Luciano Berio has made significant contributions to the development of electronic music, from the Studio di Fonologia Musicale of the RAI in Milan, to IRCAM in Paris, to the Italian Centro Tempo Reale, founded in Florence in 1987 with the objective of creating a structure in which to investigate the possibilities of real-time interaction between live performance and programmed digital systems. Tempo Reale is today a center of musical production, research, and education where many major Italian composers, in addition to Berio himself, create their works and where important works from the electroacoustic repertoire are performed.

In this article, we focus on three compositions by Berio that are not only particularly significant in themselves but also represent an important testimonial to the production activity of the center in recent years: Outis, the azione musicale composed in 1996 for La Scala theater and then performed again in 1999; Ofanìm [1988–1997] for female voice, two children’s choirs, two instrumental groups, and live electronics; and finally, Altra voce (1999), a chamber music composition for mezzo-soprano, flute, and live electronics. The electronic parts of these compositions were totally revised beginning in 1999, and various updated musical–technological contributions have been presented in their recent performances. They are in any case works that, ranging from musical theater to chamber music, clearly exemplify Berio’s approach to composing for live electronics in different contexts.

This article discusses the problems involved in this approach within the context of the musical–technological solutions designed and implemented by Tempo Reale for the live performance of the three works. The techniques adopted are first described in relation to their use in music; they are then viewed within their proper context in a more detailed description of the three specific works. The performances in question are the most recent ones for each composition, namely Outis in Milan [September 1999, La Scala Theater] and Paris [November 1999, Théâtre du Châtelet], Ofanìm in Milan [October 2000, Sala Verdi], and Altra voce in New York [March 2001, Carnegie Hall], Tokyo [October 2002, Kajimoto Music], and Rome [March 2003, Renzo Piano’s Auditorium].

Technology Serving Music

One of the major features of Berio’s work is undoubtedly his search for continuous mobility in music. The possibilities of physical movement of sound offered the composer by new technologies are many, involving, for instance, the trajectories followed by sound events through space, continuous modulation on harmonic and dynamic levels, and various types of proliferations of sound layers. But what truly interests Berio are not these situations in themselves, but rather the relationships that are established between such physical–acoustic sound mobility and the effective mobility of the musical thought.

Another fundamental aspect in the use of technology is what Berio himself defines as “adaptability of the musical thought to different spaces and listening situations.” Computer technologies and those of sound diffusion allow the composer to inhabit new, unconventional acoustic spaces, as well as to open up and render flexible spaces that are typically closed (such as traditional theaters) and often strongly linked to standard modes of music presentation.

Analytical Listening: Principles of Amplification and Sound Spatialization

The simple amplification of a sound should be viewed, according to Berio, in the light of its musical consequences:

Our listening is today conditioned by top-quality recording. A recording of this type al-
ways has an analytic nature and therefore my ideal is that of creating a type of acoustics and sound that is typical of a great recording studio. (Berio 1999b)

This consideration implies a series of consequences for the entire electroacoustic chain, from microphone techniques to sound diffusion systems. These decisions must, however, take account not only the maximum possible quality of the sounds reproduced through the loudspeakers but also the interaction between these and the natural sounds of instruments and voices:

Technologies interest me when they become an extension of human work, of the performance, the sound, the voice, but not as an end in themselves, not as “effects.” In fact, I have no interest in searching for new sounds. A new sound is created when there is a new musical idea to produce it. What interests me is extending the possibilities of instruments, of the voice, but in an organic manner, which is not in conflict with the sources of sound. (Berio 1999b)

This concept differs profoundly, for example, from the traditional amplification of a rock-and-roll concert. In fact, here it serves not so much to increase the loudness of the sound, but rather to modulate the natural acoustics of a space. This calls for great homogeneity between the natural and the amplified sound—homogeneity that can be achieved only by analyzing the acoustics of each individual space and adapting accordingly all of the parameters important to the spatial perception of the sound: the number of sound loudspeakers used for amplification and sound spatialization, their positions, equalization, delaying systems—even slight reverberations to avoid excessive superimposition of the more directional sound emanating from the loudspeakers over the natural one.

