CELLULAR ORGANIZATION

A **cell** is a small collection of pitches (typically three or four) which, together with its various transformations, and perhaps with other cells, forms the melodic/harmonic basis for a work. While a motive is normally conceived as a melodic/*rhythmic* unit, the cell is a melodic/*harmonic* unit and its pitches can appear in *any rhythmic configuration.* They may also appear simultaneously as a single harmony. Cells are typically transformed with greater freedom than motives, and they may appear in the following forms.

Illustration 17.1

1 Original cell

2 **Verticalization** (all members sounding simultaneously)

3 Octave displacement (one or more members transposed an octave)

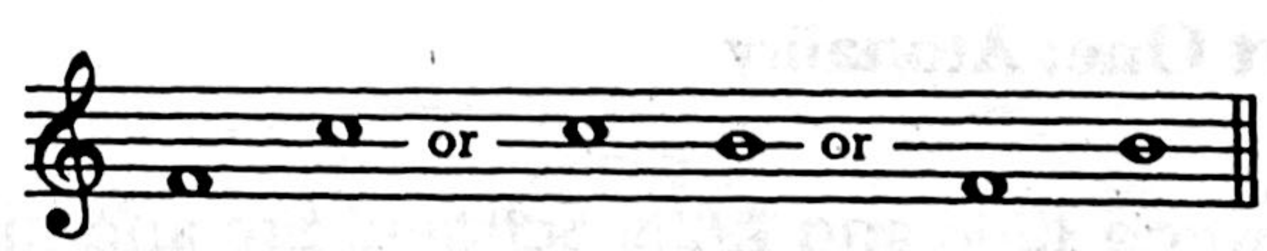
4 Transposition (all members transposed by the same interval)

5 Melodic inversion (Also called **mirror inversion,** each upward interval is replaced by its downward counterpart and vice versa.)

6 **Retrograde** (members in reverse order)

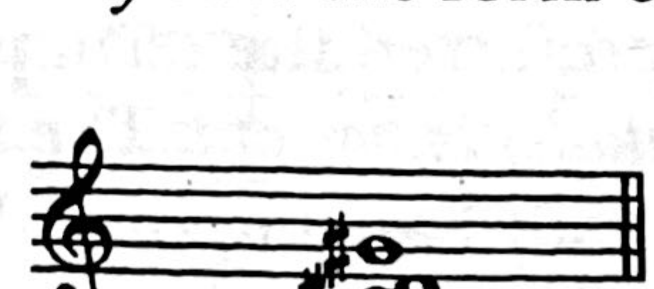
7 **Permutation** (*any* reordering of the members)

8 Fragmentation (omission of one or more pitches)

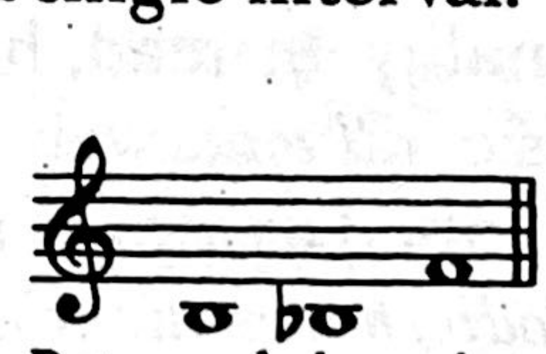


Note: Because of the brevity of the cell itself, this really amounts to a "fragmentation of a fragment" and *may* take the form of a single interval.

9 Any of the above processes in combination



Transposed verticalization of the inversion



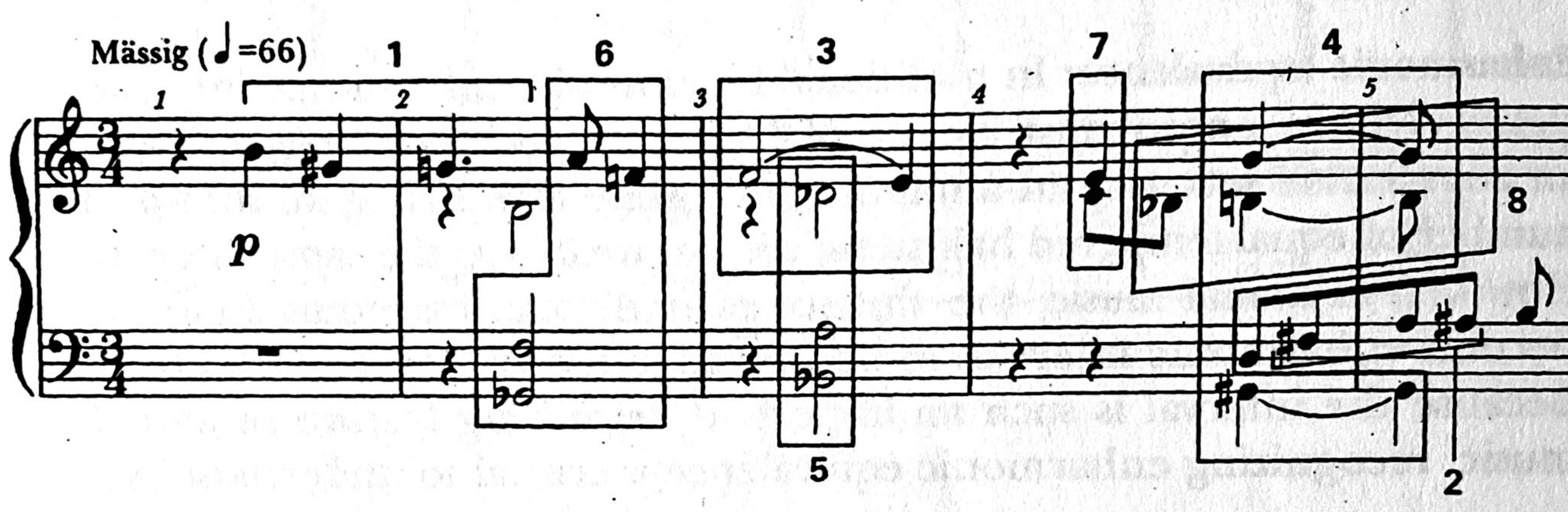
Retrograde inversion

Note:

Retrograde inversion is normally accomplished through *retrograde* (reverse order) *of the inversion* (R of I), not through *inversion of the retrograde* (I of R). With this particular cell, either procedure yields the same result. However, in most cases, R of I and I of R will yield different transpositions.

The following excerpt, from one of Schoenberg's earliest atonal compositions, shows several of these transformations in combination, employed with the consummate artistry and subtlety of a master composer.

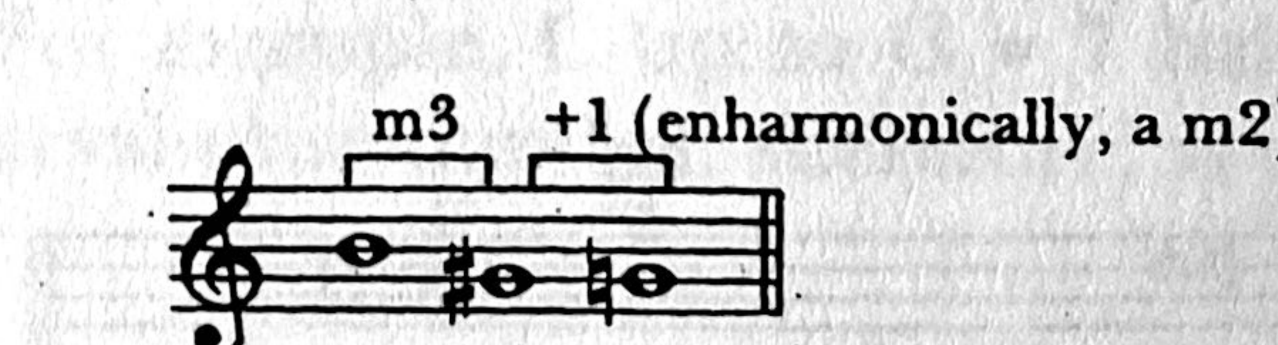
Illustration 17.2 Schoenberg: *Klavierstücke, Op. 11, No. 1**



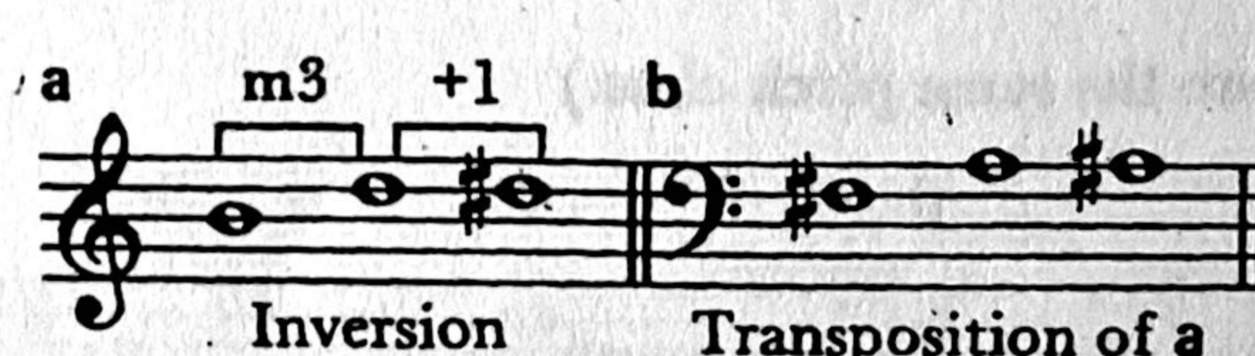
Used by permission of Belmont Music Publishers, Pacific Palisades, CA 90272.

*This piece is contained in its entirety in *Anthology for Musical Analysis*, fifth edition, by Charles Burkhart (Harcourt Brace College Publishers, 1995).

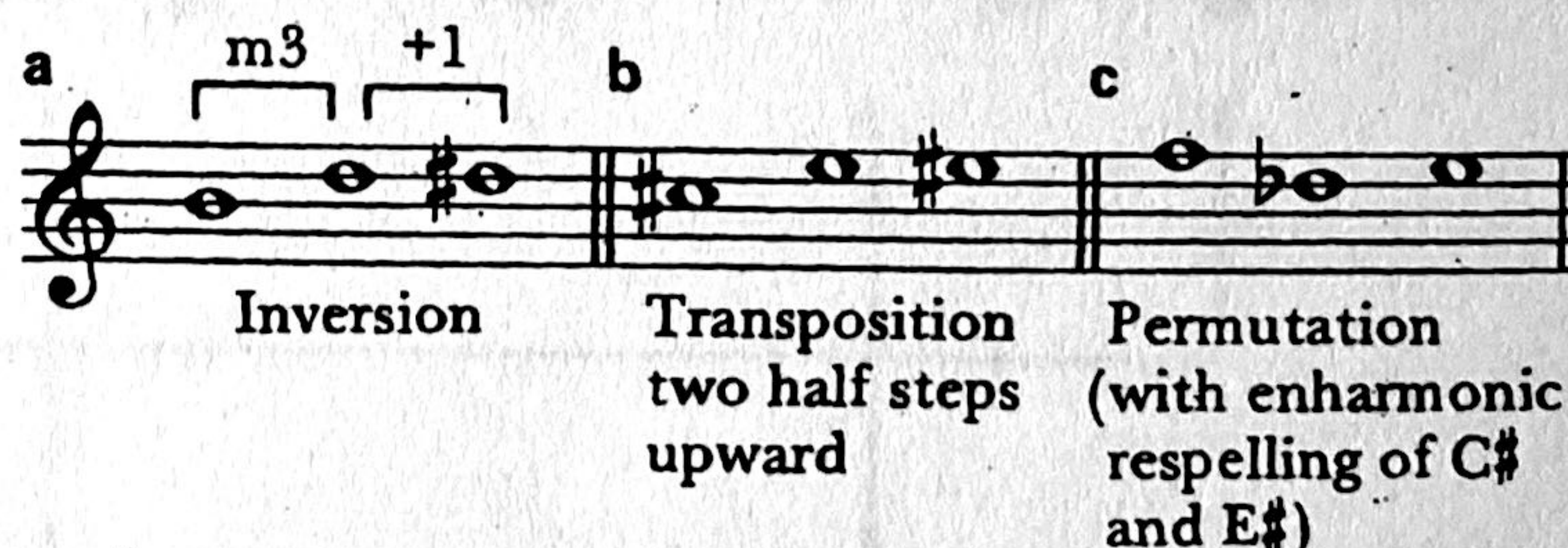
1 Original cell



2 Transposed inversion (the process is shown in steps **a** and **b**)



3 Permutation of transposed inversion (the process is shown in steps **a**, **b**, and **c**)



4 Verticalization with octave displacement (the process is shown in steps **a** and **b**)

FOR CLASS DISCUSSION

In a similar manner, describe the transformations that appear in boxes 5–8 in Illustration 17.2.

