James Ingram

The Notation of Time

A too pragmatic approach to the problem of notation has many disadvantages, among which is the encouragement of the reactionary belief that the experiments of the fifties and sixties can be written off as the ravings of a group of dilettantes. It must be admitted that those experiments have failed to supply us with any powerful alternative solutions, but the unquestioning use of the standard notation (and the consequent lack of understanding about the reasons for its particular conventions) is responsible for much sterility in the world of new music.

The achievements of this notation are very considerable, but it is my contention that there are important areas (above all with regard to the subdivision of time) in which the conventions that control the symbols have no relation to the events experienced by musicians, and that these areas are masked by a continuing tradition of performance practice. My intentions are, however, not entirely negative, and I hope that while destroying some of the credibility of the standard notation I can promote a more thoughtful attitude to the subject, and show that it is possible to develop more efficient notations.

As we know it, the standard music notation is fundamentally dualistic. The real world is described as differing from a formal world by means of an element that we call 'expressivity'. This dualism between the absolute world described by the symbols, and the vaguely defined expressivity, lies at the heart of the problem of modern notation, and a brief review of its evolution is therefore necessary.

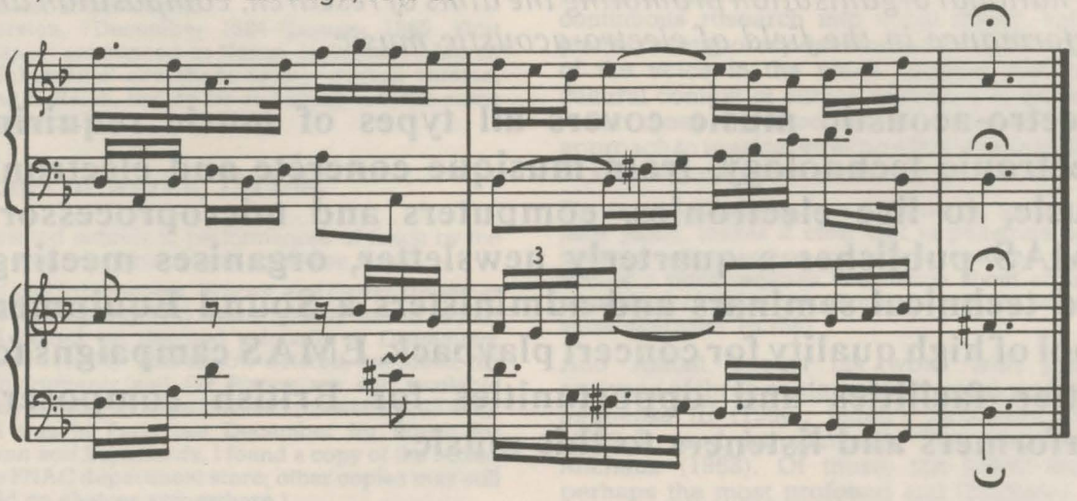
Although this kind of dualism can be traced back to Plato, serious attempts to notate musical time begin with the invention of clockwork in the 15th and 16th centuries. Clockwork was invented by men who were trying to predict the motions of the stars. It was therefore, from the beginning, closely related to the idea of heavenly immutability, and consequently had a profound effect on contemporary thinking about time.[1] Regularity and quantisation were, at this period, given a new emphasis both in the music and in the new notations (by means such as bar-lines and duration flags). Bar-lines and graph paper have much in common, and graph paper was to play a crucial part in the advances of 17th-century science.

Newtonian mathematics treated the dimensions of space and time as being formally equivalent (as is the case in clocks and other mechanical objects), and made use of powerful notations to describe certain formal systems. The correspondence between such systems and the real world was, at first, a matter of heated debate, but Newton and his followers were eventually victorious because they were overwhelmingly successful in the field of mechanics, and because they were able to limit the argument to areas in which they could reason logically.

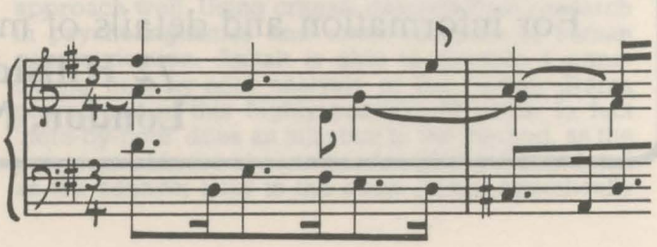
Such impressive progress in physics inevitably led musicians to try to improve their own notations, and it is no accident that the ornament signs (𝆖 𝆗 𝆘 𝆙 etc.) were replaced at this time by written-out decorations using the much more powerful duration symbols of a more formal system. It should be noted that the symbols were not used as rigorously then as later; this was due to the intrinsic impossibility of describing contemporary performance practice in terms of any absolute world (witness the many books on the subject). Nevertheless, there was a wish to formalise the notation and it developed

Example 1

(a) J.S. Bach, from *Die Kunst der Fuge*, 1749-50



(b) Bach, Sarabande, from Partita BWV829



The alignments are those of the edition published by Bach himself in *Clavier-Übung*, vol.1 (Leipzig, 1731)

accordingly.