One of Berio’s special interests is the potential for mobility in space of the amplified sound. Already in his works without electronics there exist many examples in which the positioning of the performers in space is used as a compositional parameter. It might almost be said that this is a constant factor in his catalogue, considering works such as Alleluiah II (1956–1958), Sinfonia (1968–1969), Coro (1974), and Formazioni (1985–1987). The musical use of space can serve very different functions. The modification of the listening perspective and the determination of a multiplicity of sound levels in continuous transformation are among its most important aspects. This is exemplified by the third group of violins in Sinfonia, placed behind the orchestra, and the two harps in Formazioni positioned at the two far ends of the stage, as close as possible to the audience. A spatial organization of this type leads to greater acoustic transparency, whereas in other cases it is possible to suggest a different mode of perception, capable of rendering listening ambiguous and orienting it toward a greater fusion of timbres. This happens in Coro, for example, where a group of 40 singers and 40 instrumentalists (not counting the keyboard and percussion instruments) is divided into 40 pairs, each composed of a voice and an instrument in the same register, thus contributing to the creation of a single quasi-hybrid ensemble of voices and instruments. As a result, the organization of space in music results at times in a greater acoustic transparency, at times in a more tight-knit perceptive unity—characteristics that even without electronic means confer a more “analytic” perspective on listening.

The effect which in the orchestral writing is achieved through static dispositions can acquire a new dimension of mobility through electronics: by artificially moving different sound structures closer or further away in space, it is possible to continuously modulate the degree of affinity between sound layers. This principle holds true for the interaction between natural sound and amplified sound as well as between different electronic layers, but can also be emphasized through suitably differentiated systems of reverberation serving to vary the degree of perception of each sound source by the listener. The “trajectories” of the movements can also become significant, as is already the case in Berio’s compositions without electronics, where at times he creates “virtual” movements of sound. Formazioni is, for example, dense in situations where identical notes or similar figures pass
between groups that are similar in timbre, but separated in space, thus creating the illusion of a shifting of the sound. But it is expressly in works such as Ofanı`m that the sound trajectories, created artificially, can acquire further significance, as will be seen in the final part of this article.

In the works featuring electronics, many parameters of the sound spatialization or transformation systems are not established in detail by the composer. However, the sound locations are fixed in relatively precise manner in an “electronic score” thanks to a notation that defines sequences of configurations of loudspeakers. (This term “electronic score” will be used repeatedly in this article: in addition to the normal, traditional score, Berio constructs an annexed document containing a general description of the points where electronics intervene and provide cues, including also the spatialization of sounds.) In this regard, the traditional score is enriched by a series of pointers that indicate the starting and ending points of the cues and of the groups of instruments progressively involved (see Figure 1). Accordingly, the electronic score is not a score in the traditional sense, but rather it constitutes a list, in symbolic form, of the general instructions to be carried out for each individual action of electronics.

In the diagram in Figure 2, an example of sound spatialization can be seen. Each box represents a certain loudspeaker, while the numbers indicate the order in which each configuration appears for the first time. To each diagram corresponds a definition of holding times $t_h$ and movement times $t_m$ (i.e., of the passage from one configuration to another). The sequence proceeds the first time in the order in which it is written, after which various types of permutation may succeed each other in the electronic score. The sequences may stop at the last configuration, or begin again from the start (loop option).

For these three works in particular, but also in general for all of the latest works realized by Tempo Reale, a general-purpose system of sound spatialization called Smov (Sound Movement) has been developed that, while retaining basically the same structure from one piece to another, allows the realization of compositions where the arrangement and number of loudspeakers for spatialization differs substantially. The system can be applied for a variable number of sound sources to be moved. It consists of a series of engines which operate on the amplitude of the audio signal, redirecting it toward a variable number of outputs according to a series of musical models of movement. In the works examined here, predominant use is made of sequences [path between sound loudspeakers selected with determined times of stasis and of movement] and some types of random algorithms [random times and localizations, weighted randomness on the localizations, permutation of localizations and time]. The reverberation parameters associated with each sound source [natural or transformed] are controlled separately by the module for general management of events described in the following sections.

