

# Symmetry: Culture and Science

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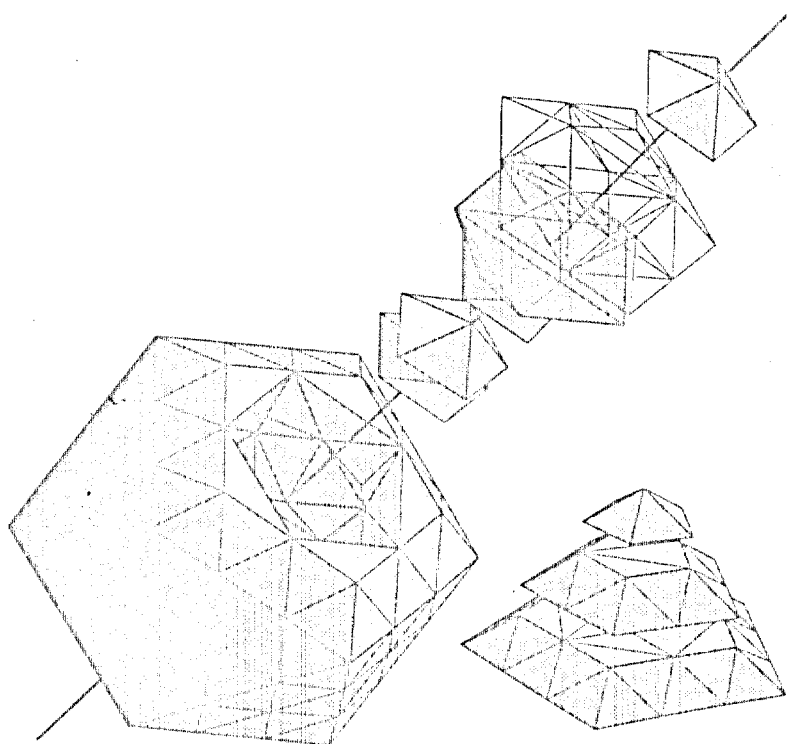


**Symmetry of Patterns, 2**

The Quarterly of the  
International Society for the  
Interdisciplinary Study of Symmetry  
(ISIS-Symmetry)

Editors:  
György Darvas and Dénes Nagy

Volume 3, Number 2, 1992



**SYMMETRY: CULTURE & SCIENCE**

**SYMMETRY AND IRREVERSIBILITY IN THE  
MUSICAL LANGUAGE(S) OF THE  
TWENTIETH CENTURY**

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*Much more than their nineteenth-century precursors, composers of our times seem to strive for order, in the sense of conscious and deliberate organization. This is not to say that order substitutes beauty or emotion. But while it seemed acceptable in earlier times to create new facets of beauty and unheard-of depths of feeling within structural patterns as conventional as the ternary form and its many derivatives, there is a striking – and increasing – need in our century to establish order on levels and in parameters unique to our age.*

*Arguably the most significant concept in this pursuit is the concept of symmetry. Apparently opposed to it, or at the very least in stark conflict with it, there is the concept of irreversible progression. Both are, as a large body of research into the fields, particularly that of symmetry, shows, omnipresent in nature. Symmetry occurs in relation with space. It is the single strongest building principle in the physical realm – be it the lateral symmetry of man and most other creatures or the more complex symmetry in crystals, minerals and many other chemical elements, in the course of atoms and the orbit of stars. On the man-made side of the physical realm, symmetry reigns supreme in architecture, geometry and ornamental art, to name just a few. Irreversible progresses, by contrast, are connected with time. From the development of*

*an individual life to world history, from the appearance and subsequent decay of mountains and flowers, cultures and ideas to the evolution of species and the expansion of the universe, there appears the same vectorial one-directedness.*

*This paper aims to investigate some of the basic aspects under which symmetry manifests itself in twentieth-century music. Examples are taken from three compositions for piano solo written around the middle of our century, by composers coming from the German-speaking (and -thinking) tradition: Anton Webern's Variations op. 27 (1935/6), Paul Hindemith's Ludus Tonalis (1942), and Wolfgang Fortner's Sieben Elegien (1950).*

## CHAPTER 1

To argue for symmetry in Hindemith's *Ludus Tonalis* (1943/1968) seems, at face value, almost trivial. The cycle consists of twelve fugues – one on each of the semitones – linked by interludes and wrapped by a prelude at the beginning and a postlude at the end. If this were all there is, it would hardly be worth mentioning. The fact, however, that the postlude is a visual retrograde inversion of the prelude – one in which the score of the prelude can literally be turned upside down and read backwards – should alert musicians; there is bound to be more to it.