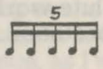
During the 18th century there was a tendency for composers to try to narrow the gap between the world described by their notation and the real world of performed music. There were, of course, very pragmatic reasons for this, apart from the understandable desire to appear logical. Composers had particular difficulty in deciding how to represent durations having proportions other than 1:1 or 1:2—triplets first appeared towards the middle of the century, and the dotted rhythms of the period (Example 1) were a source of much puzzlement to 19th- and early 20th-century musicians (and engravers).

When the early Romantics introduced 'irrational' durations, in order to break out of the limitations set by classical notation, they did so at a moment of supreme confidence in the system. The convergence, during the previous century, of compositional style with the possibilities inherent in the notation had, after all, been crowned by some very great pieces of music. Composers were, as always, concerned primarily with the effectiveness of the notation and secondarily with its logicality. The beginning of the 19th century was far too early for anyone to be questioning received wisdom about the nature of the (Newtonian) world. Interestingly enough the Romantics are the supreme dualists.

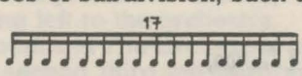
At this period the remaining 'illogicalities' within the notation were finally resolved and there have been exact rules for the use of dotted notes and subdivision symbols ever since. These rules demand that duration symbols should add up within a bar: they thus involve the theoretical equivalence of a duration symbol with a segment of absolute time—one should in principle be able to substitute an absolute value (number of seconds) for each duration symbol.[2] (It was also at this date that the metronome became important.)

The confusion surrounding 'irrational' durations arises because in absolute time the size of a time segment can be determined without reference to its context. Musicians thought they were subdividing time, when they were really comparing tempos. Contemporary philosophy treated time as if it were equivalent to a dimension of space, and it seemed natural, when it was found possible to distribute the symbols regularly by subdividing a single segment of space, to think that time could be treated in a similar manner (Example 2).

The subdivision of a single time segment is, however, completely impossible. In order to subdivide anything equally, we first need to know how big it is. In time, this means being given at least one more (comparable) time segment as a unit of measurement. For



to be meaningful, two tempos must exist. Firstly the tempo created by the total length of the group and the preceding unit of measurement, and secondly the tempo created by the notes within the group. Symbols for high degrees of subdivision, such as



are meaningless because the notes cannot be played fast enough to produce a total duration shorter than the maximum that can be accurately remembered.

Once expressivity had been necessarily established as an article of faith, it was inevitable that tempos should become more flexible—and that the notation should cease to develop! (Musicians do, after all, live in the real world, where the use of rigid tempos is not obligatory.) This had the effect (since subdivision is the estimation of a tempo relationship) of forcing musicians to rely more and more heavily on (unnotated) performance practice in order to remain synchronous: one learns how to play Wagner in rehearsals, not just by reading the notes. Visual (conducted) and aural cues thus became increasingly important.

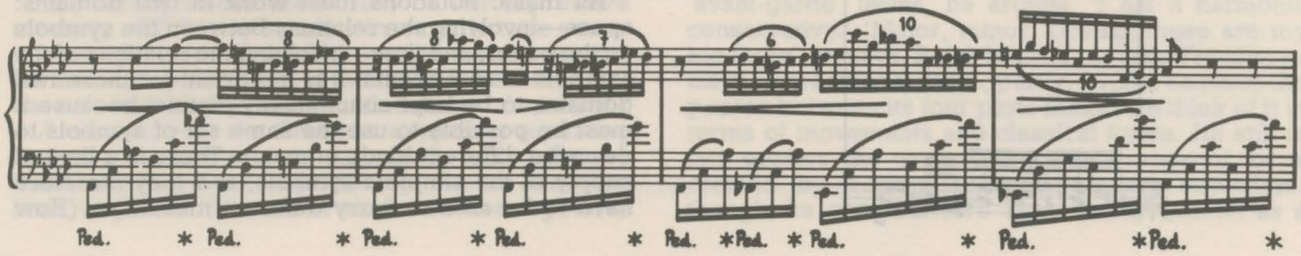
It is not surprising that the widening gap between the real world and the conventions governing the symbols eventually led to a catastrophic loss of control. The famous collapse at the start of this century is often wrongly and rather vaguely interpreted as being the result of an exhausted harmonic language. Time and harmony are of course related, but time is the more fundamental. The classical rules of harmony assume that simultaneities are predictable, and when this was no longer the case the rules simply became meaningless. We know from early recordings that very considerable amounts of *rubato* were used at this date (and not only in performances of the then contemporary music).