**Ramifications and Accumulations:**

**The Use of Harmonizers**

The creation of a homogeneous path between acoustic sources on the one hand [voices and instruments] and electroacoustic sources on the other [live electronics] is undoubtedly one of the main concerns of Berio’s recent composing with electronics. In this sense, his decisions are oriented toward processing algorithms that do not radically transform the sound but are akin to the procedures of vocal and instrumental composing. This is certainly true of the use of harmonizers, algorithms that transpose the pitch of the input signal a certain interval, thus adding to the input one or more transposed signals. Berio is well aware of the possible hazards of this type of processing, consisting primarily in the rigidity of a fixed transposition, at times resulting in parallelisms that may easily become annoying. To render the perceptive effect of harmonizers more mobile in time, he often uses asynchronous time sequences of intervals, describing them in detail in the electronic score (see Figure 3).

Fixing the tempo in such a precise manner may seem like excessive control, but in reality, owing to the freer performance times of the interpreters, the result is never “mathematical.” Rather, it consists of a certain indetermination in the effective harmonic results that break away from the algorithm in time. To give even greater range to the use of
Figure 1. Excerpt from the score of Outis. (Copyright 1996 by Ricordi-BMG. Used with permission.) The electronic processing refers to woods (cues 9–11) and brasses (cues 10 et seq.).
this technique, Berio also requests continuous modulation of the relationship between the original signal and the transformed signal. As a general principle, their contributions should be practically the same (as with two orchestral groups, for example). However, the relationship between the levels should never sound mechanical but constantly in motion.

The harmonizer is used mainly in two types of musical situations, the first linked to the concept of heterophony, the second to that of sound masses. In the case of heterophony, a melodic line appears simultaneously with other lines derived from it. This principle can be easily applied by superimposing on a line played live its transformations from the harmonizer. The example appearing in Figure 4, taken from [Altra voce], shows the part of the mezzo-soprano line with one of the possible results of its electronic transformation.

In other situations, characterized instead by the presence of sound masses, the harmonizer serves to augment the vertical density of structures already very rich harmonically. This is the case, for example, of Section V of [Ofanîm]: in the harmonic excerpt shown in Figure 5, the results of the transpositions are not explicitly indicated, but it is instead possible to see the temporal development of the harmonic shifting in relation to the chords of the first of the two instrumental groups.

**Memory and Continuity:**

**Delay and Sampling Algorithms**

In the relationship between instrumental sound and transformed sound, delay and sampling are of crucial importance. The so-called “real-time freeze” processes are one of the most distinctive features of the newest versions of [Altra voce] and [Ofanîm]. This involves the real-time recording of selective fragments of the performance in process and their reappearance in loops at subsequent times shown in the score. In some cases, the duration of the recorded fragment is established independent of a particular performance, while in others it is deduced from the sampled event (as, for example, in every case in [Altra voce]).

Usually, the freeze operation concerns the continuous reproduction of individual notes, individual chords, or notes and chords with rhythmic articulation or internal melodic profile. This situation results in the perception of prolonged, interwoven, dynamically variable textures of sound that function as structures of continuity in the economy of the compositions. In other cases, the freeze may operate instead on the reproduction of longer fragments articulated rhythmically and melodically (entire musical phrases, for instance). This use of sampling, which plays on the stratification of memory, resembles the use made by Berio himself of delay algorithms with relatively long delay times.
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This also reiterates the concept of the dialogue and of proliferation in time of the sound events in question, characteristics common to all of the works analyzed here.

Concerning other sampling systems, in Ofanìm and Outis we find among the performers a sampler ("keyboard" in the score) that is used with instrumental or vocal timbres to augment the potential of the originals in both harmonic aspects and rhythmic articulation (e.g., clusters of large size, particular glissandi, rhythmic figures). In both of the compositions, the sampled sounds never stand out alone from those of the orchestra but blend with the rest of the live sounds and serve the function of both sound enrichment and orchestral extension.