Practice Assignment A on page 392 can be completed at this time.

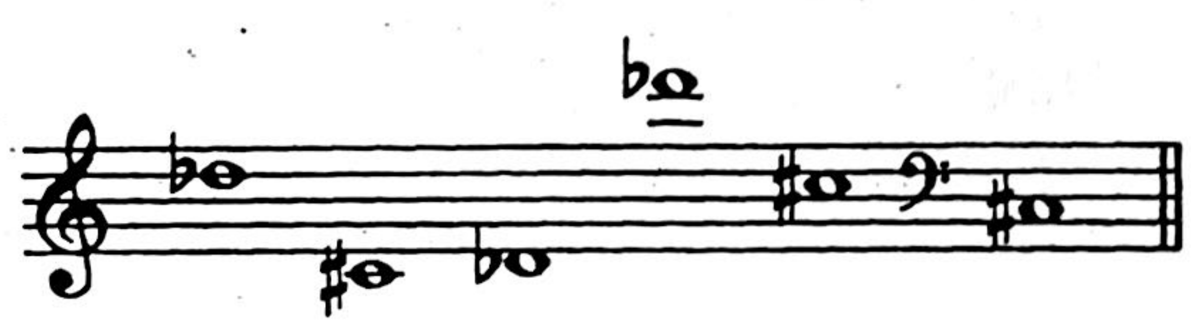
FUNDAMENTALS OF SET ANALYSIS

Because of the great freedom with which composers have manipulated cells, a method of analysis using principles of *set theory* has been found useful. The following concepts are fundamental to an understanding of this analytical tool.

Enharmonic equivalence: In traditional tonal music, enharmonic intervals sound identical only on instruments of fixed pitch, such as the piano. Thus, an augmented second and a minor third, while comprising an identical number of equal-tempered half steps, are not treated as the same interval. However, in atonal music, the absence of traditional harmonic function permits enharmonic intervals to be treated and considered as identical. Because the interval is such an important organizing feature in atonal music, recognizing enharmonic equivalence is crucial to understanding.

Pitch class (PC): any given pitch and all its octave transpositions and enharmonic spellings.

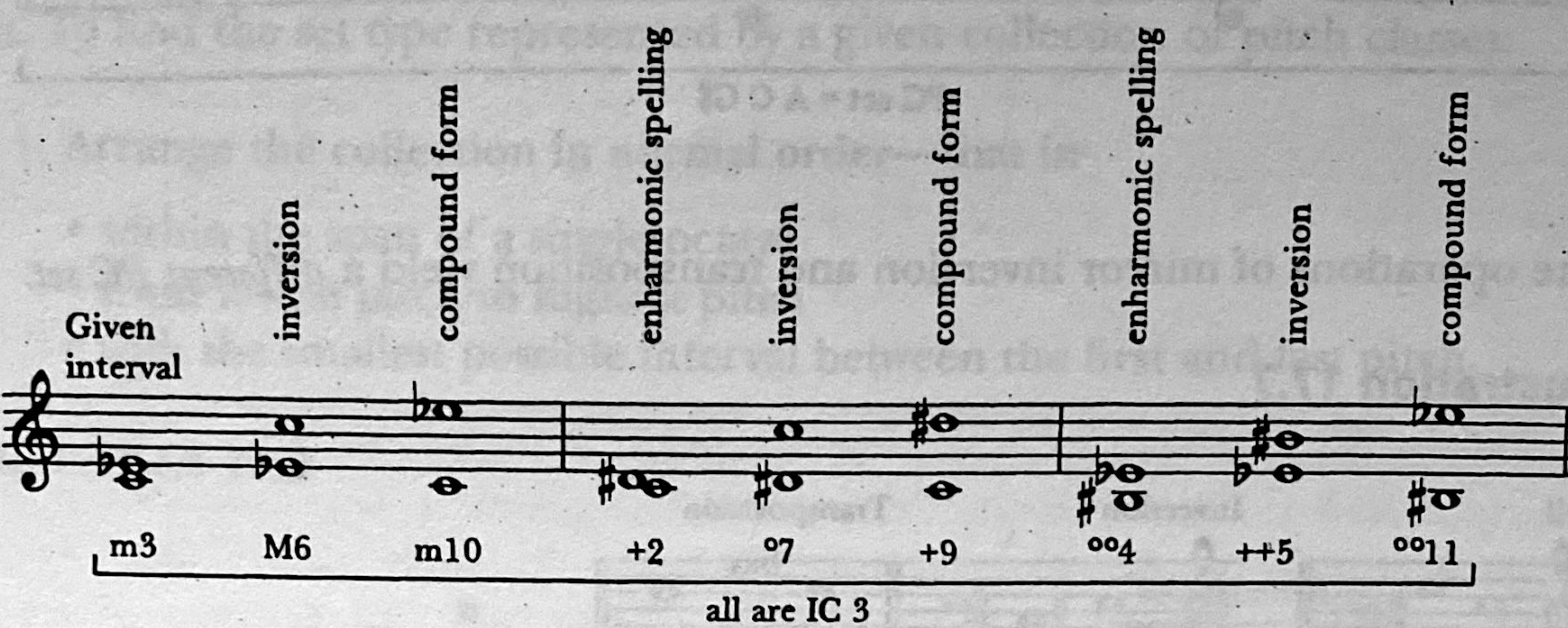
Illustration 17.3



(All are the same pitch class.)

Interval class (IC): a group of intervals that can be arranged through octave transposition to contain the same number of half steps. Any single interval, its inversion, and all associated enharmonic spellings and compound forms compose a single interval class. For example, all these intervals belong to the same interval class: IC 3. That is, all can be arranged to comprise three half steps.

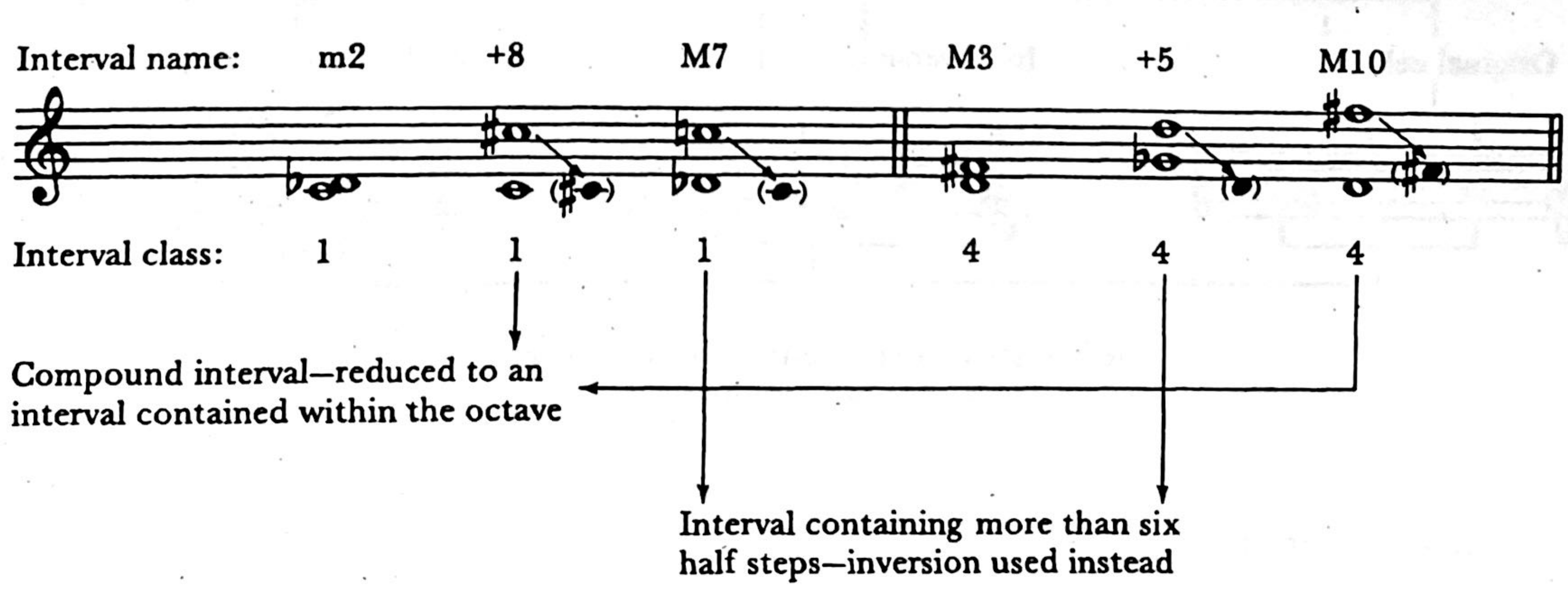
Illustration 17.4



In determining interval class:

1. Compound intervals are reduced so that they lie within the octave.
2. Simple intervals containing more than six half steps are given the interval class number of their inversion. This can be found by subtracting the number of half steps from twelve. For example, C up to G = 7 half steps. 12 – 7 = IC 5. The largest interval class number, therefore, is 6 (six half steps).

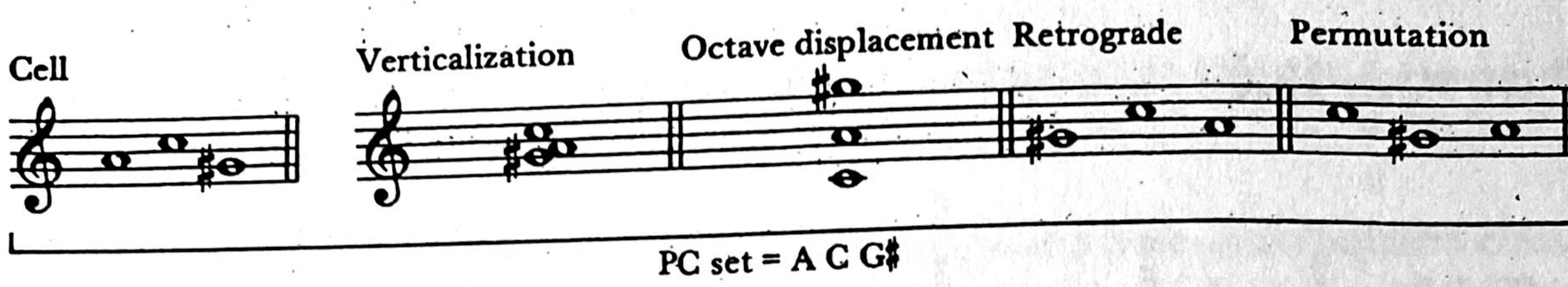
Illustration 17.5



Practice Assignment B on page 393 can be completed at this time.

