introducing a consistent *prolongation* to the listener's ear. In other words, in general the mode of decay of the concert hall replaces the mode of decay of the instrument itself; it is the former that is usually termed "reverberation."

In this large class of reverberating decays, or prolongations, we shall distinguish *continuous* reverberations, the simplest, and *vibrating* reverberations, which have the same characteristics of vibrato or impulse as the body of the note itself (fig. 29).

In traditional instrument making, the methodological distinction we have just made between attack, body, and decay of the note would be quite artificial, because traditional instrument making can give us only a very limited number of combinations of these various elements. So, for example, all the notes of the piano, attacked percussively, reach an instantaneous maximum, the body of the note is nonexistent, and the decay is very long, comprising only two numerical values, *pedal* or *muted*, which, considering their size, cannot really be modified by the concert hall. The violin note, and this is one of the causes of the richness, the success, and the difficulty of this instrument, has an aeolian type of attack, of very variable steepness (staccato, legato), a well-defined sustain with vibrato, and a fairly rapid decay, which is very subject to modifications from the concert hall.

Concrete music, on the contrary, will be able to dissociate each of these parts, choose its own character on aesthetic grounds, and assemble them, creating a considerable number of combinations, corresponding to an almost indefinite number of pseudoinstruments, and this on the dynamic plane alone, without even considering the planes of tessituras and harmony, which we shall now discuss.

VI. HARMONIC PLANE

The distribution of levels in accordance with the pitch of simple sinusoidal sounds that make up a complex sound, forms what physicists call the *spectrum;* amplitude in relation to frequency, or what musicians call *timbre,* which familiarity with musical instruments leads us to think of as stable within the note, and even as presenting a sort of sameness from one note to another, which leads us to speak of the general *timbre of an instrument.*

Strictly speaking, this concept of timbre will retain only momentary value in the complex note, since the level and pitch of each component develop independently over the duration of the note. In practice, however, various physiological and aesthetic reasons will lead the ear to cut out instants at least 1/20 of a second long from the continuity of the note, in which the spectrum of the note will be permanent enough to be considered as typical.

One of the most consistent characteristics of traditional musical instruments is the use of the vibratory properties of quite simple material bodies (strings, metal sheets, membranes, columns of air), which obey numerical laws, the main one being what is called the *harmonic law:* the frequencies of the various components of an instrumental note are simple multiples of each other or of a larger common divisor, the

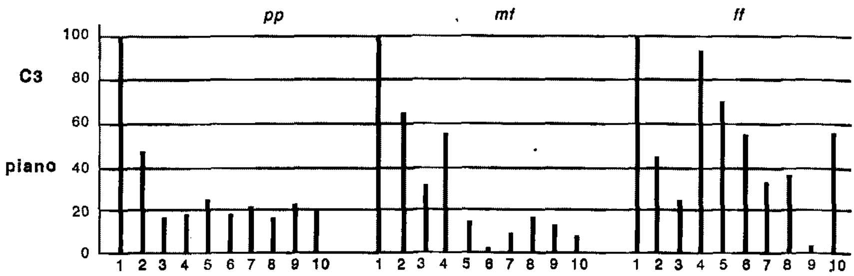


FIGURE 30. [Example of various harmonic resonances of a C3 on the piano struck at various intensities.]

fundamental, these frequencies being termed *harmonics* (fig. 30). Thus the spectrum of a musical instrument will present in the form of a certain number of harmonics—rarely more than about twenty—and their amplitude will generally decrease when the harmonic increase in frequency. Between these harmonics there is nothing: the musical instrument produces only a "discrete" sequence of simultaneous frequencies. The word *pitch* is used for the note given by the instrument, either the fundamental mentioned above, or the most important of the harmonics, and the indecision about this reflects the arbitrariness of this concept.

Outside the limitations imposed by traditional instruments, concrete music considers that every natural or artificial sound can, by reason of its position in a structure, take on a musical character, so it will seek to find a way of representing the immediate timbre of these sounds without turning to the quite arbitrary concept of harmonics. More precisely, we shall have to turn either to new concepts (thickness of sound), or to classical notions as far as timbre is concerned, depending on the extent to which a complex sound, composed of ordinary musical sounds, justifies these concepts, at least by analogy.