Algorithms and Musical Events: System Management and Technological Solutions

The algorithms employed by Berio are not in themselves complex but belong to the classical repertoire of live electronics. The possible problems of implementation regard on the one hand a series of micro-level details (e.g., selection of the individual parameters of the algorithms, times and modes of their input and output, etc.) and on the other the global management of the score. Regarding the latter aspect, some of Berio’s scores often call for, at least in two of the cases described, large orchestras with electronics that at various times operate on different instrumental and/or vocal groups. These scores also call for very large amplification systems for both the sheer number of instruments involved and the number of diffusion groups. In addition, the high degree of stratification of the electronics (i.e., the number of individual operations in parallel), which evolves continuously during the playing of the pieces, contributes still further to the general complexity, making it necessary to devise very highly evolved solutions for managing the plurality of events.

Over the years, Tempo Reale has developed a system based on a number of fundamental characteristics: versatility and adaptability to different musical contexts, simplicity and rapidity in bringing about changes in events (changes that become necessary in regard to compositional requisites and potentially at any stage in production), stability of the entire system, and overall sound quality. In the general construction of the system, a primary goal was that of attaining the maximum degree of

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automation possible, but without excessively constraining the freedom of the performers, both instrumental and electronic.

The system has a central management core with a series of collateral elements whose interaction and integration ensure easy management of a wide range of musical and control events. The logical scheme of the control structure (see Figure 6) is conceptually simple, which guarantees its adaptability to numerous situations. The central node of the system consists of an audio matrix including one or more mixers within which converge all audio signals to be processed or to be amplified. In Altra voce, the work that calls for the fewest performers (flute and voice) of those discussed here, a single digital mixer is used, while Outis (a musical theater composition involving, in addition to chorus and an orchestra, numerous soloists), requires two digital mixing boards, an analog mixer of large size for the orchestral premix, and an additional small analog mixer for the vocal group. The structure of the audio matrix can thus vary substantially, but the central core always consists of one or more digital mixers entirely controlled by MIDI. Thanks to this feature, it is possible to remotely manage the quantity of each individual signal to be sent to the signal processors and to the diffusion or spatialization system, thus obtaining the greatest possible degree of flexibility in signal routing.

For signal processing operations that are particularly computationally demanding, dedicated commercial hardware systems have been selected that share with the entire system the characteristics of programmability and reliability in the majority of operational situations. These devices have been used basically for the reproduction of recorded samples and for three types of algorithms—harmonization, delay, and reverberation, as well as for different combinations of the three. In all cases, the various parameters are controlled by MIDI. For other operations, a different approach has been used: that of programming workstations in the Max/MSP environment. This is the case with the reproduction of “playlists” of long duration, of freeze algorithms, and of the sound spatialization system. The management module (Cue Manager), which controls all of the elements of the system, is also programmed in Max/MSP. Through internal messages, MIDI, and Ethernet, it controls all of the other subsystems, opening and closing the channels of the matrix, sending sequences of intervals to the harmonizers, actuating the spatialization engines, controlling the sampling systems, generating monitoring signals, and so on.
The Cue Manager is based on a structured sequence of events in which each block represents a precise point in the score (cue) along with all of the electronics events associated with it. During a live performance, the list is scrolled manually by means of a computer keyboard or through a MIDI peripheral. (In Ofanı`m, for example, the keyboard player in the orchestra controls the Cue Manager.) To the possibility of sequentially scrolling the list of events, the system adds that of jumping directly to any point in the score, instantaneously recalculating the lines of the electronics enabled at that point, and repositioning itself at the musical situation requested. This characteristic is highly useful in the testing stage and during rehearsals with the instrumentalists.

The structured list of events is normally complex and thus difficult to write and to edit. A specially designed relational database (Meeg, or Max Electronic Events Generator) is used expressly for the purpose of facilitating writing and subsequent editing. This database can be automatically generated after the formalization of the electronics commands. Through interaction between Meeg and the Cue Manager, it is possible to recreate the entire configuration of the system and the ensemble of instructions specifically used in each composition without having to act directly on the database code. Thanks to this approach, Meeg, like most of the system, can be used in a broad range of situations without requiring modifications in its code, and it allows rapid changes in the sequence of events to satisfy new musical or technical requisites.