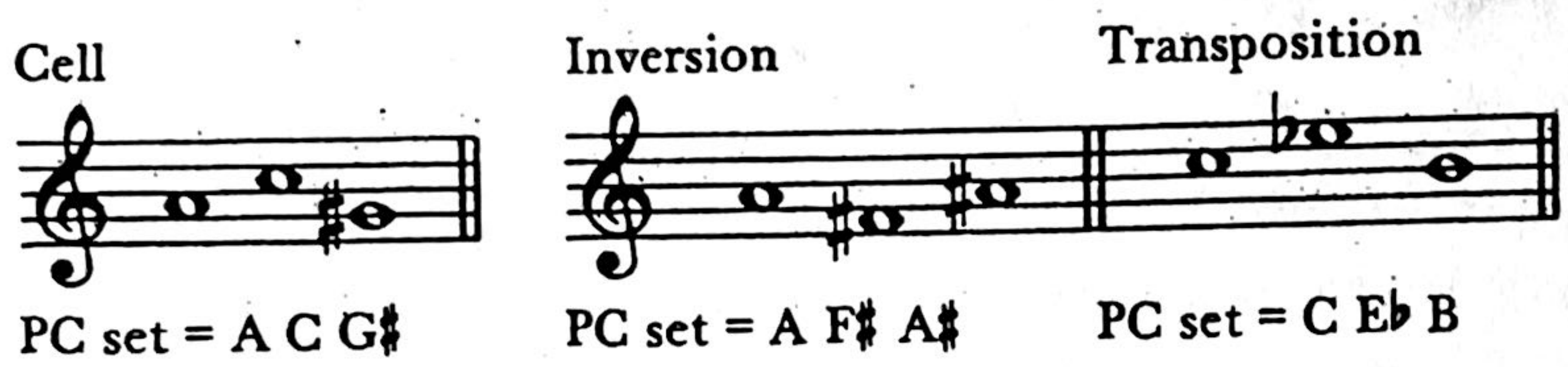
Set: an ordered or unordered collection of items, usually pitches. A cell may be regarded as a set of pitch classes (**a PC set**). Verticalization, octave displacement, retrograde, or permutation of a cell all yield the *same PC set.*

Illustration 17.6



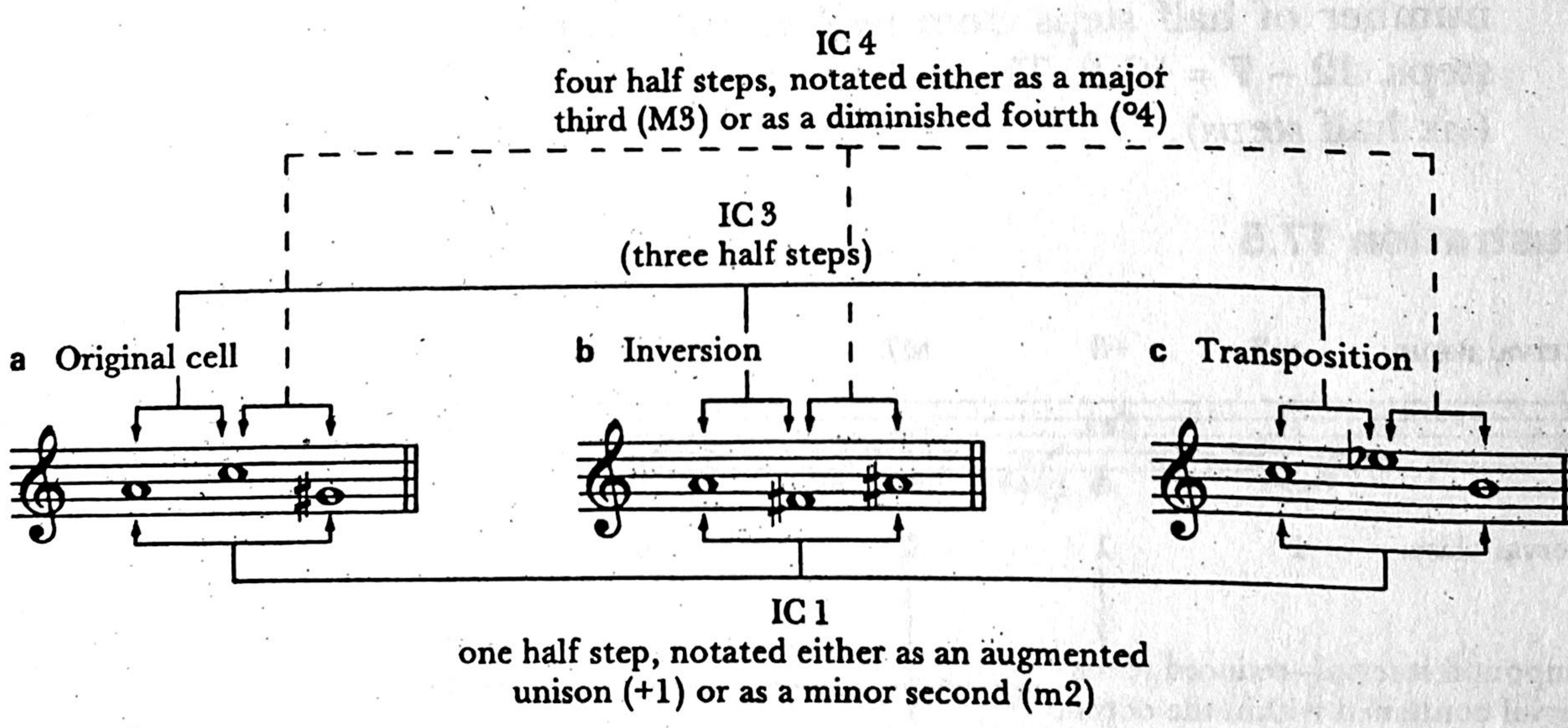
The operations of mirror inversion and transposition yield a *different PC set.*

Illustration 17.7



More importantly, however, a cell may also be viewed as a *set of interval classes* (an **IC set**). Notice that *all* the above operations result in the *same IC set.*

Illustration 17.8



Note on Illustration 17.8:

Although the *pitch classes* are different, the *interval classes* contained in each are identical.

Referring back to Schoenberg's *Klavierstücke, Op. 11, No. 1* (see Illustration 17.2), it should be obvious that the *true* organizing factor in this music is a collection of *interval classes* rather than pitch classes. That is, it is not the pitches themselves but *the relationships between them* that provide the unity and logic of the music. In analysis, it is necessary to have a means of identifying these aural units. For this reason, the following method has been devised.

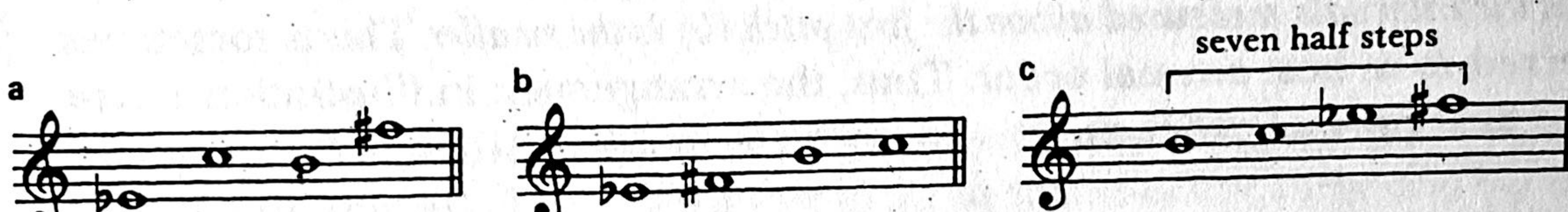
THE SET TYPE

The **set type** is a numerical description of the interval content of any PC set. To find the set type represented by a given collection of pitch classes:

NORMAL ORDER

1. Arrange the collection in **normal order**—that is:
    - within the span of a single octave
    - from lowest pitch to highest pitch
    - with the smallest possible interval between the first and last pitch

Illustration 17.9



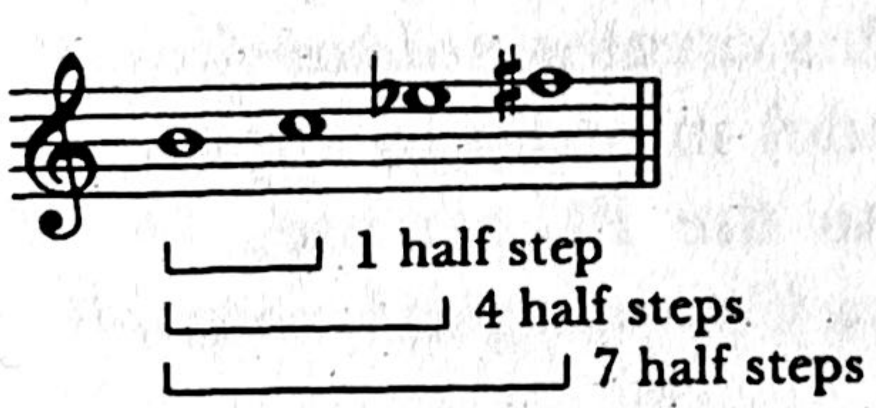
PC set

PC set arranged from lowest to highest pitch within an octave

PC set positioned so that smallest possible interval exists between first and last pitch. (Note that in **b** the interval is nine half steps, whereas in **c** it is seven half steps.)

2. Assign the lowest pitch the number *zero*, and list the number of half steps in the intervals formed by *this* pitch and *each succeeding pitch* in the collection.

Illustration 17.10

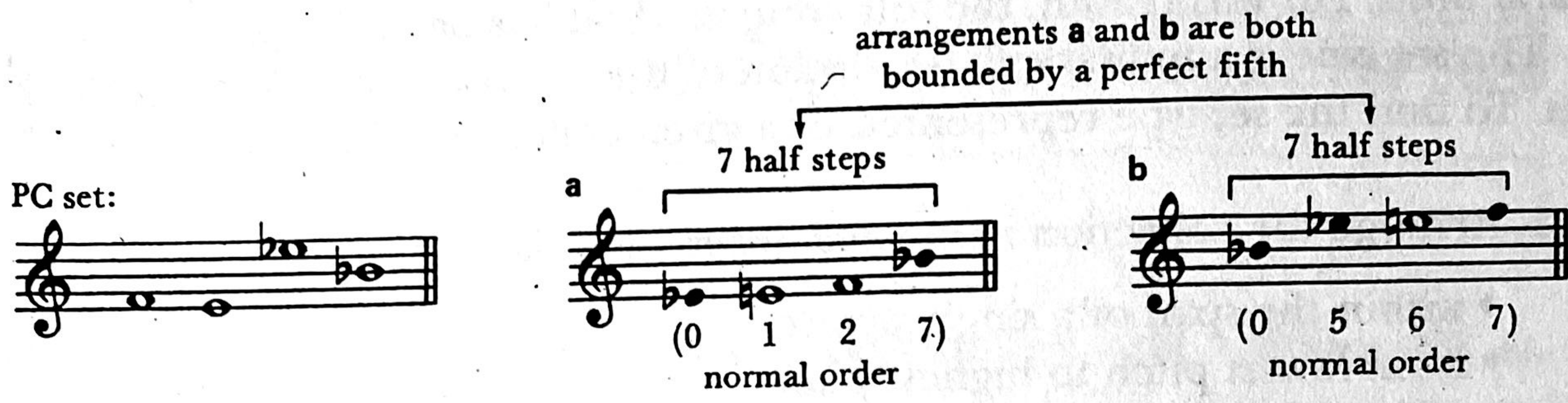


(0 1 4 7) = set type*

*Some theorists place commas between the members of the set type.