So first we shall have to discern whether or not a complex sound comes near to a musical sound, i.e., if it has a "spectrum of lines" or a "spectrum of bands."

The terms "thick" or "thin" will be used for a sound made up of a more or less extensive "package" of fundamentals (fig. 31b). Depending on the timbre of each of these fundamentals, it will be possible to classify the

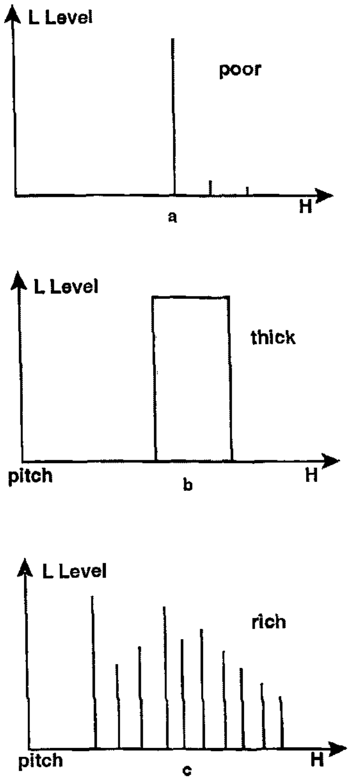


FIGURE 31. [Spectra of a sound that is: a, poor; b, thick; c, rich.]

resulting general timbre either quantitatively (poor or rich) or qualitatively (brilliant, bright, dark).

We shall use the terms:

poor, for a sound with a spectrum made up of only one or a very small number of components of significant amplitude (fig. 31a).

rich, for a sound that has a significant number of harmonics with significant amplitude. It is different from a thick sound in that it has a finite number of components that may be spread across the whole acoustic range instead of a continuous band in one piece (fig. 31c).

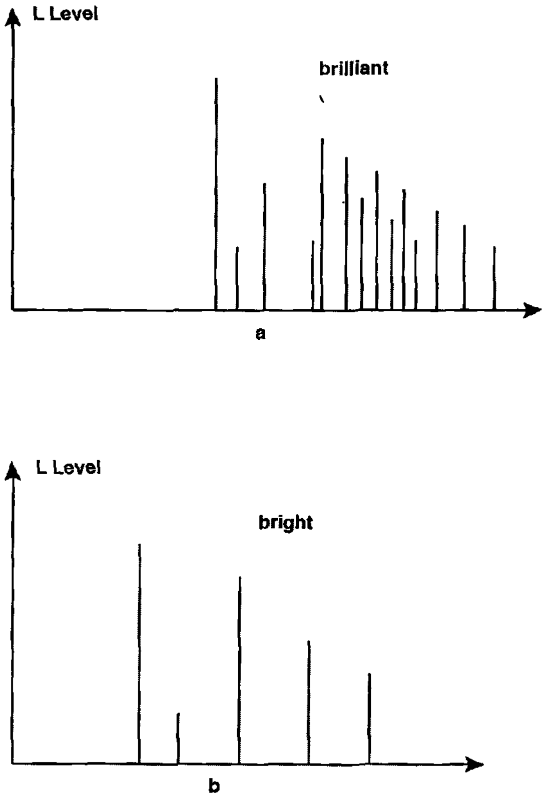


FIGURE 32. [Spectra of a sound that is: a, brilliant; b, bright.]

These quantitative characteristics of timbre will be complemented by the qualitative concept of *color.* We shall distinguish:

brilliant sounds, made up of a large number of harmonics, and where the amplitude does not decrease rapidly with the range (fig. 32a)

bright sounds, which have the same property, but with a very limited number of harmonics (fig. 32b)

dark sounds, which have only a few harmonics, and where the amplitude decreases rapidly with the range (fig. 31a)