The problem of stability is particularly important in musical systems having a high degree of integration between software and hardware devices and has been the subject of special attention. Usually, the weak point lies in the computer sub-systems, which may be subject to complications of various kinds not always easily predictable. To lessen the possibilities of a system crash, redundant sub-systems that function as backup devices have been integrated into the structure. These subsystems, proceeding synchronously with the main ones, can be used instantly in case of problems during a performance.

**Inside the Music**

Although many of the musical concepts in the three works are in some way correlated, and the guidelines for designing their electronics comply with a unifying logic, it seems useful to describe in greater detail the relationship between music and technologies within the context of the three compositions which, as a whole, offer a panorama of different aspects of making music, from chamber music to musical theater. In this article, the three works are examined in chronological order based on the first drafting of the scores. Actually, the evolutionary cycle of the latest revisions of the electronic parts should follow a different order (Outis–Ofanı`m–Altra Voce). This indicates how Berio constantly reconsiders each performance with electronics; in this sense, each new version is inevitably influenced by previous experience and work.

**Inhabiting Space: Ofanı`m**

Ofanı`m for two children’s choirs, two instrumental groups, a female voice, and live electronics can be considered a work in progress. The first version was presented in Italy, at Prato, in 1988, and it has since undergone various processes of rewriting of not only the electronics but also the entire score (Bernardini 1995). In the latest versions, the vocal and instrumental parts have undergone no changes, but Berio already specified the “open” nature of the electronics part in these terms:

Musical thought today must be able to interact with the new technologies and to adapt itself creatively to every kind of space, exploring its virtualities and reshaping acoustically. The image of music as sound architecture is no longer a mere metaphor: it represents a concrete possibility, realizable in all its aspects. It is, of course, a mobile and flexible architecture, capable of adaptation to different situations and environments. Therefore, the acoustic strategy of Ofanı`m has to be modified with each new performance and consequently several aspects of the entire work are recomposed (Berio 1992).
In his program notes, Berio also explains the use of the texts:

The text of Ofanı`m (in Hebrew both “wheels” and “modes”) alternates fragments from the book of Ezekiel with verses from the Song of Songs. The dramatic vision of Ezekiel (Chapter 1)—the most personal and apocalyptic of all prophets—stands in strong opposition to the earthly sensuality of the verses from the Song of Songs (Chapters 4 and 5). The phantasmagoric apparitions of Ezekiel’s vision whirls around in perpetual motion against a burning sky: the poetic images from the Song of Songs dwell longingly on the face and body of the beloved. [Berio 2000]

Sound spatialization assumes a crucially important role in characterizing the formal sections musically, while amplification is entrusted to a specific stereophonic system [see Figure 7, groups L–R]. The eight groups of loudspeakers employed for movement in space form a circle around the audience [see Figure 7, groups 1–8], thus reinforcing the initial concept of the wheel. Alternation between the two levels of the text [Ezekiel and the Song of Songs] takes place formally by blocks with very strong contrasts. The fragments of Ezekiel are linked to very rapid movements of striking physical impact, while the fragments of the Song of Songs are often distinguished by fixed sound locations. Table 1 illustrates the formal scheme, including very simple verbal descriptions of the spatialization, and gives some idea of the dramaturgical relationship between the various sections of the piece. The table also shows how at certain moments the spatialization anticipates textual and musical elements of the next section [I–II, VIII–IX] or reiterates and develops characteristics from the previous section [III–IV, V–VI].