As it turns out, Hindemith has conceived the twelve fugues and the eleven interludes in such a way that they form a strikingly symmetrical cosmos (this despite the fact that the obvious purpose of each interlude is modulation, the transition from the key of the preceding fugue to that of the subsequent one: a clearly linear process). Let me explain a few details on a transparency (Fig. 1).

The interlude which forms the centre of the cycle, connecting Fugue 6 with Fugue 7, is a March. With its strong sense of tonality and slightly rambunctious mood it represents a character of its own which is not repeated in any other part of the cycle.

The fifth and seventh interludes, those before and after the March, can both be identified as Romantic piano miniatures – romantic in their aesthetics, not, of course, with regard to the tonal language employed. One of them, with intensely emotional treble lines and elegant accompaniment patterns, seems reminiscent of Chopin's style, while the other, in thicker homophonic texture and a heavier, in some instances brooding character, recalls Brahms' expressive language.

The fourth and eighth interludes recall Baroque patterns; one is composed in a style similar to that found in many of Bach's preludes, the other appears as a toccata. The third and second-from-last interludes – note the dissymmetry! – are conceived as folk dances. While their melodic and rhythmic idioms are basically timeless, their metric organization links them to two well-known dance forms known from early music: the gavotte and the courante. Complementing the dissymmetry, the second and third-from-last interludes both represent pastorales: melodies reminiscent of a solo flute or recorder, floating in languid mood above a simple accompaniment<sup>\*1</sup>. Finally, the first and the last interludes are held once more in the style of Romantic piano pieces. The former is an improvisation which, although written in triple time throughout, is so full of intricate metric shifts that it

appears much more 'impromptu' than any of the nineteenth-century pieces formally carrying that name; the latter is an elegant waltz.