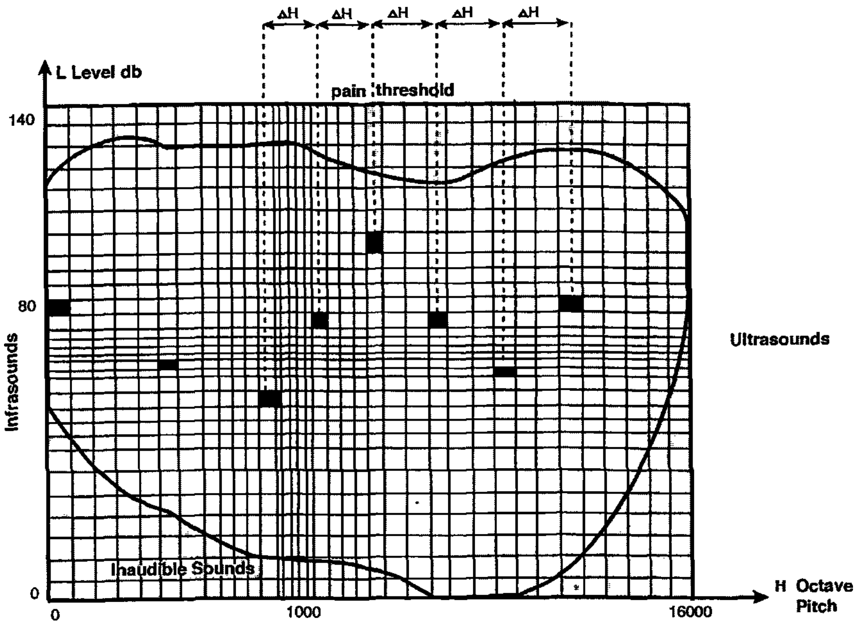


FIGURE 33. [Instantaneous spectrum of a complex sound in the course of development.]

This "instantaneous" spectrum is simply a cutting of the three-dimensional representation of a complex sound through a perpendicular plane on the axis of durations at a moment t.

VII. PLANE OF TESSITURAS OR MELODIC PLANE

Strictly speaking, melodic development in relation to time, i.e., the development of the complete spectrum in duration, cannot be described in simple terms. However, the problem is simplified by a concept that is very important in the psychology of perception: *the thickness of the present,* a duration in which all acoustic phenomena are considered as simultaneous by the listener. This thickness of the present is of the order of 1/20 to 1/30 of a second: during this moment every acoustic element that appears—all the rectangles in the level-pitch spectral diagram (fig. 33)—are perceived simultaneously, and the section of the volume of the note

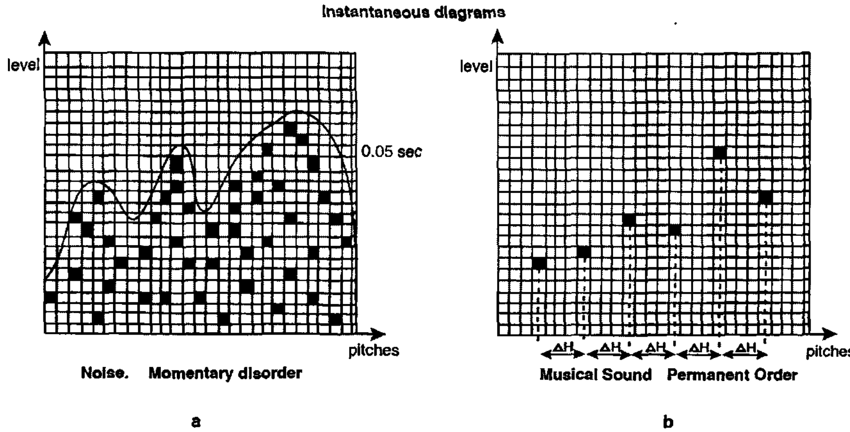


FIGURE 34. [Instantaneous spectrum: a, of a noise; b, of a musical sound.]

through the plane of tessituras, shown on this diagram, describes its melodic development over time.

In practice, the general laws of the theory of information in acoustics allow us to discern two types of very different moments in this development:

1) Very brief moments that in general correspond to periods of attack or very sudden change of form in the complex note on the dynamic plane. During these moments, the spectral diagram is very complex: a large number of rectangles is used simultaneously, forming what is usually called a continuous spectrum—white noise—and these elements have no simple numerical relationships to each other; they follow no or very few of the rules of selection set out in relation to the plane of timbres. They evolve haphazardly, in total disorder, during these short moments. Thus the concept of the transitory is linked to the concept of *noise,* or *disorder,* and this is quite a fundamental result as far as aesthetic perception is concerned (fig. 34a).