Composers *write* music, and their natural reaction to a hopeless situation was to decide that expressivity had caused the problem, and that the exact correspondence between the duration symbols and absolute time (which had become an integral part of their notation) should be 'restored'. It is, of course, impossible to remove half a dualism and retain a system that will work in the real world. Compromises therefore had to be made from the start. The 19th-century expedient of relying on performance practice to ease the apparent rigidity of the notation was, however, not acceptable—it was thought to have been entirely responsible for the recent disaster! The consequent overuse of rigid tempos led, inevitably, by the middle of this century, to the composition of some incredibly boring music.

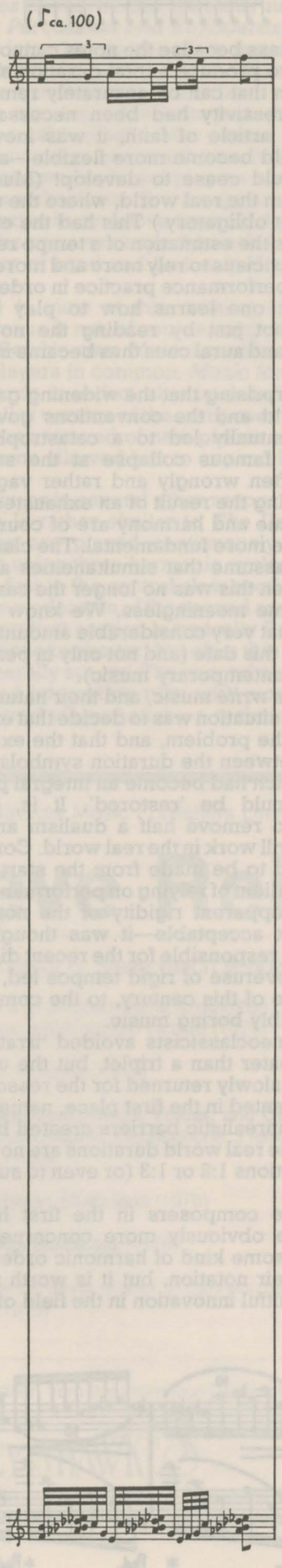
The early neoclassicists avoided 'irrational' subdivisions greater than a triplet, but the use of such subdivisions slowly returned for the reason that they had been invented in the first place, namely to break through the unrealistic barriers created by classical notation. In the real world durations are not restricted to the proportions 1:2 or 1:3 (or even to sums of such proportions).

Progressive composers in the first half of this century were obviously more concerned with re-establishing some kind of harmonic order than with rethinking their notation, but it is worth noting that their most fruitful innovation in the field of technique

Example 2 Chopin, Ballade op.52, 1842, bars 152-5

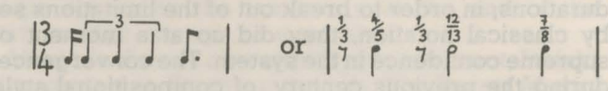


Example 3



(serialism) blurs the distinction between vertical and horizontal.

Because the equivalence of the duration symbols to absolute time was not in question, there seemed no obstacle in the early 1950s to the introduction of an unrestricted use of fractional durations. However, as I have already shown, 'subdivision of time' is really a loose term meaning the existence of a tempo relationship; it is therefore nonsensical to use subdivision symbols to write music that avoids a perceivable tempo of reference. The expression of durations as precise fractions of other durations inevitably leads to serious restrictions on the positions in space and time at which they can begin. Diagrams such as



are possible only as constructions in space, in spite of their seeming to represent perfectly reasonable segments of absolute time. They do not, however, mean anything, because each fraction is not preceded by a duration of comparable size, and there is therefore no tempo of reference for the 'subdivision'.

Of the attempts to create expressive (non-rigid) notations, the most important is space-time notation whose expressivity is stressed because it is, for typographical reasons, impossible to read accurately. Unfortunately the inability to perform it correctly also restricts the amount of information it can successfully transmit, and therefore its degree of usefulness as a music notation. That it remains fundamentally dualistic is revealed by equations such as 1 cm = 1 second. Composers were still notating an ideal world from which the real one would differ, and another catastrophe was unavoidable.

That the available notations all seemed to be in some way out of control, contributed to the idea that 'chance' could play a significant part in musical technique. If there is a weak link between the symbols and the reality, then the symbols can be moved about at random without affecting the reality significantly. No rational organisation of the symbols will alter the reality significantly either. Randomness can in this situation be used instead of expressivity to complete the dualism inherent in the notation.