To investigate the function of electronics in Ofanı`m, we may consider some details of the composition. The score begins with a continuous proliferation of elements. The whole originates from a single note sung by the soloists in the chorus, which is sampled and immediately reproduced in loop. At the moment in which the recorded version becomes perceptible, the soloists begin a melodic path that arises from this central note, while subsequently other “ramifications” of the clarinet and the sampling of the children’s choir are added. In this fragment, marked by a strong timbral affinity between the instrumental and vocal elements, the electronic amplification contributes to a very amalgamated acoustical result. The process of sound “opening,” both harmonic and timbral, is accompanied by spatial projections that slowly oscillate between the front loudspeakers, creating a sense of inner motion along the vast stereo front. At a following stage, onto this sound texture are superimposed more lively figurations of the two clarinets as well as rototoms, diffused with “zig-zag” motions around the circle of loudspeakers—a moment of great surprise which seems a preparation for the explosion of sound at the beginning of the second part, a sort of presentiment of Ezekiel’s vision of the hurricane.

Another section of Ofanı`m of great importance for the electronics part is the clarinet solo (Section IV). Throughout the preceding fragment, taken from the Song of Songs, the first clarinet emerges strongly with figurations that are almost arpeggiations, very sweet and played pianissimo, but that remain well integrated into the overall harmonic structure. From this series of figurations emerges...
Table 1. Formal diagram of Ofanim and of the relevant distribution of the text with respect to the individual sections. The third column contains a verbal description of the sound movements.

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<tr>
<td>I.</td>
<td>EZEKIEL [1:28] And I heard a voice of one that spake.</td>
<td>frontal calm movements; rototoms with fast “zig-zag” movements through full space</td>
</tr>
<tr>
<td>II.</td>
<td>EZEKIEL [1:4–10] And I looked, and, behold, a whirlwind came out of the north, a great cloud, and a fire infolding itself . . . four living creatures . . . and every one had four faces, and every one had four wings . . . and the sole of their feet was like the sole of a calf’s foot . . . they four had the face of a man, and the face of a lion . . . the face of an ox . . . the face of an eagle.</td>
<td>fast movements of various kinds (full space)</td>
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<td>III.</td>
<td>SONG OF SOLOMON [4:16] Awake, O north wind; and come, thou south; blow upon my garden, that the spices thereof may flow out. Let my beloved come into his garden, and eat his pleasant fruits.</td>
<td>fixed diffusion [frontal]</td>
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<td>V.</td>
<td>EZEKIEL [1:14–21] And the living creatures ran and returned as the appearance of a flash of lightning . . . behold one wheel upon the earth by the living creatures . . . and when the living creatures went, the wheels went by them: and when the living creatures were lifted up from the earth, the wheels were lifted up . . . and when those stood, these stood.</td>
<td>fast movements [full space]</td>
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<tr>
<td>VI.</td>
<td>INSTRUMENTAL “TUTTI”—“ROTATING”</td>
<td>fast movements</td>
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<td>VII.</td>
<td>SONG OF SOLOMON [5:3–4] I have put off my coat; how shall I put it on? I have washed my feet; how shall I defile them? My beloved put in his hand by the hold of the door, and my bowels were moved for him.</td>
<td>fixed diffusion [frontal]</td>
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<tr>
<td>VIII.</td>
<td>TROMBONE SOLO</td>
<td>fast movements on the first four loudspeakers</td>
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<td>IX.</td>
<td>EZEKIEL [1:22–24] And the likeness of the firmament upon the heads of the living creature was as the colour of the terrible crystal . . . and . . . I heard the noise of their wings, like the noise of great waters, as the voice of the Almighty . . . as the voice of an host.</td>
<td>fast movements [full space]</td>
</tr>
<tr>
<td>X.</td>
<td>SONG OF SOLOMON [4:1–9] Behold, thou art fair, my love; behold, thou art fair; thou hast doves’ eyes . . . thy teeth are like a flock of sheep, which came up from the washing . . . thy lips are like a thread of scarlet; and thy speech is comely: thy temples are like a piece of pomegranate . . . thy neck is like the tower of David . . . thy two breasts are like two young roes . . . how fair is thy love . . . thou hast ravished my heart, my sister, my spouse.</td>
<td>fixed diffusion [frontal]</td>
</tr>
<tr>
<td>XI.</td>
<td>EZEKIEL [1:26–28] And above the firmament . . . was the likeness of a throne . . . and the appearance of a man above upon it . . . as the appearance of fire . . . and . . . brightness round about . . . as the appearance of the bow that is in the cloud in the day of rain . . . A voice . . .</td>
<td>fast movements [full space]</td>
</tr>
<tr>
<td>XII.</td>
<td>EZEKIEL [19:10–13] Thy mother is like a vine in thy blood, planted by the waters: she was fruitful and full of branches by reason of many waters. And she had strong rods . . . and her stature was exalted among the thick branches, and she appeared in her height with the multitude of her branches. But she was plucked up in fury, she was cast down to the ground, and the east wind dried up her fruit; her strong rods were broken and withered; the fire consumed them. And now she is planted in the wilderness, in a dry and thirsty ground.</td>
<td>calm movements [full space, gradually moving away from the female voice, then returning to her]</td>
</tr>
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the solo passage, accompanied only by a few “punctuations” of the two choirs, the percussion, and the sampler. The entire section is treated with a single algorithm of live electronics, a combination of spatialization, harmonization, and delay with variable feedback (see Figure 8). The sequences of spatialization, harmonization, and the amount of feedback in the delay are all looped and superimposed in an irregular manner, both among each other and with the original sound. The result is a kind of dialogue of the clarinet with its electronic double. The score oscillates between zones dense in arpeggiation and other more rarified ones (see Figure 9), continuously shifting attention between the original clarinet sound and its electronic transformation.