2) During the other moments, which constitute the major part of the duration of the complex note, and are separated into sections by the preceding moments, the spectral diagram is much simpler. With fewer elements being used, it develops slowly in duration,

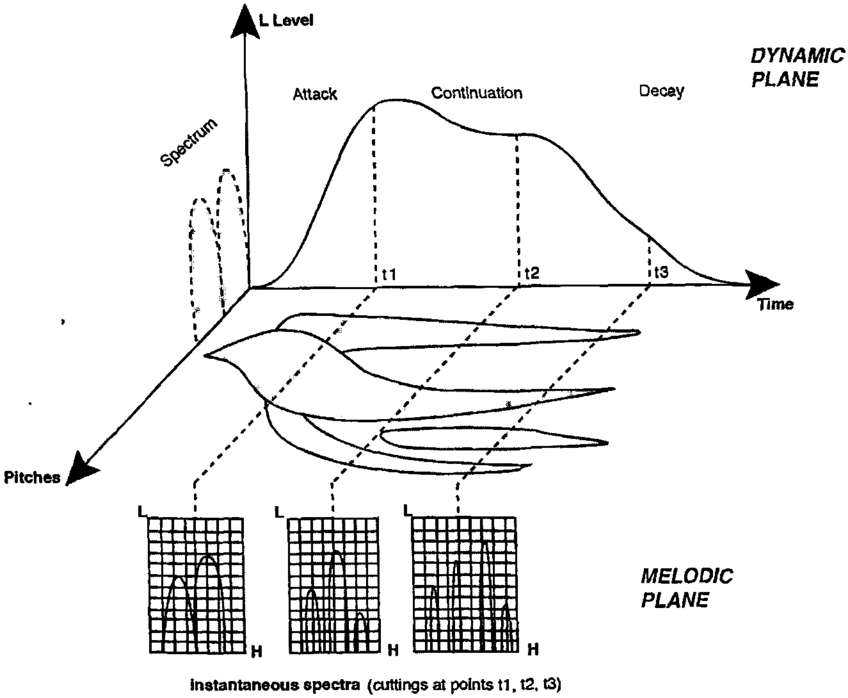


FIGURE 35. [Instantaneous spectrum at the points t1, t2, t3 of a complex sound in the course of development.]

keeping a sort of memory, an approximate permanence, which gives the ear time fully to appreciate its modalities. An average tessitura can be distinguished here, with a perceptibly consistent spectrum (figs. 34b and 35).

So we shall distinguish the following tessituras:

a) *stable* or *unstable* depending on whether the average pitch over time is consistent or not
b) *rising* or *descending*, depending on the development of the average zone of the spectrum over time
c) *extensive* or *narrow* depending on the size of the musical interval (if it is discernable) in which they develop

At a more detailed level, we shall distinguish:

- *vibrating tessituras*, where the nominal pitch has periodic fluctuations, generally at a rhythm of five or six per second, with amplitudes of 1 to 5 percent in pitch, which furthermore correspond to the effects of vibrato already discussed under dynamic plane, to which they are linked by the properties of many instruments or pseudoinstruments: thus, a vibrato on a violin or an ocarina is always simultaneously a vibrato in amplitude and a vibrato in frequency
- *spun tessituras*, where the pitch of the complex sound develops very rapidly within a fairly limited margin during the course of the note, and especially toward the beginning and the end. This is an effect known in classical music with instruments such as the ukulele and the balalaika *(the Hawaiian effect)*, or, to a lesser degree, the harpsichord or the zither
- *scintillating tessituras*, where the rapid connections between perceptible sounds, despite their disorder, does not allow them to be easily located
- *indistinct tessituras* (white noise)

VIII. APPEARANCE OF CRITERIA FOR SOUND CHARACTEROLOGY

While keeping the word "parameter" for the variations of the classical note in duration, intensity, and pitch, we can define as *criteria* for characterizing sounds types of symbols used to analyze projections of complex sound on to the three planes of reference. In this way we can finally arrive at a method for classifying complex sounds into families.