PAUL HINDEMITH: LUDUS TONALIS

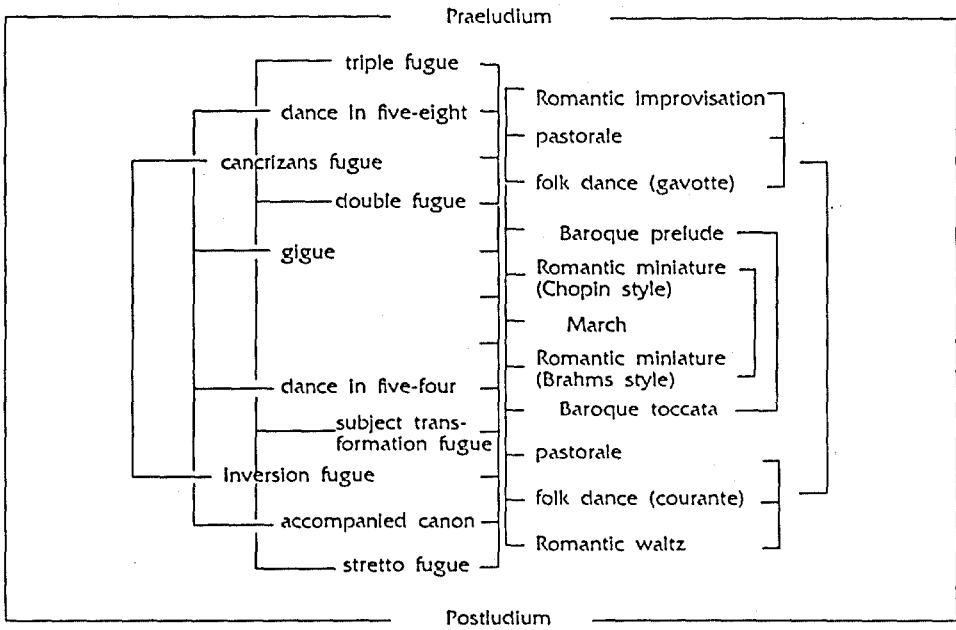


Figure 1

The fugues, too, profess a strikingly symmetrical layout, with possibly the only exception in the centre of the cycle. Fugue 3 and Fugue 10, in actual playing time almost equidistant between the prelude and the postlude, each reflect one of the compositional principles governing the framing pieces: in Fugue 3, the second half retraces the first half in retrograde; in Fugue 10, the second half is the exact inversion of the first.

Next, there are four symmetrically located fugues – the first and the last as well as the fourth and the fourth-from-last (i.e. Fugue 9) – which build on strict contrapuntal technique. At the beginning of the cycle there are a triple fugue (Fugue 1) and a double fugue (Fugue 4); towards the end, the subject appears in

almost constant stretto in Fugue 12, and developed section by section through all possible transformations in Fugue 9.

The remaining four fugues, while certainly true fugues in both texture and structural layout, actually represent character pieces. There is a dance in five-eight time (Fugue 2), a dance in the rhythmic pattern of a gigue (Fugue 5), a dance-like form building on a subject in five-four organization, and a two-part canon supported by a very metric bass accompaniment.

## PAUL HINDEMITH: Series I

"gradually lessening relationship to the centre"

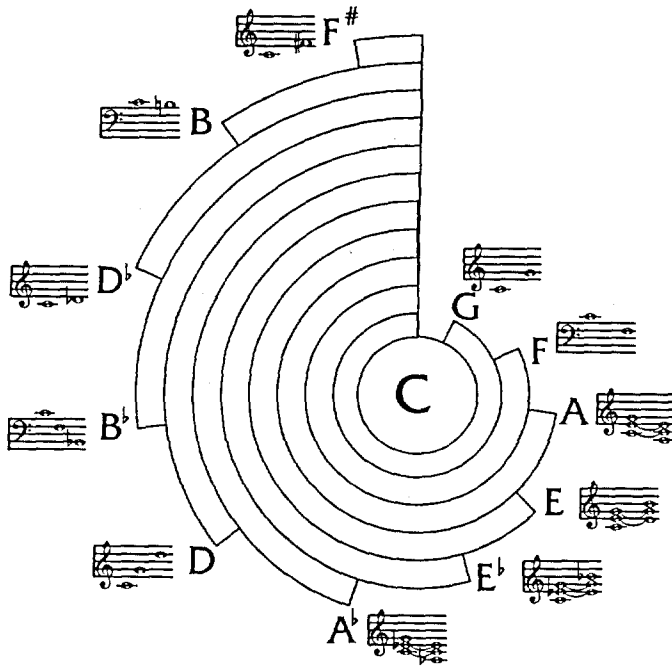


Figure 2

## CHAPTER 2

The opposing concept, that of irreversible progression, proves to be equally present in the *Ludus Tonalis*. Although the fact that Hindemith writes twelve fugues on the twelve semitones of the scale has earned his work the nick-name of the 'Well-Tempered Clavier of the Twentieth Century', his tonal organization is by no means that of Bach who, as we all know, progresses chromatically: on each semitone one

prelude & fugue in the major and one in the minor mode. Nor does Hindemith follow the tonal layout employed e.g. by Chopin in his twenty-four Préludes who proceeds through the circle of fifths, pairing each major-mode piece with one in the relative minor key. These two types of tonal organization are of the symmetrical kind insofar as the distance between all major-mode pieces on the one hand, all minor-key works on the other hand is equal, and the initial work in C major would in fact constitute a logical continuation of the final work in each collection.