With practice, you can quickly … that yields the smallest possible outside interval. However, for certain PC sets, more than one such arrangement may be found to satisfy this condition. For example:

Illustration 17.11



In cases such as the one above, *the preferred arrangement is that in which the sum of all the intervals measured above the first pitch (0) is the smaller.* This is sometimes referred to as **best normal order**. Thus, the arrangement in Illustration 17.11**a** is the best normal order since:

BEST NORMAL ORDER

$$0 + 1 + 2 + 7 = 10 \qquad \text{whereas} \qquad 0 + 5 + 6 + 7 = 18$$

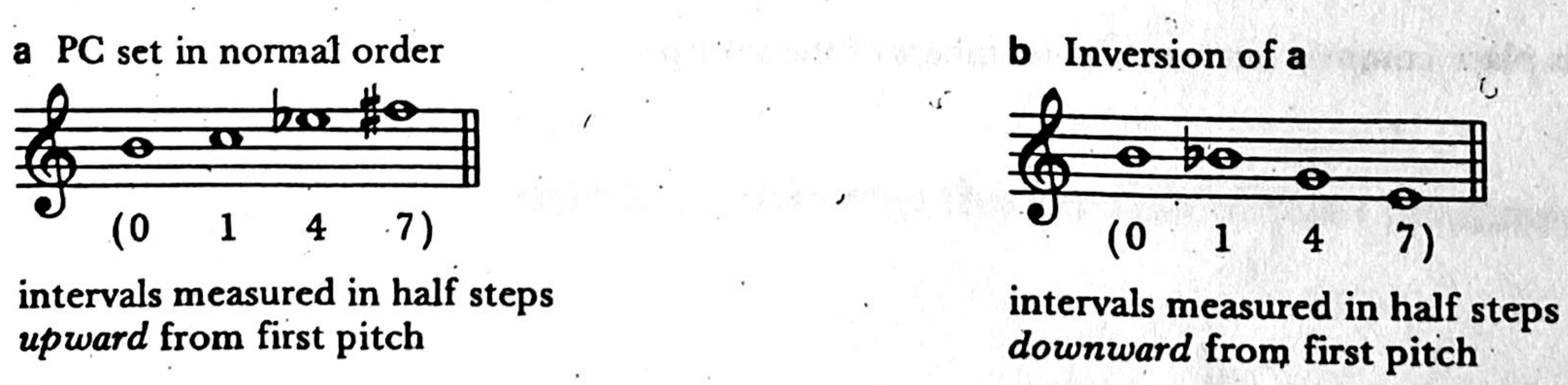
Practice Assignment C on page 393 can be completed at this time.

Whether the members of a set are reordered or displaced by one or more octaves, its set type will remain the same. Likewise, if the entire set is transposed by a given interval, its set type will *still* remain the same. This allows us to recognize and identify the set in its various guises.

One operation, however, requires special attention—inversion. When a PC set in normal order is inverted, its structure is mirrored—that is, every upward interval is replaced by its downward counterpart. This creates a *descending* PC set that must then be reversed (placed in retrograde) in order to appear in normal (i.e., ascending) order. We will return to the PC set used in Illustration 17.9 to show this.

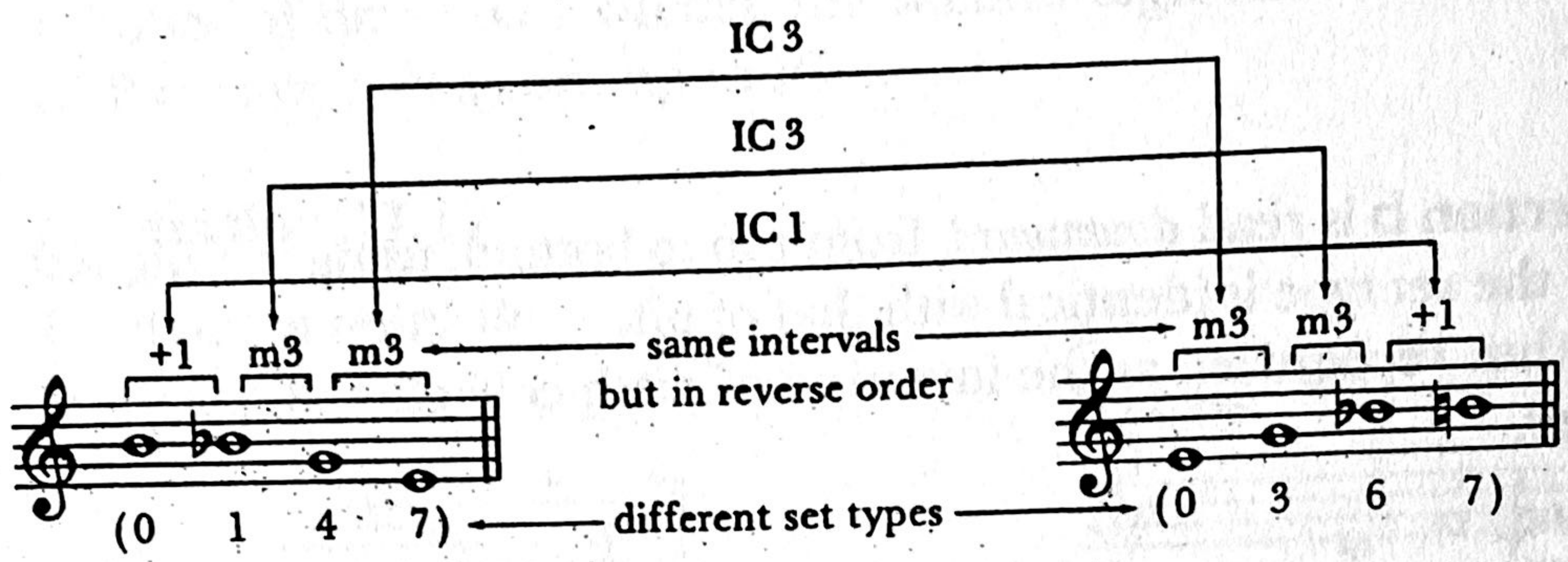
INVERSION

Illustration 17.12



As shown, if read *from left to right* the set type remains the same in both the original form (0 1 4 7) and the inversion (0 1 4 7). However, when placed in *normal order*—from lowest to highest pitch—the inversion yields a *different* set type. Notice that the same interval classes are present. They are simply in a different order.

Illustration 17.13



PRIME FORM Here again, we have the problem of different set types designating the same collection of interval classes. This brings us to the concept of **prime form.** The *prime form* of a PC set is either the best normal order of the original set or the best normal order of its inversion—whichever of the two contains the smaller total interval content, as measured above the first pitch.* A set type in prime form is designated by enclosure in brackets rather than parentheses.

Illustration 17.14

[0 1 4 7]	=	prime form (note the use of brackets)
(0 3 6 7)	=	inversion (*not* prime form)

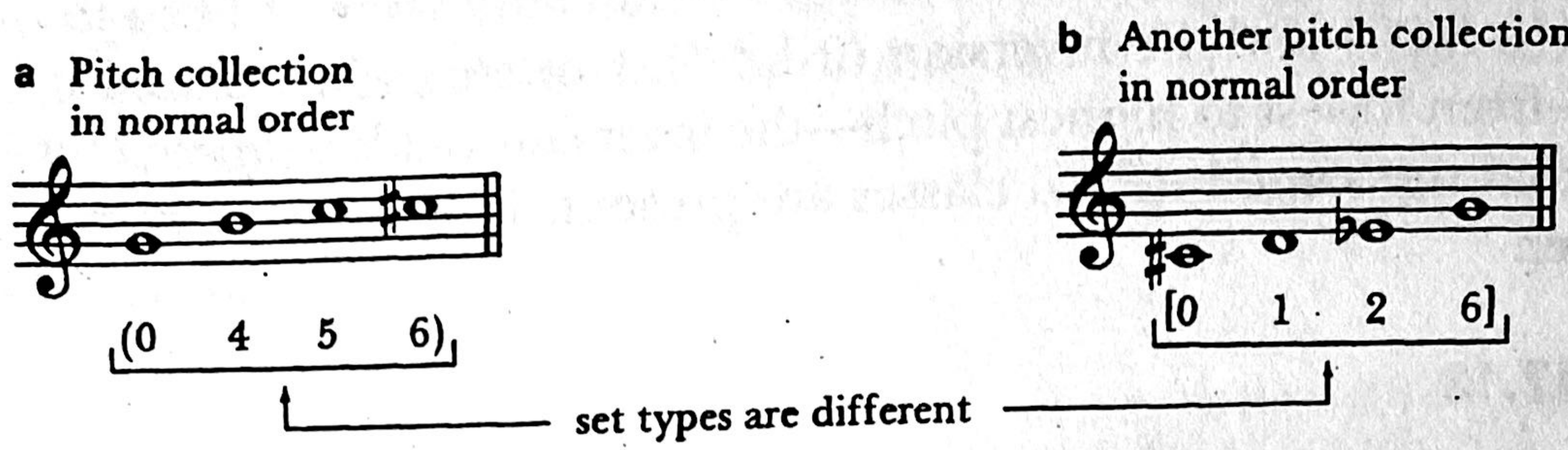
In all analytical work, you should seek to identify the prime form of a set and then use this designation for all appearances of the set, whether transposed, reordered, or inverted.

Practice Assignment D on pages 394–395 can be completed at this time.

RECOGNIZING INVERSION In analysis, you will be confronted with the problem of recognizing sets that are inversions of each other. An easy way to do this is to calculate their intervals *both upward (forward) and downward (backward)* as shown in Illustration 17.15.

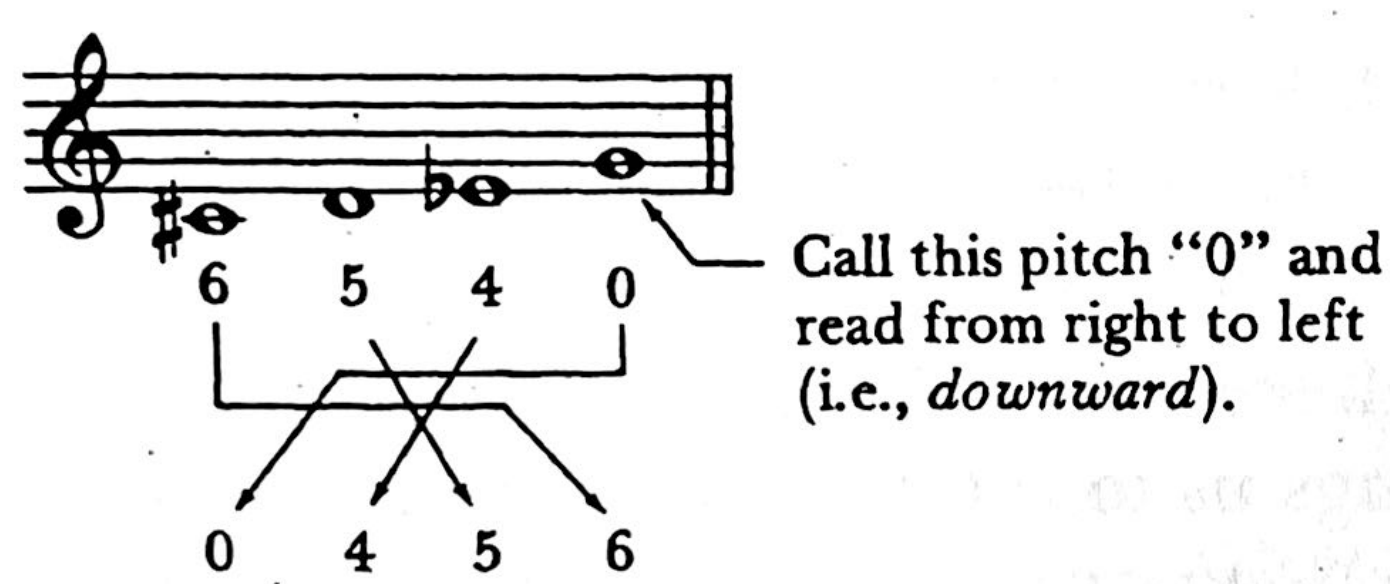
*Prime form can also be identified as the ordering in which the smallest intervals are at the beginning (at the left).