We may also, out of curiosity, wonder how many types of sounds, i.e., ultimately how many pseudoinstruments, could be produced through *numerical combinations* of these criteria, by a generalization of musical means such as those at the disposal of concrete music.

On the other hand, we may observe that some of these criteria are not independent, that a certain criterion in the plane of tessituras automatically corresponds to a similar criterion in the dynamic plane. These will be *exclusions*, which will reduce the number of possible combinations.

Finally, we can look into certain families of particularly characteristic sounds that obey certain laws or set requirements. The necessary and sufficient conditions for obtaining such families, or at least for the possibility of obtaining them, will be the *conditions of compatibility*, by analogy with mathematical language.

We shall now develop these concepts one by one:

The main criteria of characterology, in the three planes of reference

The number of possible combinations (without taking exclusions into account)

Conditions of compatibility, in certain examples of particular interest

IX. MAIN CRITERIA OF SOUND CHARACTEROLOGY (Fig. 36)

Total no. of criteria

A. *Dynamic plane or plane of sound forms*

1) Criteria of attack — 3

The attack can be *plucked*,
percussive,
aeolian,
depending on its steepness.

2) Criteria of sustainment, concerning the way the body of the note is sustained — 6

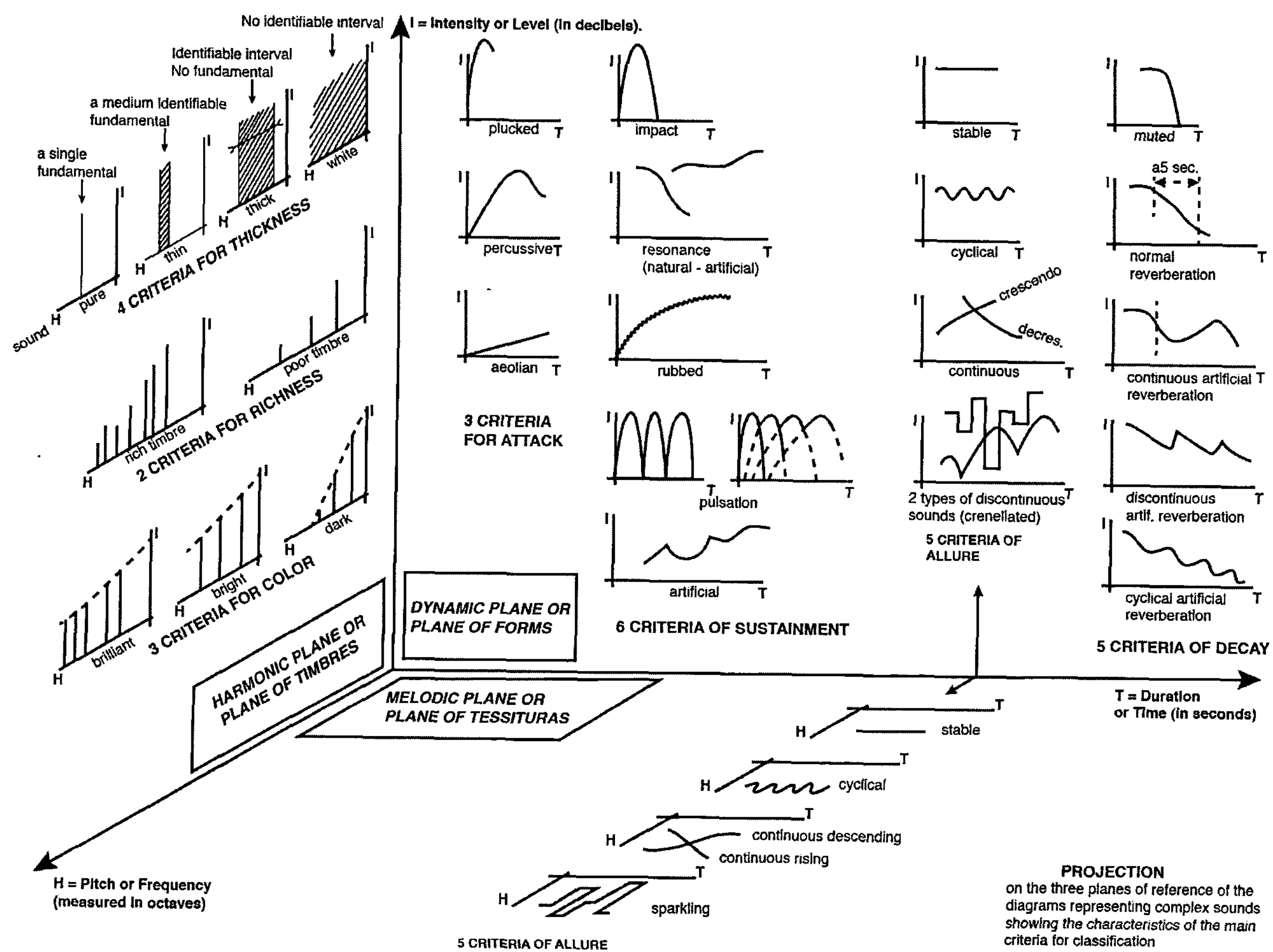
No sustainment at all; *impact*
Sustainment by *natural* or *artificial resonance*
Sustainment of the same type as the attack: *rubbed*
Sustainment by repetition of the attack: *pulsation*
Artificial sustainment by montage