The proliferation of different ways of describing time led to a situation in which it was thought that different kinds of time actually exist.[3] Though understandable, this view is unrealistic and lacks a convincing simplicity. It is possible to formulate any number of ideal worlds from which the real one will differ more or less significantly, and within each of these worlds rules may be applied with great freedom and logicality. But problems will always arise when such absolute worlds are translated into the real one via interpretation.

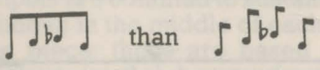
It is now more than 80 years since physicists began telling us to regard with suspicion the Newtonian world view which makes this kind of dualistic thinking necessary. The remainder of this article describes a practical, non-dualistic, approach to the problem of notating musical time.

All music notations must work in two domains: space—involving the relations between the symbols on the paper; and time—involving the relations of the symbols to real events. It is important for these two domains to be kept conceptually distinct because it must be possible to use the same set of symbols to describe different kinds of music. There is a limited supply of the simplest symbols, and they therefore have to be able to carry different meanings. (How

many ways are there to use a dot?) In order to process the information carried by a symbol it first has to be read, and legibility is therefore a major requirement of any notation. Since the standard notation is the product of an evolution lasting several hundred years, we may expect it to contain some valuable lessons about legibility, and a closer inspection is therefore in order.

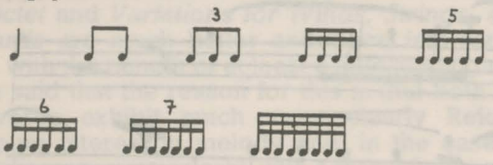
As part of their concern with notation, composers in the fifties and sixties made a concerted attempt to improve the standard notation, but with only limited success. They did not fail simply because musicians were unwilling to change old habits. It was generally thought that smoother symbols would lead to a less cluttered notation, and would therefore be easier to read. This is sometimes, but not always, the case. The substitution of straight flags for curly ones on the duration symbols was perhaps the most successful reform of this type. The failures were more numerous, and included the attempts to replace oval note-heads with round ones and five-lined staves with fewer lines, to introduce different kinds of symbols for the accidentals, and, in texts, to use sanserif typefaces instead of serriffed ones. A detailed psychological analysis would be necessary in order to explain this patchy success, but as usual, musicians will be content with a more pragmatic approach...

The importance of being able to read whole groups of symbols as composite entities has been realised only in the last couple of decades (the lack of such entities in space–time notation is a major reason for its illegibility). It used to be thought that we read words letter by letter or understand language sound by sound, but it has become clear that the ability to make high level descriptions is crucial. In music notation, beams and ligatures assist in just such a function—how much easier it is to read



Beams create word-sized objects which are read as single entities. Bar-lines have a similar function at a higher level.

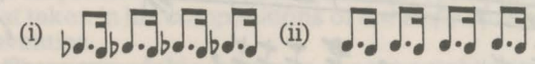
Consider the following series of composite symbols simply as a set of ink marks:



In the standard notation these diagrams obey a typographical rule, which states that they can be interchanged at will in the space between two imaginary vertical lines on the paper. Notice that note-heads require a discrete quantity of space, and that there is a characteristic minimum space into which each composite symbol will fit. Nowadays, when notating two such groups one above the other, every conscientious copyist will work out the order in which all the notes come in absolute time, and then ensure that the note-heads come in this order from left to right on the page, regardless of the tempo or any spatial considerations. This procedure is often accompanied by the feeling that he is doing something rather silly! In minimum horizontal space, and with awkwardly occurring chords and accidentals it can lead to situations like that shown in Example 3.

Since the function of a beam is to make a 'word' that is read as a single object, it seems curious that absolute time should have any particular significance within it. In such extreme cases all copyists will occasionally be satisfied with simply making sure that the outer verticals are correct. (I do not, however, recommend sloppy copying!) That the notation can remain legible, even in rather brutal circumstances, is one of the main reasons for its success. Such resilience can be observed in Example 4. Notice that this copyist thinks of bar-lines as enclosing packets of information, and that notes therefore tend to come in the middle of a bar, with the spaces between symbols being of no significance. A symbolic use of space developed during the course of the 19th century because the symbols themselves are not efficient enough in complicated music. In recent decades the space following a bar-line has often caused problems because these two ways of using space are not compatible.

The symbolic use of space is not, however, a simple matter, since the sizes of symbols and the physical confinement of a sheet of paper must be taken into account (as we have seen, the idea that space can be directly equivalent to time also contributed to the confusion surrounding 'subdivision'). Although the note-heads in the following examples are identically spaced, the spacing of (i) is correct in a constricted space, while (ii) is nowadays always incorrect.



Notice that we do not measure such spaces according to some absolute standard (we do not need a ruler to measure them or get them right), and that it would be incorrect always to reserve exactly 32 times as much space for a semibreve as for a demisemiquaver. In fact semibreves are nearly always shorter than that. This has to do with the way we read (whether we understand it or not) and the practicality of including as much information on the page as possible.