Illustration 17.15



But:

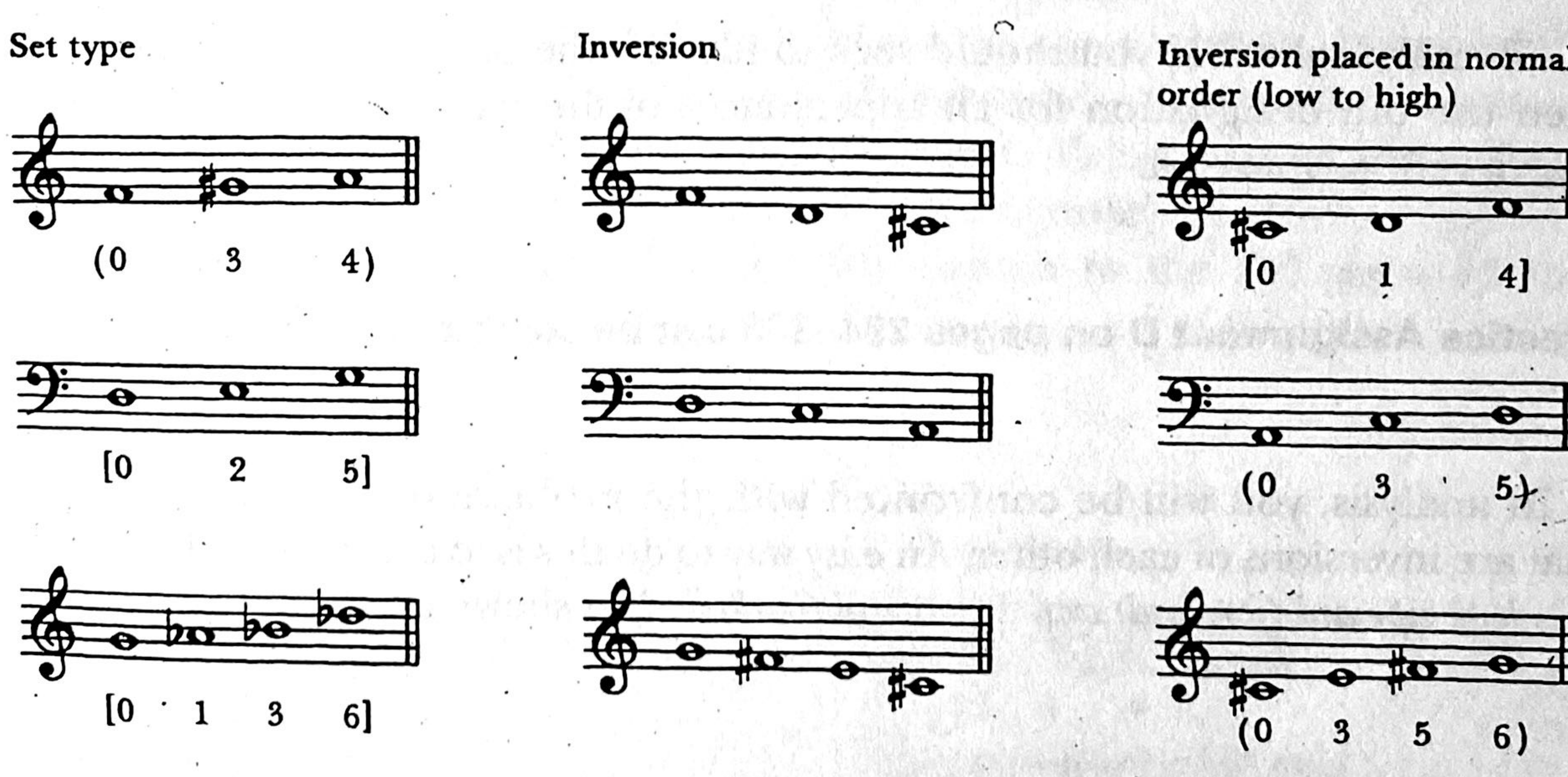
If pitch collection **b** is read *downward*, from top to bottom, using the highest pitch as "0," the set type is identical with that of pitch collection **a**. Pitch collection **b** is thus recognized as the inversion of pitch collection **a**, placed in normal order.



Note that collection **b** is in prime form: [0 1 2 6].

Following are some set types and their inversions. The prime form is bracketed in each case.

Illustration 17.16



THE INTERVAL VECTOR

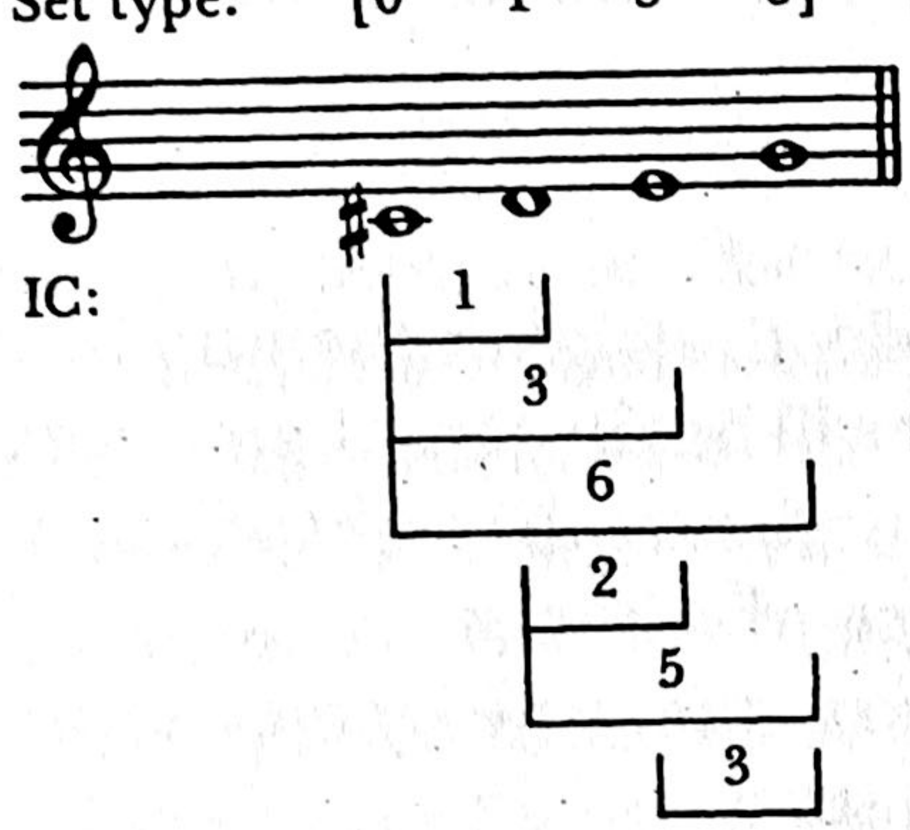
In works where it appears that more than one set is employed, it is helpful to have a convenient way of comparing their intervallic content. Very often, doing so will show that the sets are closely related intervallically (and thus *sound* similar), or that they are *subsets* of a single larger set. The **interval vector,** devised by Allen Forte* serves this purpose.

Every vector contains six digits, representing the number of occurrences of each interval class (e.g., 1, 2, 3, 4, 5, 6) in a set. The first digit shows the number of times IC 1 occurs; the second digit shows the number of times IC 2 occurs, and so on, up to IC 6.

Illustration 17.17

a

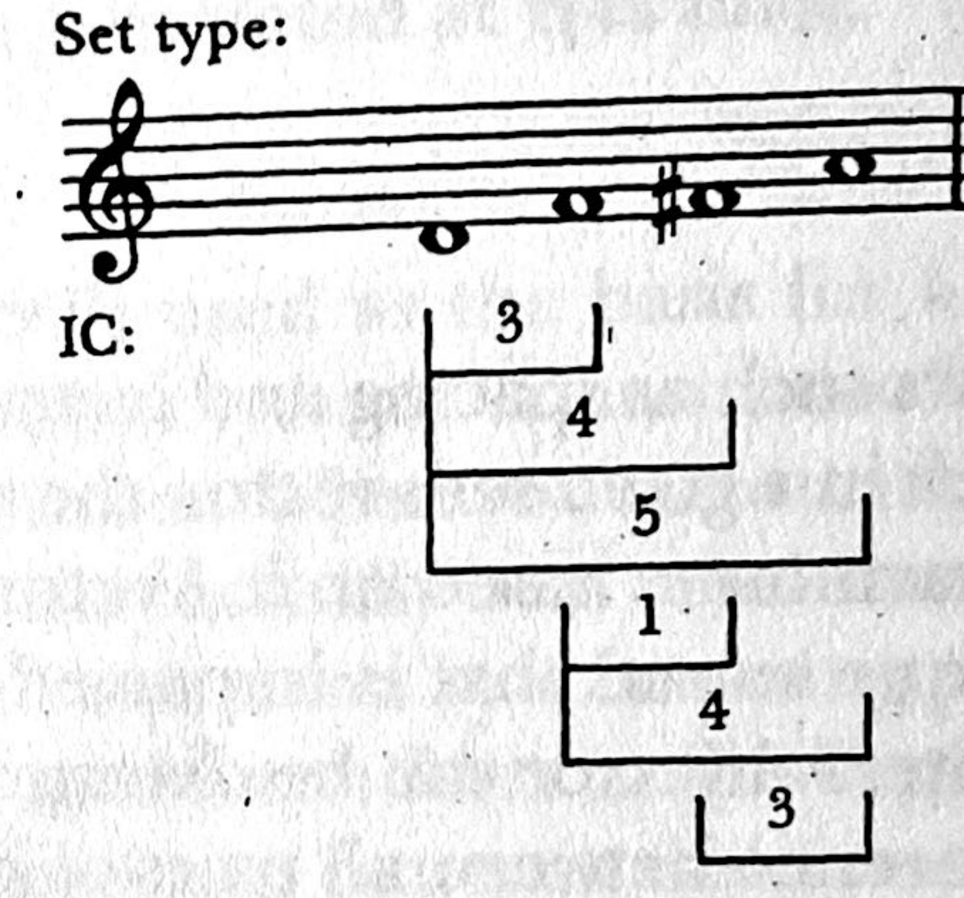
Set type: [0 1 3 6]



IC:	1	2	3	4	5	6	
Number of occurrences:	1	1	2	0	1	1	(vector)

b

Set type:

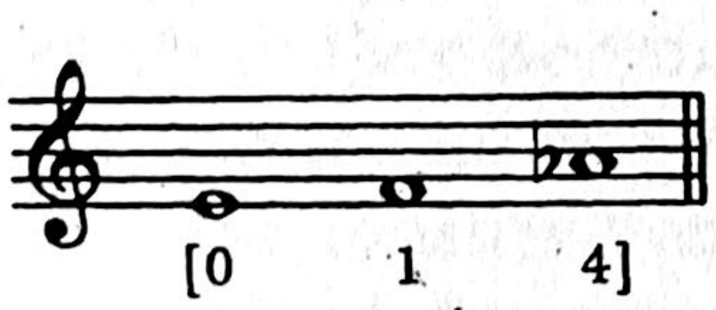


IC:	1	2	3	4	5	6	
Number of occurrences:	1	0	2	2	1	0	(vector)

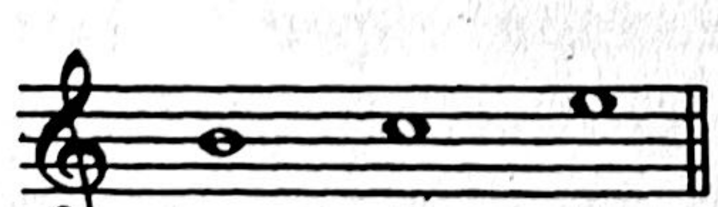
Illustration 17.18 shows how a comparison of interval vectors can reveal relationships between sets that might otherwise escape attention.