Not so in the *Ludus Tonalis*. While Hindemith, like Bach, Chopin and many others before him, begins in C, he interprets this C as the tonal centre of the cycle from which is triggered a progression of tonal areas in an order of gradually lessening relationship. G, the fifth above C, is most closely related, followed by F, the fifth below the centre. Slightly weaker in their relationship to the centre are those tonal areas which draw their relationship to C from presumed triads with shared notes: A, as the keynote of the relative of C major, is thus more closely related to the centre than E (which, as E minor, also shares two notes with the C major triad); E<sup>b</sup>, as root of the relative of C minor, follows next in line, preceding A<sup>b</sup> (which, in the form of the A<sup>b</sup> major triad, also shares two notes with the C minor chord). More remote but still related to the centre are D (two fifths above C) and B<sup>b</sup> (two fifths below C). No relationship of natural frequencies but only spatial proximity links the semitones above (D<sup>b</sup>) and below (B<sup>b</sup>) to the central C. Finally, the irreversible progression away from the centre is concluded with the interval that was regarded as offensive through much of music history: the tritone (F<sup>\*</sup>). The tonal organization of the fugues in the *Ludus Tonalis* thus resembles an open spiral (Fig. 2).

### CHAPTER 3

Wolfgang Fortner's *Sieben Elegien* (Seven Elegies) date from 1950, a period during which the composer is known to have worked towards his own approach to twelve-tone music. All seven pieces are built on a single dodecaphonic row, and musicologists compare the cycle to Schoenberg's famous *Suite op. 25*. While such a relationship with the exemplary work of the great master of the Second Vienna School may sound fascinating to students of musicology, we must realistically admit that it is not likely to inspire confidence in musicians; Schoenberg's cycle is notoriously difficult for fingers, ear and mind. Equally, the information that the work is strictly serial in its pitch organization will frighten rather than attract most prospective performers – not to speak of their potential audiences.

While the factual information about Fortner's *Elegies* can thus be expected to cause a shrinking from the work, rather than an interested curiosity towards it, investigations into the use of symmetry in this work can be shown to contribute essentially to an adequate understanding of the tonal vocabulary and grammar. Let me demonstrate this with the help of the first of the *Seven Elegies*.

The elegy is short (44 bars), metrically regular (four-four time throughout), and fairly easy to overlook in its structural layout. A four-bar 'main theme', introduced with a one-bar anticipation of its accompaniment pattern, leads into two short developmental phrases before it recurs in variation. A contrasting secondary

theme, consisting of a four-bar phrase and its sequence in inverted hands, is followed by a transposition of the main-theme variation. After a very melodious closing theme in monodic texture, the elegy is rounded off by a four-bar coda. All thematic material is easy to recognize, containing none of Schoenberg's often highly complicated rhythmic modification. The texture is organized in such a way that all passages allow to clearly distinguish leading voices from secondary lines. So far for the general, quite encouraging details.

Assistance with the musical language can be provided by a number of observations for which the following may serve as an example (Fig. 3).

WOLFGANG FORTNER  
SEVEN ELEGIES, NO. I

Main theme

"D major" "B<sup>b</sup> minor" "D major"

"F minor" "G major" "F minor"

primary "keys" on polar axis D - f,  
contrast on "subdominant" axis G - b<sup>b</sup>

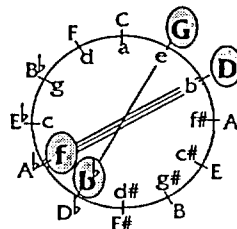


Figure 3

1.a

In the first, second and fourth bars of the main theme, Fortner uses the first half of his twelve-tone row (the pitches C B<sup>b</sup> F A<sup>b</sup> D<sup>b</sup> B<sup>f</sup>) to create an accompaniment. Due to the particular interval structure, the first four notes of the row are heard as

D<sup>7</sup> – T of F minor. The remaining two pitches appear, particularly in the position where the composer places them, as a two-fold leading-note to the dominant (D<sup>b</sup> B<sup>#</sup> being semitones above and below C). The left-hand part would thus sound a fairly tonal F minor. In the thematic right-hand part, the second half of the twelve-tone row is employed to create the impression of D major, with the scale segment D E F<sup>#</sup> G A only coloured by an additional – yet spatially detached – E<sup>b</sup>.