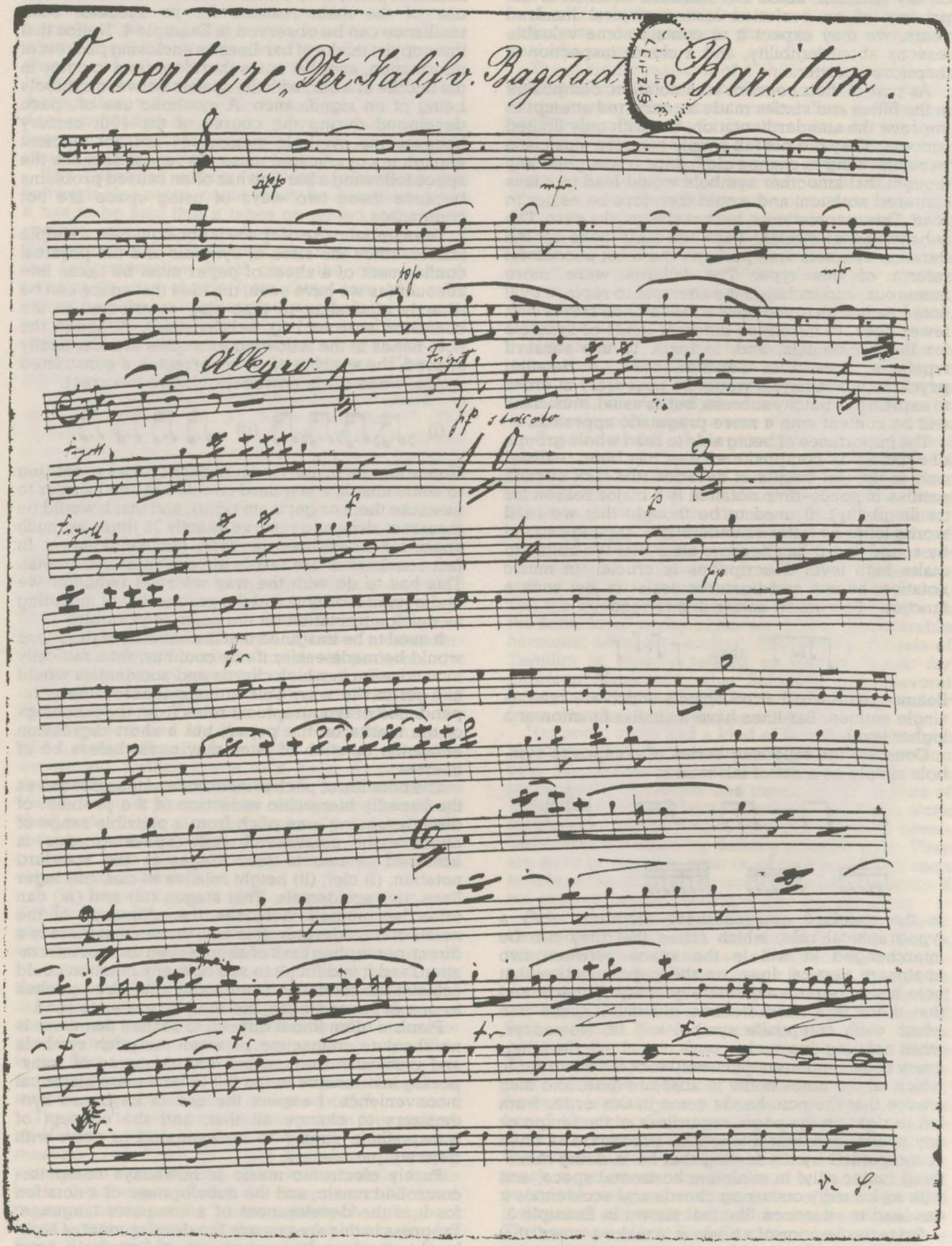
It used to be imagined that the notation of durations would be made easier if one could invent a radically new notation in which chords and accidentals would not get in the way. This attitude ignores the independence of typographical rules from the meanings of the marks on the paper, but a short digression about the notation of pitch may nevertheless be of interest.

The notation of pitch in instrumental music requires the broadly hierarchic reduction of the problem of directly 'seeing' one pitch from a possible range of about eight octaves. Broadly speaking, this is achieved in two to four stages in the standard notation: (i) clef, (ii) height relative to clef, (iii) leger lines, (iv) accidentals. That stages (iii) and (iv) can often be omitted increases the efficiency of the notation considerably. It is well known that there is a direct-perception limit of about seven units of information, and it is difficult to see how any notation could achieve the reduction from about a hundred pitches to one in fewer stages and thus be easier to read.