Illustration 17.18

a Sets [0 1 4] and [0 1 5] have two of their three intervals in common and are thus closely related in sound.



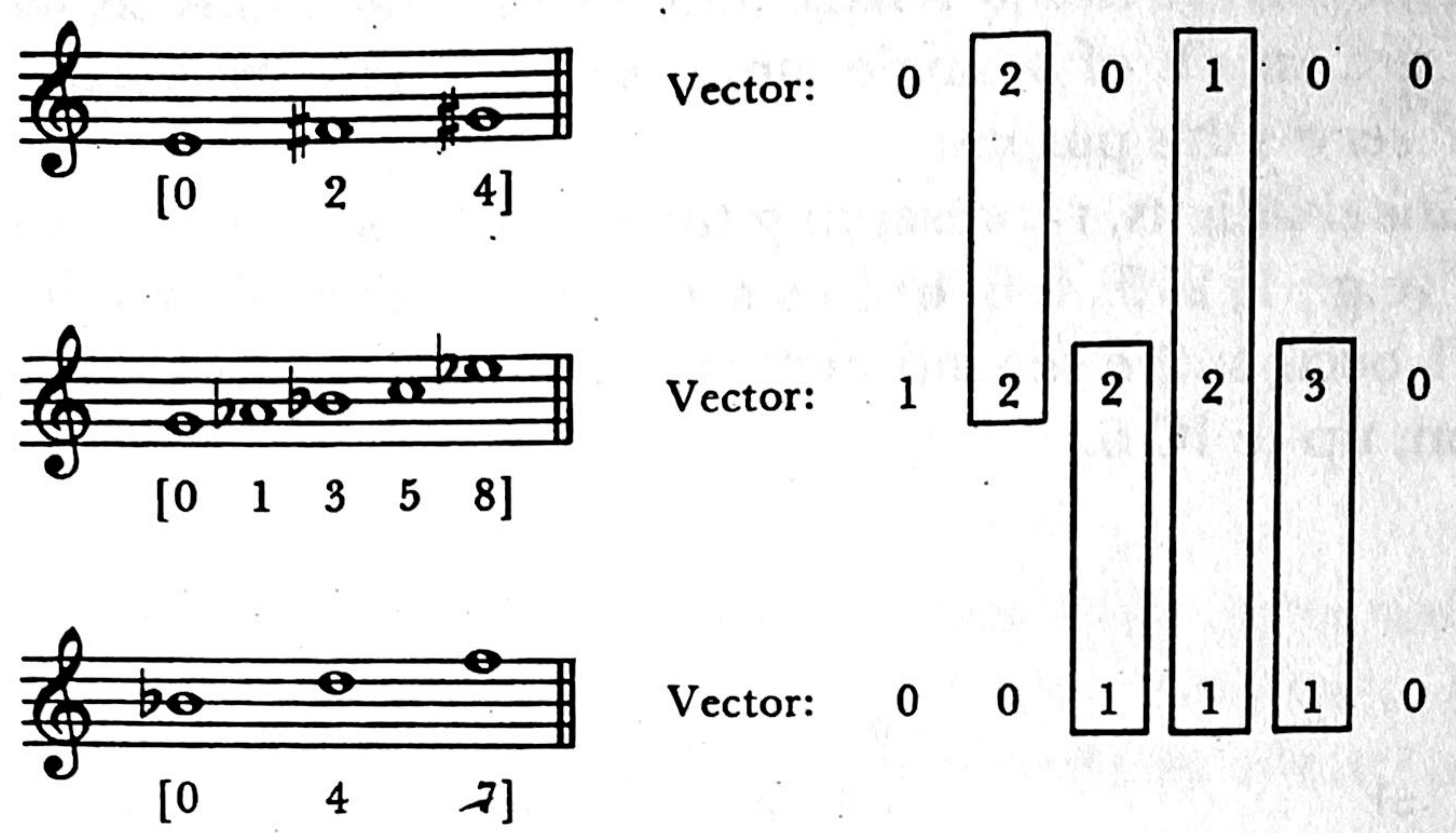
[0 1 4] Vector: 1 0 1 1 0 0



[0 1 5] Vector: 1 0 0 1 1 0

*Allen Forte, *The Structure of Atonal Music* (New Haven: Yale University Press, 1973).

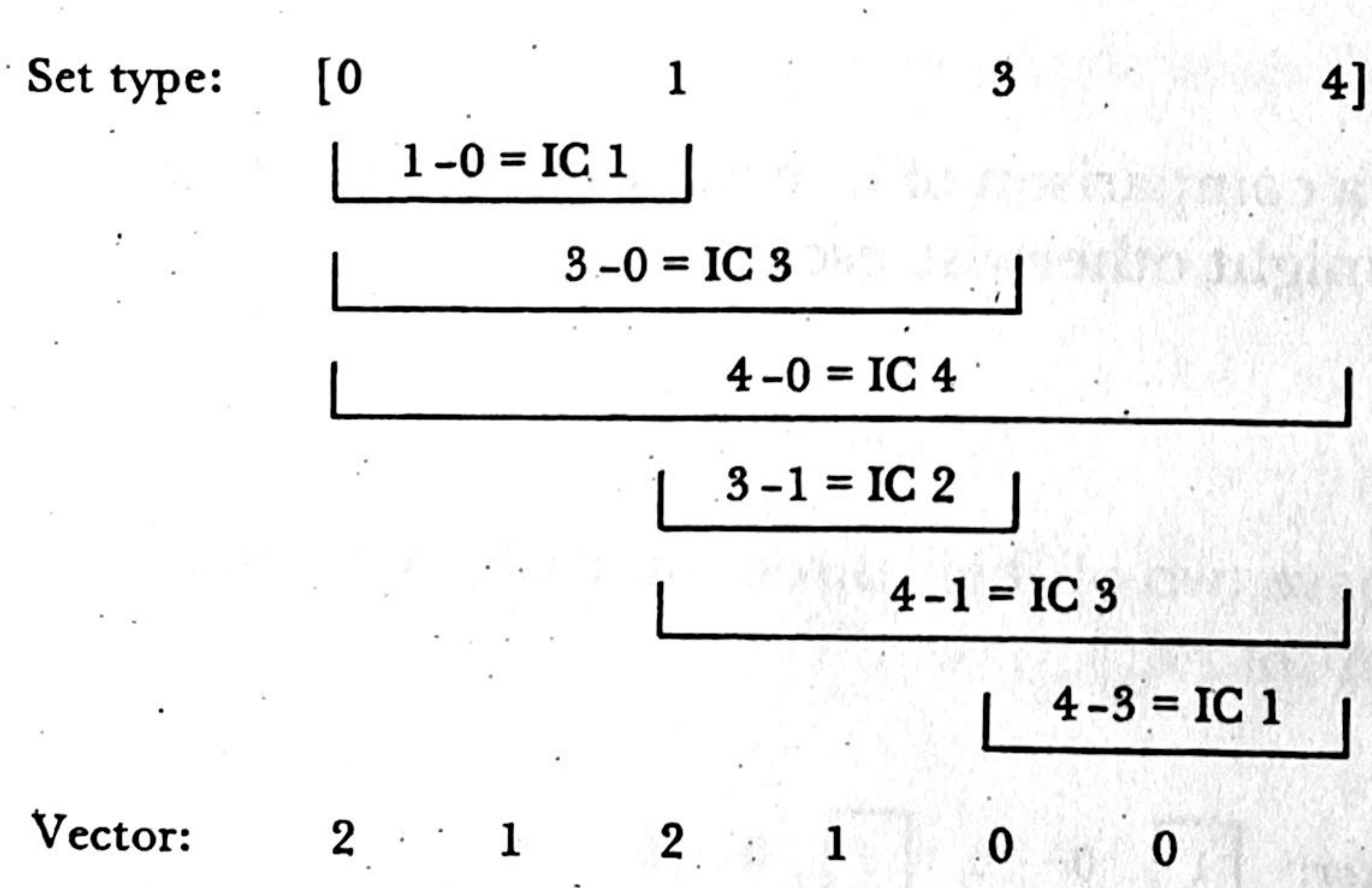
b While not closely related to each other, sets [0 2 4] and [0 4 7] are both subsets of set [0 1 3 5 8].



Factors such as spacing and instrumentation aside, the higher the numbers to the left in a given set's vector, the more dissonant will be the sound produced by the harmonies based on it. Vectors with a high number at the right will have the unique sound that is imparted by the presence of tritones.

An interval vector can be determined directly from a set type by measuring the difference between all pairs of numbers in the set type.

Illustration 17.19



Often, it is possible to determine if two set types are related in a general way simply by "eyeballing" the two for any noncommon intervals. For example, a quick look at the set types in Illustration 17.20 reveals an essential difference to be the lack of IC 6 in the first and the lack of IC 2 and IC 3 in the second.

Illustration 17.20

[0 2 3 5] [0 1 6 7]

Practice Assignment E on page 396 can be completed at this time.