1.b

The third bar of the main theme provides a contrast with regard to both the melodic components of the right-hand part and the tonal organization. The left-hand pattern, recognizably related to that of the surrounding bars, evokes G major (with F<sup>#</sup> and G<sup>#</sup> as double leading-note to the root of the triad), while the right-hand part, particularly towards the end of the bar, tonally refers to B<sup>b</sup> minor.

1.c

As the graph below the score excerpt shows, the keys paired in each of these two bitonal combinations represent the opposite poles of an axis through the circle of fifths. The main axis D major/F minor is interpolated in the third bar by a second axis G major/B<sup>b</sup> minor. As the keys in the second pair embody the subdominant of the corresponding keys in the main pair (G = IV/D, b<sup>b</sup> = iv/f), the main theme of Fortner's *First Elegy* can be interpreted as a 20th century equivalent of the I-IV-I plagal progression.

2.a

The main-theme variation (Fig. 4) is drawn from the original by way of several inversions. The most obvious are the inversion of hands and the mirroring of the pitch lines. Other inversions require closer inspection: the melodic part of the first, second and fourth bars sounds now in minor mode while its accompaniment is in major, and the 'V<sup>7</sup> - i' impression is here created in the contrasting third bar (not, as before, in bars 1, 2, and 4).

2.b

These inversions result in an interesting modification of the tonal relationships: the combination of the two polar key-pairs B<sup>b</sup> major/C<sup>#</sup> minor and G major/B<sup>b</sup> minor creates a perfect axis symmetry<sup>\*2</sup>. The same holds true for the transposition of the main-theme variation, the keys of which are given in the graph at the bottom right corner of the transparency.

2.c

The tonal relationship between the main theme and its variation is rooted in the 'subdominant': both share the secondary axis G major/B<sup>b</sup> minor. Having observed this, it may hardly come as a surprise that Fortner conceives the transposition of the main-theme variation as a further step in the subdominant progression (see e.g. main tonal axis E<sup>b</sup> major/F<sup>#</sup> minor = subdominant of B<sup>b</sup> major/C<sup>#</sup> minor, etc.).



WOLFGANG FORTNER  
SEVEN ELEGIES, NO. I

Main-theme variation 1

variation (bars 13-16)

transposition of variation (bars 26-29)

= mirror of original (bars 2-5)

Inversion of motives + Inversion of hands results in modified tonal relationships

For comparison: Main theme

variation:  
main tonal axis =  $B^{\flat} - c^{\sharp}$   
contrast axis =  $G - b^{\flat}$

transposition:  
main tonal axis =  $E^{\flat} - f^{\sharp}$   
contrast axis =  $C - e^{\flat}$

equidistant relationship between primary-key axis and contrast axis;  
"subdominant" progression from the variation to its transposition

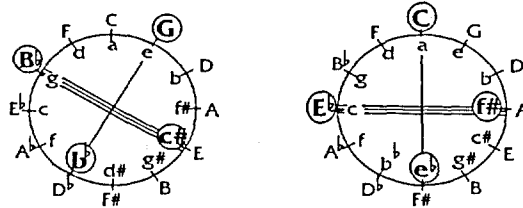


Figure 4

3

Many more details could be mentioned. May it suffice here to add the following brief remarks regarding the remainder of the piece.

3.a

The secondary theme and its sequence, the two phrases in the closing theme, and the two segments within the coda, although each entirely different from the main theme in material, structure, texture etc., are equally each built on one polar axis.

3.b

Secondary theme, closing theme and coda share one axis (F major/G<sup>♯</sup> minor) which represents a further step in the subdominant progression (compare this axis with

the secondary axis C major/E<sup>b</sup> minor in the transposition of the main-theme variation).

3.c

Finally, the two axes of the coda complement the continuous subdominant progression with a plagal close (IV-I).

Thus, while the very idea of axis tonalities provides a perfect example for the use of symmetry as a building principle, the various elements and their bi-tonal frames are clearly organized along a single progressive line.