Pianists often find it difficult to realise that there is no absolute connection between the pitch symbols and particular frequencies, the existence of transposing instruments being felt to be a mere historical inconvenience. I expect the use of keyboard synthesizers to change all that, and the concept of transposition simply to be extended to cope with different parameters.

Purely electronic music is nowadays computer-controlled music, and the development of a notation for it is the development of a computer language. Progress in this area means the development of high-level computer languages, whose symbols have useful and intuitively graspable meanings for the users. There is no fundamental reason why the

Example 4 Adrien Boieldieu, *Le calife de Bagdad*, 1800 (19th-century copy)



symbols of such languages should be alphanumeric—indeed words and numbers have never been very good at describing musical objects. Incidentally, it should be remembered that computer specialists measure time in terms of the smallest repeatable unit that can be found (for example the single vibration of a particular crystal) and that time appears not to subdivide for them either! Machines can produce streams of equal time segments because those time segments are individually related to the machine's unchanging physical structure. Musicians, however, relate time to their short- and long-term memories rather than to the physical objects in their brains, and the circumstances under which they perform are therefore very different. The degree to which one can communicate with a computer in terms of less rigid time will, I think, be a good measure of its 'intelligence'.

While the standard notation can boast a high degree of legibility, it must be said that its evolution has also resulted in some very doubtful accretions. These must now be examined and, where necessary, pruned away. I am attempting to produce a non-dualistic notation, so all metronome marks and other references to absolute time have to be dispensed with. Tempo is to be considered a local phenomenon which may or may not be used in a composition. It is not necessary, in a long series of supposedly equal time segments, to compare the first with the last—one need only compare them locally in order to experience tempo. The experience of a persistent tempo involves remembering that the experience of local tempo has itself persisted! This is an experience of a different order. Whether there is a tempo or not, the absolute tempo (measured by a stopwatch or a metronome) is redundant, since the units in terms of which the time will be measured or defined will be actual, recently performed, time segments. Such a concept of tempo is normal in performed music.

All references to subdivision (⌐—3—¬ etc.) should be removed because their use implies that durations occur only in rational proportions, and because it is meaningless to use such symbols in music that does not necessarily have a rigid tempo. It is no longer necessary to have symbols for fractional durations in order to make the bars add up in absolute time. Notice that while the use of a bracket to indicate irrational subdivisions such as the triplet is a recent invention, even the numeral was optional until the middle of the 19th century. As we have seen, the augmentation dots (♩.) are close relatives of the subdivision symbols and should therefore share their fate. These dots may have uses later, but for the moment let us regard their function as purely cosmetic and dispense with them.

The introduction of grace notes into the standard notation was a necessary expedient. In using them a composer says that he is unable to define the symbols in terms of either absolute or local time. It is unnecessary to consider them while formulating precise typographical rules for symbols that will be able to carry meaning in local time.

As we have seen, the space following a duration symbol has gradually increased in significance in order to increase the symbol's legibility. The space following a bar-line is not related to a duration and should therefore be abolished. The bar-lines themselves do, however, have important functions relating to legibility. They are convenient signposts for conductors, they break up the space into manageable units for the eyes, and they assist in general orientation at rehearsals. They will therefore remain, even though they will not retain all their original functions. The meanings of all symbols are to be considered freely composable.

Our textbooks are often rather vague about the number of duration symbols that exist:

𝅜 , 𝅝 , 𝅗𝅥 , ♩ , ♪ ,

𝅘𝅥𝅯 , 𝅘𝅥𝅰 , 𝅘𝅥𝅱 etc.

That there is potentially an infinite number of them was important at the end of the 17th century when, as we have seen, composers were replacing the ornament signs. In practice, of course, symbols such as

have never been used (even though they are members of the same group of symbols) because they are illegible and take up too much space on the page. Notes longer than a breve or a semibreve are still expressed using a symbol of a different type (the tie) and certain ornament signs (e.g. *tr*) are still used even though the duration symbols are capable of describing time segments of the same order of size. The duration symbols have therefore not been entirely successful in describing all kinds of musical objects. The use of the tie, combined with the (potentially infinitely small) duration symbols, means that we have symbols for durations extending infinitely in both directions away from the orders of size necessary for pieces of music. This seems excessive, and in my opinion the above series of symbols should be cut short at the short end. Needless to say, this has consequences.