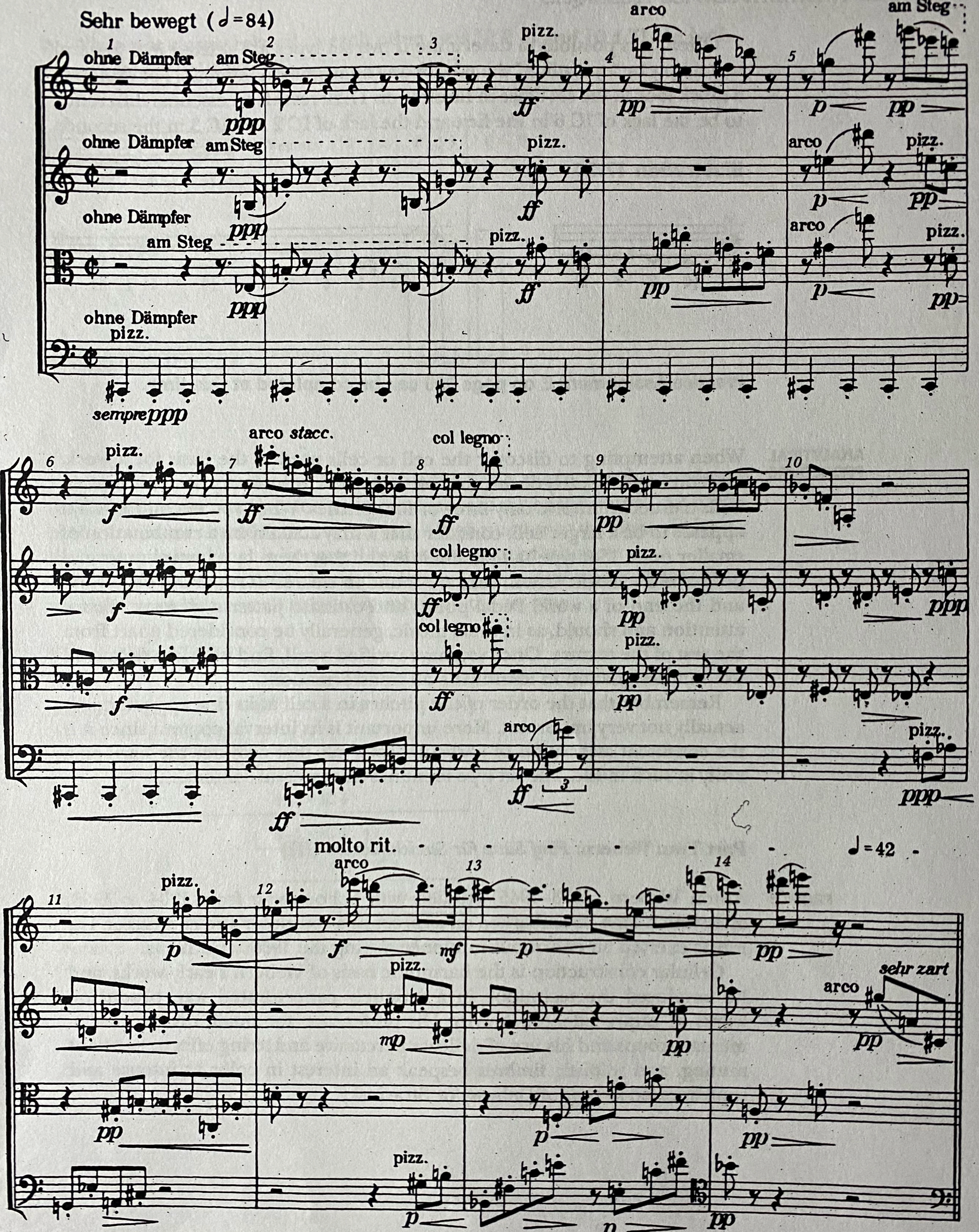
ANALYTICAL PROCEDURE When attempting to discover the cell or cells used as the basis for a work, first consider all clearly distinguishable melodic/rhythmic or harmonic figures. Cells most often involve only three or four pitches. When you encounter what appears to be a larger cell, consider that it may actually be a combination of smaller ones. "Set type" all possibilities and test them by examining several points in the music. Often, cells are found in clearest form at the beginning and the end of a work. Pedal points and ostinato patterns deserve special attention and should, as in tonal music, generally be considered apart from the rest of the texture. Once you have verified a cell, find its prime form and use this designation in identifying all transformations.

Remember that the order of the pitches in a cell at its first appearance is actually not very important. More important is its interval content since it is the consistent association of particular intervals that provides the harmonic unity in such music. The set type identifies this interval content.

Part Two: Webern: *Fünf Sätze für Streichquartett* (III)

PROFILE Anton Webern (1883–1945) studied with Schoenberg from 1904 to 1908, after which time he embarked on a career as a composer and conductor. His music exerted an enormous influence during the 1950s and 1960s.

Cellular construction is the harmonic basis of Webern's early works, and he employed the technique in a uniquely concentrated way, producing works of unprecedented brevity. His preference for small, diverse instrumental groups and his use of delicate percussive and string effects, constant muting, and soloistic timbres bespeak an interest in color as intense and sophisticated as that of Debussy or Stravinsky.


Sehr bewegt (♩=84)
ohne Dämpfer
am Steg
pizz.
arco
sempre ppp
arco stacc.
col legno
molto rit.
♩=42
sehr zart

Analysis

FORMAL STRUCTURE

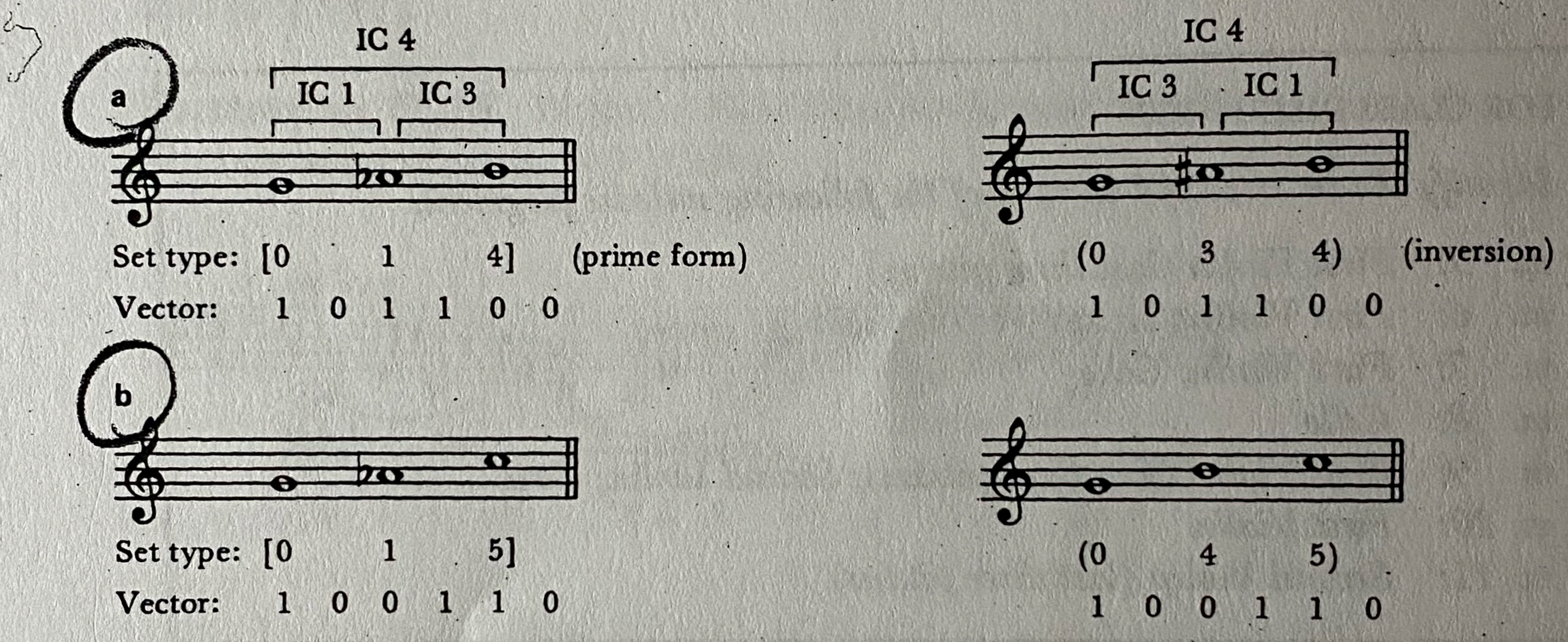
The movement is in two parts of unequal length. This excerpt includes only the first part. The point of division is created by:

- tempo (*molto ritardando* in mm. 12–14)
- texture (reduction to a single line at m. 14)

INTERVALLIC ORGANIZATION

The melodic and harmonic units of this movement are based, to a great extent, on one of two PC sets shown in Illustration 17.21.*

Illustration 17.21



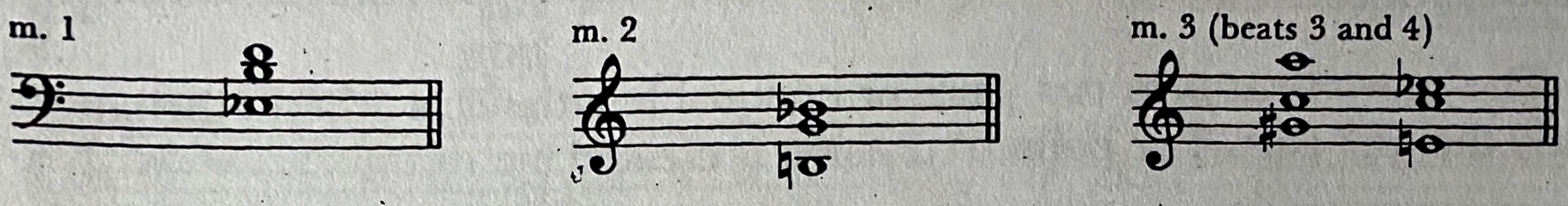
Note on Illustration 17.21:

Sets **a** and **b** above are related in that they have two of their three intervals in common (IC 1 and IC 4).

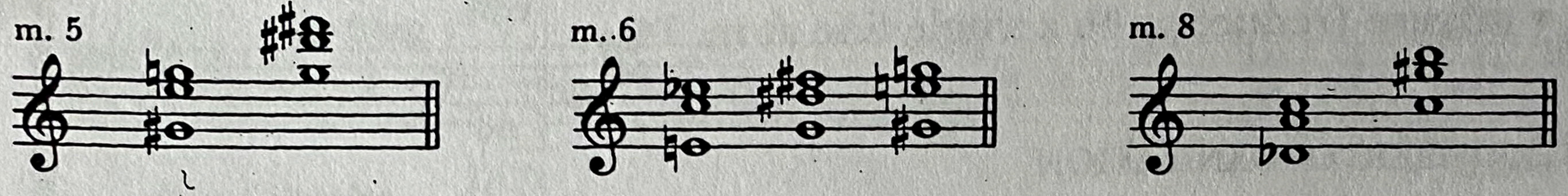
Harmonic appearances are limited to [0 1 4] and its inversion, formed by the three upper parts and occurring in the first eight measures.

*It is common to find more than one set forming the melodic/harmonic basis of an atonal work. Actually, these two sets can be regarded as subsets of a larger one employed in the first movement, which can be found in *Anthology of Twentieth-Century Music*, second edition, by Mary Wennerstrom (Prentice Hall, 1988).

Illustration 17.22



These two sonorities are repeated at the end of m. 2 and the beginning of m. 3.

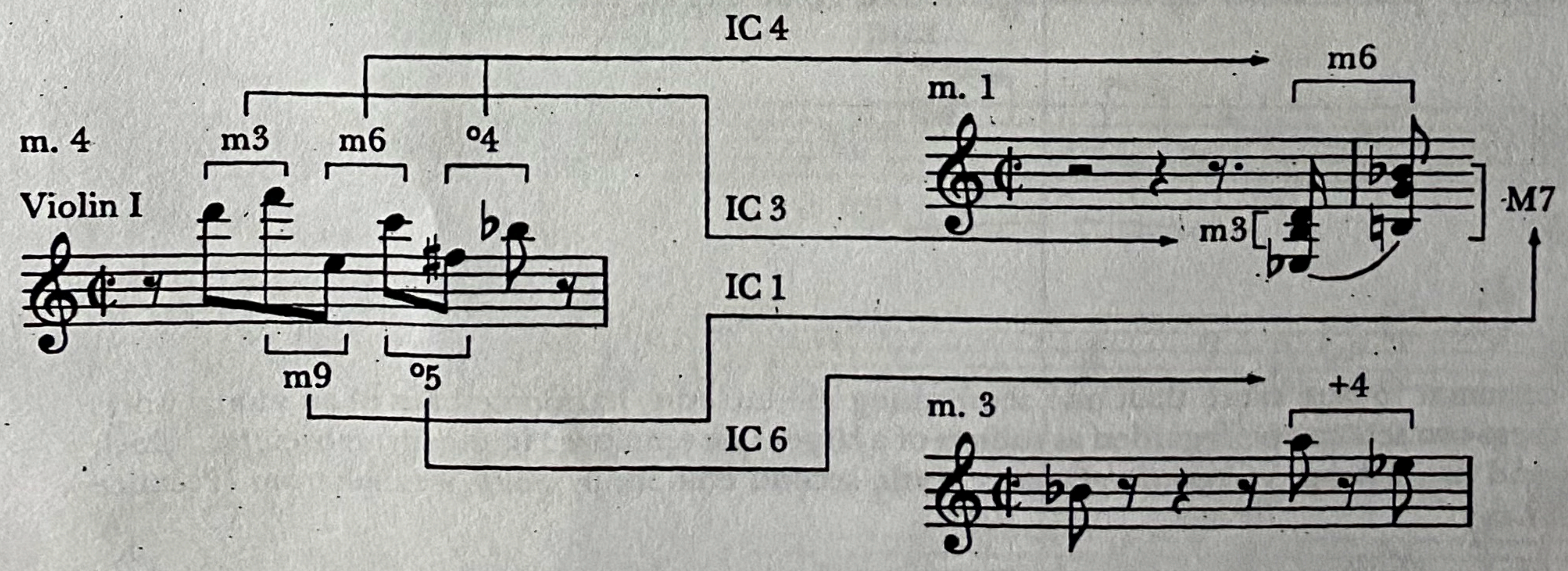


Melodic appearances gradually replace harmonic appearances and include [0 1 5] and its inversion.