3) Criteria characterizing the allure of the body of the note — 5

Stable (consistent intensity)
Cyclic
Continuous varied *(crescendo or decrescendo)*
Discontinuous (crenellated, etc.)

4) Criteria for the decay of the note — 5

No reverberation *(muted)*
Normal reverberation *(reverberating)*
Artificial reverberation, which may in its turn have the preceding criteria (*continuous, discontinuous, cyclical* reverberation)



PROJECTION
on the three planes of reference of the diagrams representing complex sounds *showing the characteristics of the main* criteria for classification

B.	*Harmonic plane or plane of timbres*	
	1) *Thickness of sound* (or purity)	4
	So-called *pure* sound (one single fundamental)	
	Thin sound	
	Thick sound	
	White sound	
	2) Strength of timbre	2
	Poor timbre	
	Rich timbre	
	3) Color of timbre	3
	Brilliant	
	Bright	
	Dark	
C.	*Melodic plane or plane of tessituras*	
	As in the case of the dynamic plane, this concerns the allure of the body of the note:	
	Stable tessitura (fixed pitch)	5
	Cyclical (vibrato)	
	Continuous (rising or *falling)*	
	Discontinuous (scintillating)	
	No. of main parameters retained:	33

X. THEORETICAL NUMBER OF SOUND FAMILIES

Thus we can allow about twenty criteria of form, about ten criteria of timbre, and four or five criteria of tessitura. These are, in effect, all the terms in italics in the above summary.

The total number of sounds, grouped into families and identifiable as if they were produced by distinct pseudoinstruments, is therefore, in theory, given by the total number of combinations of these criteria. In reality, it should be much bigger if the degree of importance of each of these criteria were taken into account, for example, if we decided to distinguish sounds that were more or less thick or thin, or attacks that were more or

FIGURE 36 *(opposite).* [Summary table of the main sound characterology criteria defined in each of the planes of reference.]

less plucked or aeolian. On the understanding that, to focus our minds, we limit ourselves to an approximate, and very arbitrary, enumeration that gives a provisional idea of both the number and the degree of intensity of each criterion as set down, we can easily calculate the total number of combinations. This is in fact given by the classification into families of all possible sounds that have in common a criterion of attack, sustainment, or allure or decay (dynamic plane), or else a criterion of thickness, richness, or color (harmonic plane), or finally a criterion of allure in tessitura.

The number of these combinations equals:

$3 \times 6 \times 5 \times 5 \times 4 \times 2 \times 3 \times 5 = 54{,}000$

that is, about fifty thousand possible combinations.

(Clearly this number is significantly reduced when there are overlaps.)

It goes without saying that the first task of classification that must be done in concrete music is to distinguish from the fifty thousand or so possible sound families those few hundreds that on first sight seem to be the most common.