Lastly, consider Section VI, a fragment without voices that follows the central movement of the text of Ezekiel, the vision of the wheels. This section begins with a great crescendo of the tremolos reinforced again by electronics that proceed with irregular “zig-zag” spatialization and with harmonization sequences that are different for the two orchestral groups. The very particular orchestral writing (combinations of whirring trills, very fast repetitions, and arpeggios), the use of slide whistles, the rhythmically asynchronous organization, and the almost “circular” melodic profile of the individual parts create, as a perceptive result, a single mass of sound, overwhelming, turbulent, and almost in “rotation.” Through the various electronic shifts (in pitch, time, and space) it becomes even more agitated and teeming with life.

At points such as these, an important change has been made in the latest version of Ofanîm presented in Milan. Whereas the former versions were always distinguished by real rotations in the spatialization, these have now been abandoned in favor of much more irregular movements that confer a somewhat “probabilistic” nature on the sense of spatialization, conveying a striking sense of discovery of acoustic space. Regarding the electronics, only the physical arrangement of the sound loudspeakers still alludes to the concept of “wheel.”

Electronics for Musical Theater: Outis

Outis is one of Berio’s two more recent works of musical theater, along with Cronaca del Luogo, which inaugurated the Salzburg Festival of 1999. It is a complex work lasting nearly two hours with texts by Berio himself and by the renowned Italian Hellenist Dario Del Corno, whose title is evocative of Homer’s Odyssey and of Ulysses’ answer to Polyphemus: “Outis emo q’oanoma” or “My name is no one” (Del Corno 1999). However, the work does not follow the narrative path of the Odyssey but is instead distinguished by a division into five cycles within which emerge a plurality of histories and plots, referring to the most widely differing authors, from Homer himself to Catullus, from Auden to Brecht, to Joyce, Melville, Sanguineti, and Celan. The multiplicity and variability of both text and scene—but above all of the music—are to be considered the true narrative constants of Outis, characteristics that make it possible to “perceive different figures and episodes in the same light or to grasp the sense of a single element in constantly changing lights and musical perspectives” (Berio 1999a). This pertains to all elements of the musical path, whose amplitude and continuous transformation bear witness to their complexity, suggested also by the relatively large number of performers: 19 soloists (13 singers, 1 actor, 5 instrumentalists on the scene), a vocal group of 8 singers, chorus, orchestra, and live electronics.