> FOR CLASS DISCUSSION
>
> *Identify the set involved in each of the following melodic fragments.*
>
> *m. 5: First Violin (last three pitches)*
> *m. 6: First Violin; Second Violin; Viola*
> *m. 7: First Violin; Cello*
> *m. 8: Cello*
> *m. 9: First Violin (first three pitches); Second Violin; Viola*
> *m. 10: First Violin*
> *m. 11: Second Violin (last three pitches)*

Two melodic passages remain to be considered. The first violin figure of m. 4, although not *obviously* based on either of the two set types, is composed *only* of interval classes heard prominently up to this point in the music.

Illustration 17.23

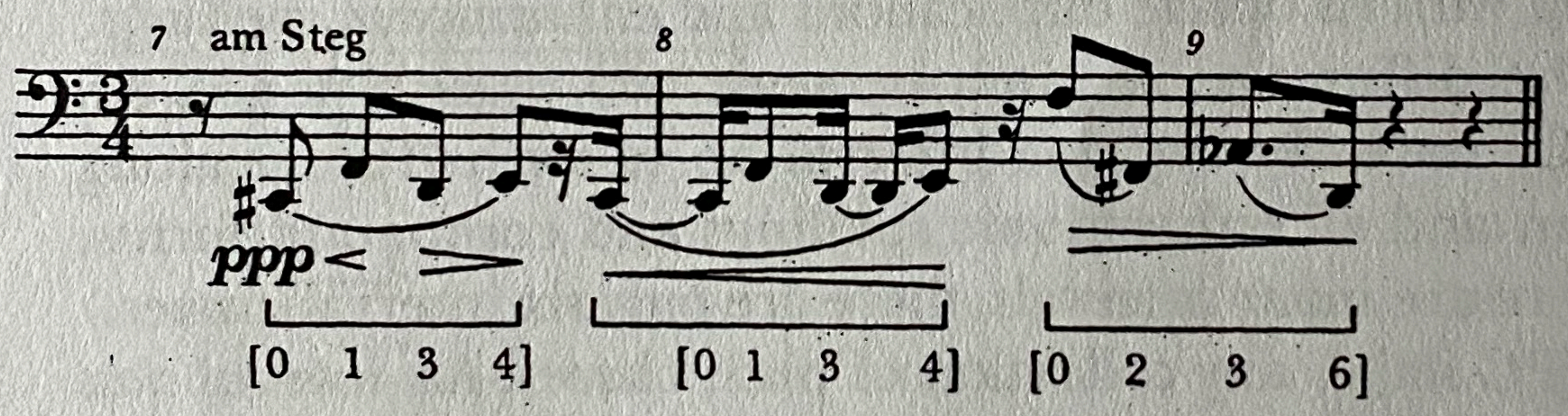


The other passage not yet considered is related to the first violin figure of m. 4. Measures 10–14 contain imitations of this figure in all parts, beginning with the cello (note the octave displacement in this part). These statements are successively fragmented until (by m. 14) the figure is reduced to only two notes.

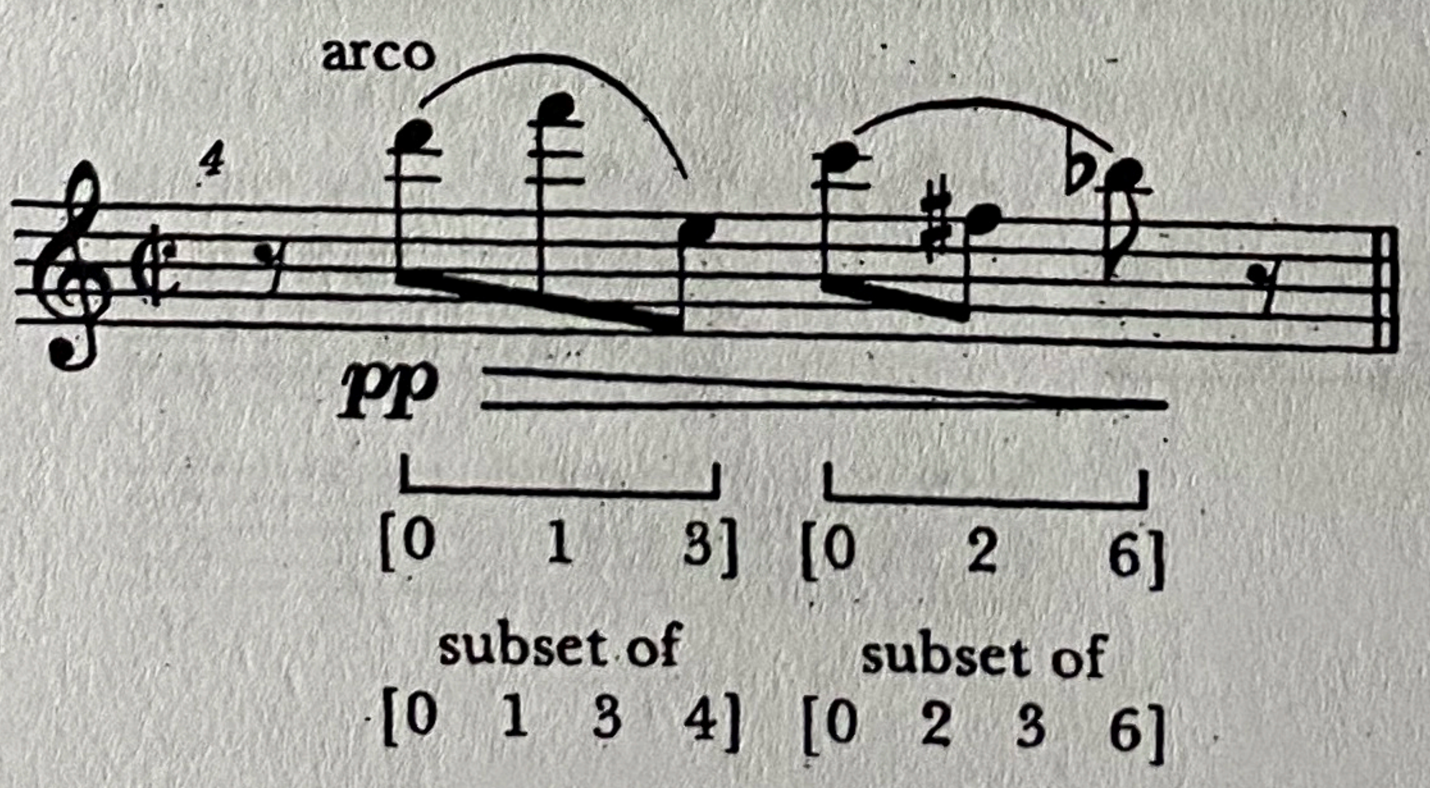
How does this passage relate to the basic sets that govern the pitch organization? While it would be *possible* to analyze most of the pitches as fragmentations of one or the other set, this might be stretching analysis beyond a reasonable point. When a relationship seems especially tenuous, it is probably not very significant. This general truism might be stated more poetically: "The harder a relationship is to see, the less important it's likely to be."

On the other hand, in a work of several movements, you always should consider the possibility that a particular passage relates to events from an earlier movement. For example, in the *first* movement of the above work, four *four-member* PC sets appear to be operative. The first violin passage of m. 4 and the passage of mm. 10–14 relate clearly to two of these ([0 1 3 4] and [0 2 3 6]).

Illustration 17.24 Webern: *Fünf Sätze für Streichquartett*
First movement, mm. 7–9 (Cello):



Third movement, m. 4 (First Violin):



TEXTURE/ARTICULATION/DYNAMICS

Contained within this short excerpt is an abundance of timbres. Observe, for example, the different ways in which the [0 1 4] is heard as a harmonic unit.

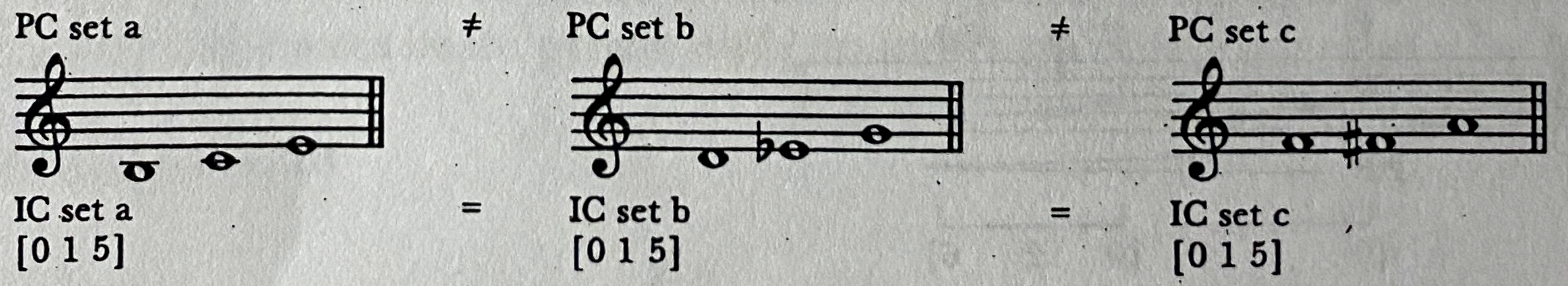
mm. 1–3:	*am Steg* (on the bridge); ***ppp***
m. 3:	*pizzicato;* ***ff***
m. 5:	*arco* (with the bow); ***p***
m. 6:	*pizzicato;* ***f***
m. 8:	*col legno* (with the wood of the bow); ***ff***

Also, notice how the viola is frequently scored *above* the second violin in these chords, creating a subtle variation in the sound. Although the overall dynamic range is wide for such a short piece (from ***ppp*** to ***fff***) the prevailing level is soft. This is typical of much of Webern's music.

Summary of Terminology

Several new terms and analytical tools have been introduced in this chapter.

1. *Pitch* refers to the highness or lowness of a musical tone. A *pitch class* (PC) is any tone along with its octave duplications and enharmonic spellings.
2. An *interval* is the difference in pitch between two musical tones. An *interval class* (IC) includes any one interval up to six half steps along with its inversion and all enharmonic spellings and compound forms. (Thus, while there are many intervals, there are only six interval classes.)
3. A *pitch class set* (PC set) is any collection of pitch classes. An *interval class set* (IC set) is any collection of interval classes. Any *PC set* also constitutes an IC set. However, any *one* IC set can comprise *many different* PC sets. Conversely, no two different IC sets can comprise the *same* PC set. Because the IC set is the more inclusive of the two, it is the more useful in analytical work.



4. A *cell* is an IC set usually comprising three or four pitch classes. It can appear as a harmony or in any ordering.