Two families, or more precisely two groups of families, in any case, are very important:

symmetrical sounds (musicians quite improperly say: nonreversible, whereas they are absolutely identical forwards and backwards)

homogeneous sounds, i.e., sounds that are identical to each other in time, and necessarily present as a closed loop, since they have neither attack nor decay

XI. CONDITIONS OF COMPATIBILITY

A sound is symmetrical if it is symmetrical in the three planes of reference (timbre, dynamic, and tessitura) at the same time.

A sound is homogeneous if it is homogeneous in the three planes of reference i.e., if its timbre, tessitura, and dynamic are constant throughout its duration, or throughout the duration of a certain portion of the sound, which will be a homogeneous fragment.

Homogeneous sounds have important applications in concrete music, where in particular they provide loops for new instruments called *phonogènes* (French patent no. 561. 539).

XII. APPLICATION OF CLASSIFICATION CRITERIA IN CONCRETE MUSIC

The classification of the elementary sound object and the complex note, based on spatial representation of level, pitch, and duration, which we have set out above, is fundamental. But while allowing the problem of characterization to be tackled in an intelligible form, this clearly has serious disadvantages, one of which is the multiplicity of aspects a note can have, a multiplicity that is difficult to grasp through a simple formula. Physical classification, which is done in parallel with this, and which does not come up against this obstacle, cannot really be used in practice except as a rough guide, where a precise numerical expression is required, i.e., for the technician of concrete music.

Generally speaking, in experimental practice and especially in artistic creation, we should be wary of aspects of phenomena that are too precise, not because they are inaccurate, but because they polarize the observer's mind and consequently tend to restrict his imaginative powers, an error that raises the hackles of every experimenter in concrete music. Therefore, numerical or descriptive classification should only be used to set up a more *formal,* direct and comprehensible, even if more superficial, classification using the vocabulary set defined above.

This objective classification seeks to define the essential *apparent features* of the complex note, which can be referred on an individual basis to any of the planes, and to any of the parameters we have discussed previously. So it will try to establish a list of priorities for the questions to be asked in the process of a descriptive definition, or, if you will, the order in which the relevant parameters should be considered. For these purposes, it will be based on perceptual appreciation, which will reintroduce the listener's consciousness as a fundamental element in the apprehension of musical forms.

In practice, we shall study the general characteristics of a sound in the following order:

- First, we shall see if the sound possesses any clear characteristic without bringing in the concept of plane of analysis: an artificial, reversed or dissymetrical sound, for example.
- Then we shall consider whether there are any characteristics that establish a correlation between the planes of analysis above: thus, the "vibrato" is a phenomenon that very frequently occurs simultaneously in the dynamic and the melodic plane.
- Only then, if the complex note being studied resists these attempts at immediate analysis, shall we systematically examine its characteristics in relation to the different planes, taking them in the order in which they draw our attention, or, failing this, in this order: plane of timbres, dynamic plane, plane of tessituras. In fact, it very frequently happens that a sound presents a clear dominant characteristic and the others are only working adjuncts in comparison.
- Only when very similar complex notes need to be differentiated will quantitative notations for each plane be introduced, which will, in any case, in every case enable us to achieve an objective classification, involving, it is true, a complexity that we could still well do without.

XIII. CLASSIFICATION TECHNIQUE

The above outline resolves the problem on the theoretical level, but practice naturally requires the application of these data. A composition of concrete music is ultimately an assembly of structures: complex notes or cells. So at the outset it will use a reserve of "concrete materials" in a repertoire of structures. In general, each of these elements will be in the form of a recording on a disc or tape, carrying a number referring to an index card with an intelligible description of its characteristics.

A concrete music laboratory therefore has, for the richness essential to both theoretical research and experimental works, the greatest possible number of sound structures from prior experimentation. As experimental discoveries come in unpredictable order, each of them will be card-indexed, with recordings in chronological order. They are a purely practical catalog.

As the card index is built up, an analysis of it should be made and kept up to date in order to make the connections necessary for the most interesting structures to be classified into families. It is without any doubt this analytical card index that will enable progress to be made in the understanding of the musical object.