**CHAPTER 4**

While the two preceding examples have shown the use of symmetry once in the field of musical structure (Hindemith) and once in that of ‘musical grammar’ (Fortner), Anton Webern’s *Variations op. 27* contribute several new aspects to the same concept. I wish to comment on the short piece op. 27/II which represents a particularly intriguing example for symmetry in ‘musical vocabulary’. Moreover, this piece demonstrates that without an understanding for the tonal vocabulary, neither phrasing nor emotional content are truly accessible<sup>3</sup>. Here is a simplified ‘dictionary’ listing the musical vocabulary employed in this piece (Fig. 5).

The tonal material of this piece consists exclusively of note-pairs. A note repetition on the tuning-fork A serves as a mirror in which are reflected the six intervals from the semitone to the tritone. The note-pairs, however, do not appear in this simple format of closed-position intervals. Webern adds extra flavour (and considerable technical difficulty) to these simple note-pairs by the devices of octave displacement and inversion. He uses only two intervals in their closed position (minor third and tritone), one interval in simple inversion (major third becoming minor sixth), one interval in simple octave displacement (increasing the semitone to a minor ninth), and two intervals inverted and displaced (whole-tone and perfect fourth sounding as compound minor seventh and compound fifth respectively). This is all there is in musical ‘syllables’; any nuances stem from either ‘pronunciation’ or emphasis (i.e. articulation or dynamics).








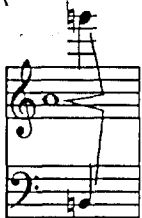

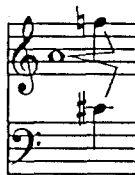


Deciphering this tonal vocabulary in its symmetrical location around the central A may already have a merit of its own. It would, however, be a task half solved to abandon endeavors at this point, before decoding the ‘grammar’ as well as the emotional content employed by Webern through and with these musical syllables. In the absence of melodic or rhythmic features, with no structural clues other indicating the repeat of the two halves, the internal layout of this piece appears almost impossible to disclose. Only through an understanding of the syntactical function of the ‘syllables’ will the phrase structure become transparent.

# ANTON WEBERN: VARIATIONS OP. 27, II

## TONAL MATERIAL



tonal centre: A

					
semitone above/below A	whole tone	minor 3	major 3	fourth	tritone
					
semitone + octave above/below A	minor 7 + octave	minor 3	minor 6	fifth + octave	tritone

## STRUCTURAL USAGE OF PITCH PAIRS




		
opens phrases	closes phrases and subphrases	re-opens a phrase

Figure 5

The piece opens with B<sup>b</sup>-G<sup>#</sup>, the note-pair composed of the semitones above and below the central A. The fact that the same B<sup>b</sup>-G<sup>#</sup> also opens the second half of the piece encourages the hypothesis that this pair might serve an initiating function. This is confirmed by the consistent syntactical usage of another 'syllable'. The note-pair concluding the final complete sentence of the piece, D-E, can be found to precede all but one of the assumed phrase-beginning pairs (the exception being the phrase ending before the repeat sign). This observation invites the conjecture of a fixed closing particle. Interestingly, the fact that this phrase-closing pair is based on the perfect fifth interval above and below the central note is strikingly reminiscent of the use of subdominant and dominant in traditional closing formulas.

ANTON WEBERN: VARIATIONS OP. 27, II

PHRASE STRUCTURE



Figure 6

Understanding the syntactical function of these two note-pairs enables the interpreter to distinguish five complete phrases in Webern's op. 27/II (Fig. 6). One step further on in the analysis it can be discovered that phrases 1, 2 and 4 are divided into 'main clause' and 'subordinate clause'. This must be concluded from the fact that the composer uses the closing note-pair occasionally in the middle of a sentence, and that in all cases, this 'half-close' is followed by the same note-pair C-F#. This syllable C-F# can thus be identified as opening subphrases.