Such drastic trimming necessitates a redefinition of the typographical rules for the remaining symbols. It is necessary that, after redefinition, the symbols behave in a way that resembles their previous behaviour as closely as possible. This will preserve their legibility and ensure that any confusion among players is kept to a minimum. Consider two fixed verticals on a sheet of paper, and use the 𝅝 to symbolise a note occupying that space. In standard notation four, five, six, or seven ♩ s can also occupy that spaces, and in general the numbers of symbols that can lie between the verticals (assuming the smallest symbol to be a 𝅘𝅥𝅱) are whole numbers lying between the following limits:

$$1 \leqslant \text{𝅝} < 2 \leqslant \text{𝅗𝅥} < 4 \leqslant \text{♩} < 8 \leqslant \text{♪} < 16$$

$$\leqslant \text{𝅘𝅥𝅯} < 32 \leqslant \text{𝅘𝅥𝅰} < 64 \leqslant \text{𝅘𝅥𝅱} < 128$$

As I have already shown, a major problem with the standard notation is that it can represent duration proportions only as the ratios of small whole numbers. If we now extend the definition of the symbols by allowing all real values (rational and irrational) between the above limits, this artificial barrier will be removed (for example, if there are 5.63 equally spaced notes in that space then they willbe ♩ s). It is clear that there are limits (having the proportion 1:2) on the space that can be occupied by any one symbol. If, for example, the verticals were 16 cm apart, then these limits would be (in cm):

$$16 \geqslant \text{𝅝} > 8 \geqslant \text{𝅗𝅥} > 4 \geqslant \text{♩} > 2 \geqslant \text{♪} > 1 \geqslant \text{𝅘𝅥𝅯}$$

$$> 0.5 \geqslant \text{𝅘𝅥𝅰} > 0.25 \geqslant \text{𝅘𝅥𝅱} > 0.125$$

Notice that a symbol does not define a distance but any particular distance is associated with a particular symbol.

These absolute limits will change according to the density of information on the page or in a particular bar. If there is no symbol shorter than a ♪ then everything can be closed up (the meaning is associated with the symbols and the relative distances between them), but a vertical line drawn through any point on the page will always pass through symbols and spaces that observe limits of this type (ratio 1:2) and in particular (in space):

all 𝅝 > all 𝅗𝅥 > all ♩ > all ♪

> all 𝅘𝅥𝅯 > all 𝅘𝅥𝅰 > all 𝅘𝅥𝅱

Notice that there are no absolute limits on the spatial distances associated with a particular symbol, and that these are as yet simply ink marks on paper, which can be replaced by other symbols (e.g. 𝄾 or 𝄿).

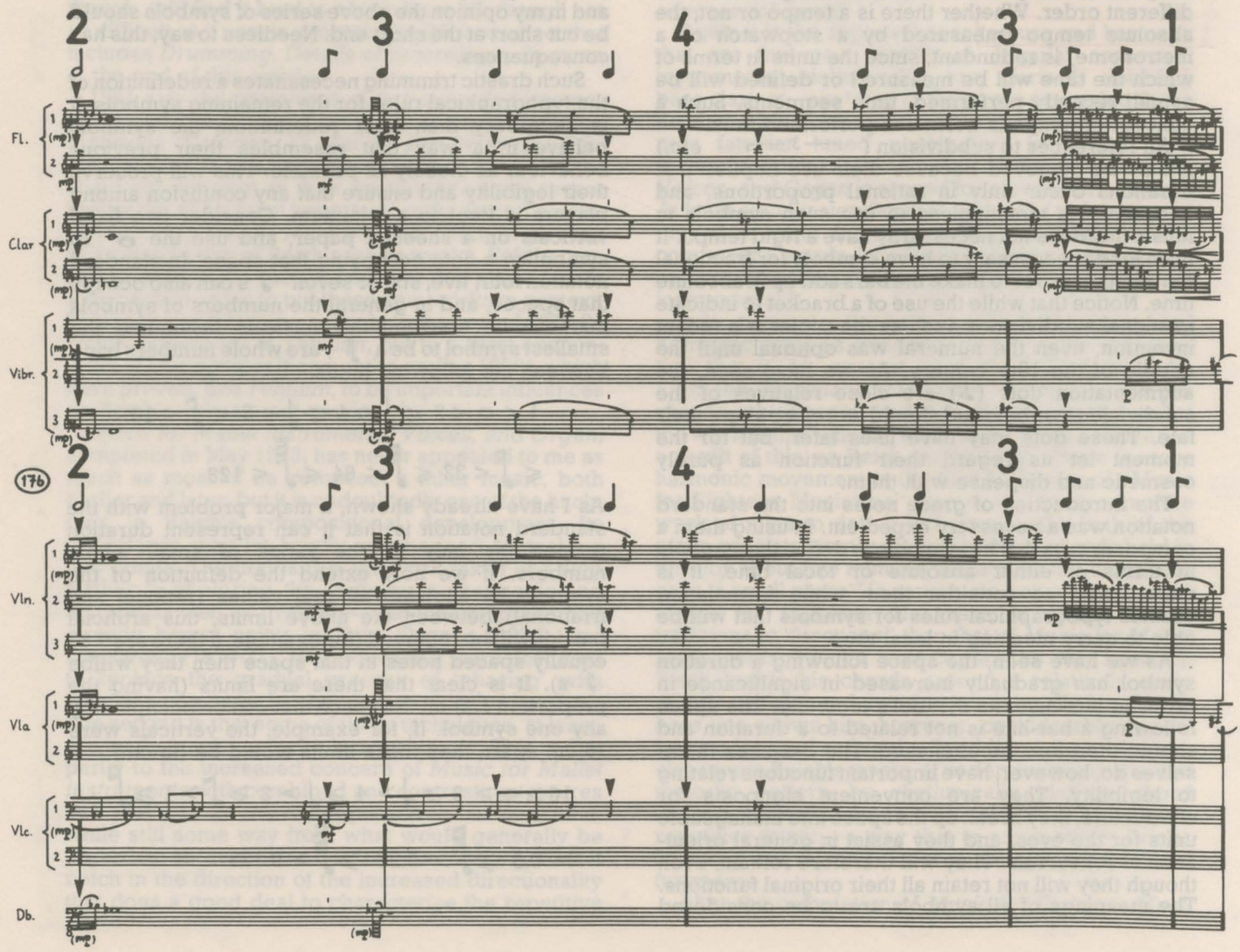
As I have already implied, I believe that the spatial position of notes within groups is of limited significance (because groups are read as a whole) and that flexibility of position at this level can be of great practical use. In this extended notation it is possible to find the duration class of a group by dividing the horizontal space occupied by the group as a whole by the number of notes. This also seems justified on the grounds that each single duration class should be defined by a single distance.