One peculiarity in the structure of this piece is worth mentioning, particularly since it seems to stress the aspect of progression vs. that of symmetry, and in a very unique way. The only moments in the course of the composition which, at first glance, would seem to require no interpretation with respect to their structural relevance, the note-pairs before the repeat of the first half and at the very end of the piece, actually both present significant exceptions from the otherwise orderly phrase structure. The final phrase of the first section ends with C-F#, the note-pair which, in the two preceding phrases, opens the subordinate clauses. Even more drastically are the final notes of the piece. Separated from the fifth phrase by a

striking four-beat rest, the composition ends with the 'opening' note-pair B<sup>b</sup>-G<sup>#</sup>. Both halves thus break off with grammatically incomplete sentences – thus pointing towards a 'progression' beyond the notes?

## CHAPTER 5

Perceptions such as the one regarding what I call the 'aborted openings' are of course of supreme importance for the performer and, indirectly, for the listener. This brings me to the emotional content of the piece. (Fig. 7) Webern takes greatest care in determining the colour and intensity of each of his musical syllables, combining the seven symmetrical pitch-pairs with five kinds of articulation (*legato*, *staccato*, *legatissimo*, *staccato* preceded by *acciaccaturas*, *marcato*) and three degrees of loudness (*p*, *f*, *ff*). Furthermore, he creates agogic tension by means of rhythmic contraction (omitting the rest in his basic quaver pattern of note/note/rest). The use of these parameters allows the following observations:

The note-pair A-A is the only one to retain its colour and intensity (*staccato/p*) in each recurrence. Already low in tension due to its position at the axis of the symmetrical system and to its note repetition, the consistent colouring specifies the expressive function of this note-pair as relaxed or introverted. At the other end of the spectrum, *marcato* occurs exclusively in superimposed note-pairs (i.e. chords), in either *f* or *ff*. These combinations must thus be identified as extroverted. Both 'introverted' and 'extroverted' pairs are introduced in phrase 1.

Phrase 2 begins with the agogic enhancement mentioned above. The omitted rest between two note-pairs creates tension not through quantity of loudness and notes as in the 'extroverted' *marcato* chords, but through intensification on the plane of time. The assumption that this 'two-syllable word' constitutes a distinct item in the vocabulary of this work is confirmed by the fact that its recurrences, towards the end of phrases 3 and 4, also combine chromatically adjacent pitch-pairs in the articulation *legato/staccato* and the dynamic setting *f/p*.

As a development of this 'two-syllable' feature there appears, right after the opening of phrase 4, the rhythmic contraction of two identical pairs in the form of a horizontal symmetry (B-G/G-B). Highest intensification is achieved where, in phrases 4 and 5, all enhancing features coincide. The 'extroverted' *marcato/ff* chords are mirrored in rhythmic contraction by one of the note-pairs.

As a conclusion, it is intriguing to observe how the understanding of Webern's musical language on the basis of his use of symmetry as a building principle can even help interpreters determine the emotional content and the grades of intensity in the composition. This is particularly important since Webern's repeated use of only three dynamic degrees might otherwise give the erroneous impression of a music static in terms of its expression.

– Phrase 1 contains both the 'introverted' and the 'extroverted' pairs, one in each of its subphrases. It is thus balanced in its expressive content.