Given a sheet of paper sufficiently large for its physical limits to be ignored, it would be possible to give fixed, absolute values to the distance limits for each symbol, though such a procedure requires an inefficient use of space and is not particularly legible. If accidentals, note-heads, and flags are each 2 mm across, the shortest distance between the beginning of one

and the next will be at least 6 mm. This means that, while all real values greater than 6 mm can be converted into a combination of duration symbols and ties, no combination of symbols can be allowed to produce a distance of less than 6 mm since there is no available symbol. In the end this means that the space will have to be subdivided in some way, if all symbol positions are to be restricted to a 6 mm grid. The inner structure of any piece written in this notation will be deeply affected by the necessity for subdividing space while recognising the impossibility of subdividing time (Example 5).

While clear rules for the spatial arrangement of symbols are indispensable to the communication of information, it should not be imagined that the meanings associated with individual symbols will also be precisely definable. If we abandon the direct

Example 5 James Ingram, *beyond the symbolic*, 1982



relation of symbols to absolute time, there is no reason to assume that symbols devoid of context necessarily have any meaning at all. The uniqueness of any score lies in the contexts created by its symbols, and it is these contexts, re-created in sounds, that make the piece recognisable when the score is performed.

There is a very real sense in which high-level phenomena, associated with the overall way in which the symbols are combined, give information about details of performance practice, and for this reason it is usually possible for musicians to infer the exact meaning of a notation without having to read performance instructions. The use of such instructions should, ideally, save the player's time and give him a sense of security. While asserting that individual symbols do not have any intrinsic meaning, I do not want to appear to have avoided the issue of time itself, but it is, after all, the job of individual composers to provide the contexts that give the meanings.

A word of caution here: the forlorn hope that there could be an exact correspondence between notation and reality has caused much disappointment among composers, and has alienated many performers. It would, however, be equally wrong to think that the inability of notations to tell the whole truth provides an excuse for muddled composers to write unclearly, or for 'virtuosos' to treat scores with contempt. It is of crucial importance that composers use notations that are efficient and precise, but that do not impose unrealistic restrictions or tell actual untruths. I believe that the removal of spatial obstructions from the standard notation can have an effect no less dramatic on the articulation of time, than the removal of inner obstructions had on the spaces articulated by Gothic cathedrals.

[1] It is ironic that this symbol of heavenly perfection and divine will should have become for us a symbol of the negation of humanity.

[2] Mathematicians divide the real numbers into two classes, the rationals and the irrationals. The rational numbers are those that can be represented as the ratios of two whole numbers (e.g. $^2/_3$, $^5/_7$, 1.5 etc.). The irrationals are all those which cannot be so represented (e.g. $\sqrt{2}$, $\sqrt{3}$, Π etc.). The musical terminology is at variance with the mathematical, and in fact musicians ignore truly irrational numbers. This is not surprising, because such numbers cannot be added together and cannot therefore form part of the ideal world described by the standard notation. The notation is, even in principle, unable to describe all absolute, real time values.

[3] See Pierre Boulez, *Penser la musique aujourd'hui* (Paris, 1963); Eng. trans. by Susan Bradshaw and Richard Rodney Bennett, as *Boulez on Music Today* (London: Faber and Faber, 1971), especially pp.91-4.