ANTON WEBERN: VARIATIONS OP. 27, II  
DYNAMICS AND ARTICULATION

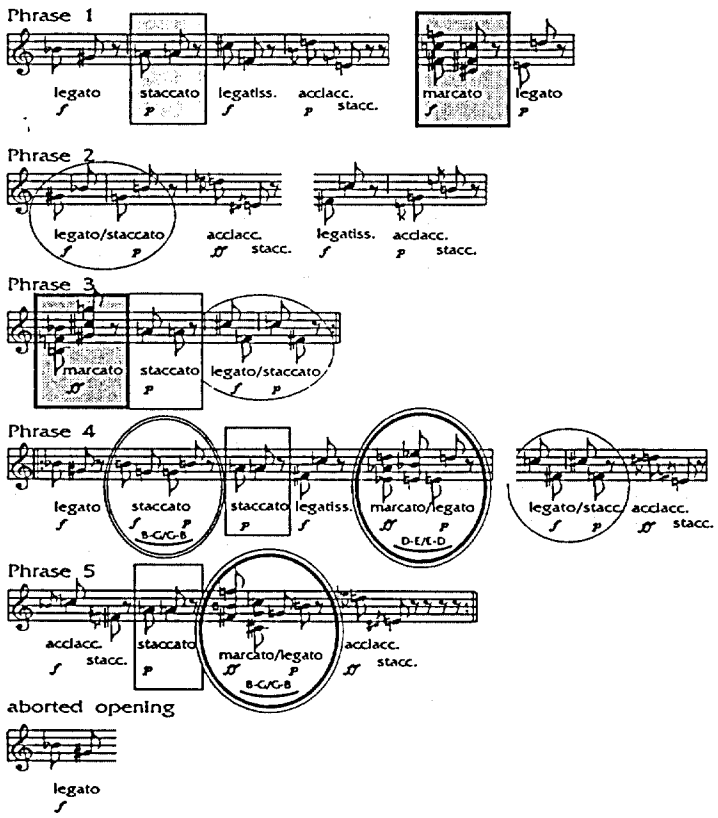


Figure 7

- Phrase 2 by contrast does not feature either of these special pairs. The dramatic tension of its first subphrase, stemming from the rhythmic contraction at the outset and the first use of *ff*, abates in the subordinate clause.
- Phrase 3 presents, at its very beginning, an immediate contrast of the extroverted with the introverted pair. This is followed by the intensifying feature of rhythmic contraction. The open phrase-ending (see the absence of the 'closing' pair D-E) gives this highly-strung phrase a strong quality of restlessness.
- Phrase 4 is not only the longest but also clearly the most dramatic, containing all of the emotionally designated features. In its first subphrase the opening pair, followed by the rhythmically contracted mirror and the 'introverted' pair leads through the 'subphrase-opener' directly into the first multi-feature climax. The shorter second subphrase incorporates the 'secondary opener' into another rhythmic contraction which is then rounded off with the closing pair.

– Phrase 5 sets out with a combination of the pitch pairs identified as primary and secondary phrase-opener (B<sup>b</sup>-G\* with C-F\*). Tension is suspended in the subsequent introverted pair but then bursts out into the second climax of the piece. By comparison with the preceding phrase 4 which contains the other main climax, phrase 5 is conceived as more concise.

## CHAPTER 6

It has been attempted to show, in a few examples out of what could be many more, how a mode of expression relying as vitally on the course of time as music does, can nevertheless be open to symmetric organization. To be sure, we are not expecting audiences to become intellectually aware of a symmetry – no more than we expect them to grasp the details of a modulation in nineteenth-century music, or to understand the poetic depth of the lyrics in a song recital. But we can – and should – request performers to thoroughly understand whatever language they are reciting.

The fact that none of these symmetries are likely to be perceived as such by all addressees (i.e. music listeners) and most mediators (i.e. performers) should not discourage anybody, as the same holds true for such intricately beautiful symmetries as those photographed in snowflakes. The futility of the art work obviously does nothing to prevent nature from repeating it in ever new designs.

## REMARKS

- \*1 I owe thanks to Prof. Dénes Nagy, president of the International Society for the Interdisciplinary Study of Symmetry, who pointed out to me the importance of a dissymmetric element in every basically symmetric organism. I intend to investigate further whether or in which respect his statement that such dissymmetry often constitutes the life force of an organism (see the heart in its off-centre location) applies in music.
- \*2 Although the axis system manifest in Fortner's piece is not identical with that used e.g. by Bartók, my understanding of these tonal relationships is greatly indebted to Ernő Lendvai's study of tonality (1979).
- \*3 To appreciate what is at stake: this is an extremely fast piece of about half-minute duration, employing exclusively one rhythmic value (the quaver or eighth note), and featuring pitches distributed without any melodic connection over four octaves. Played by an uncomprehending performer, it is most likely to sound like a madam's nightmare.

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