Performed for the first time at La Scala in Milan in 1996, directed by Graham Vick, Outis was presented again in 1999 first at La Scala and then at the Théâtre du Châtelet in Paris, where it was directed by Yannis Kokkos. For these two performances, Berio designed a new electronics part more suitable to both solving problems typical of electronics for the musical theater and the identification of the particular musical and sound features of the work itself. The basic premise for electronics in Outis is an attempt to free the sound from the undesirable tube-like effect deriving from the posi-
tioning of the orchestra in the theater pit, an effect which undoubtedly conflicts with the ideal of analytical listening. What finds application here is the general concept of an orchestral sonority, which, thanks to amplification and proper equalization, can approach the character of a perfect studio recording. In this case, however, the sound diffusion must be such as to prohibit any perception of the presence of loudspeakers or of evident electronic transformations; the processing of the sound is something that appears but which the audience should not have time to identify and recognize:

In this work—where there is not, in effect, any "real" live electronics, but there is a great respect for the musical acoustic substance of the work and also for space itself—the technologies tend to prolong certain aspects, to develop them interiorly in a way that might almost be called devious and concealed. [Berio 1999b]

In this sense, the difference between this concept and the electronics of Ofanìm, where the presence of loudspeakers constitutes an element of great dramatic impact, is striking.

In the case of Outis, amplification and diffusion systems adapted to the scenic space of La Scala and of the Théâtre du Châtelet were used. The frontal arrangement of the loudspeakers provides four groups of loudspeakers placed in the stage boxes, to which is added a central cluster serving to close the stereo front and for diffusion of the voices (see Figure 10). The four side groups are also used to achieve sound diffusion with horizontal, vertical, and diagonal movements. Furthermore, a group of loudspeakers is placed inside the chandelier located at the center of the ceiling over the stalls and is used to play particular recorded sequences of children’s voices. As a whole, this is a diffusion system that, on the one hand, reiterates structural features of the work, while on the other interacts with and is grafted onto the most classic and difficult scenario, that of the traditional theater space. Berio himself clearly explains this dual function of the diffusion techniques:

An acoustical dimension is created which no longer corresponds to that of the orchestra pit. There are loudspeakers concealed at the sides of the stage and above the stalls, of which the audience will be unaware, but which will serve to enlarge the sound perspective. The central interest of these sophisticated systems occurs when they are adapted to the musical work. There can be no indifference toward this type of technology in relation to the work represented; it must enter into it and be redesigned in accordance with the nature of the work. [Berio 1999b]

Although the computer music environment uses conceptually simple algorithms, it is their relationships with the musical score and with the orchestral sound that determine their functioning. The
spatialization and the harmonizing as well as, the microphone choice and placement, thus contribute to a process of extending the orchestral sound and projecting it into a dimension of continuous mobility and transparency:

I have always tried to renew the instrumental sound, the one produced by known and accepted instruments. I have tried to transform it to make listening more analytical, with several layers interacting with each other. . . . There are articulations which are harmonically very complex and the microphone can, in effect, contribute to better listening. Basically, it is used as a microscope, for the enlargement of minimal aspects, acoustic and musical, of the work. (Berio 1999b)

All of the instruments in the orchestra, the choir, and the instrumental soloists are given individual microphones, whereas the voices all sing without amplification with the exception of the speaker and the vocal group. “Microphoning” has the objective of capturing the signals both for sound reinforcement and for the live electronics algorithms. The electronics includes the spatialization and a series of delay and harmonization algorithms that are applied at various times to different orchestral groups. In addition, recorded sequences (playlists) containing both recited phrases and real sounds of various kinds (animal sounds, a ship’s foghorn, birds, and so on) are reproduced.

The setup also includes a sampler placed in the orchestra pit with which a keyboard player executes sound events with mainly instrumental or choral timbres. During the second, fourth, and fifth cycles, the work uses a motion detection system (realized already for the first version of Outis by the Musical Informatics Laboratory of DIST in Genoa). The system is based on two footboards placed at stage level that, when activated by a movement of the foot, effect reproduction of percussion samples.

Figure 10. Configuration of the loudspeakers in Outis (front view).
Many aspects thus make *Outis* a complex and important work among the recent musical achievements of Berio: the fragmentation of the texts, the many ways of singing them, the concealed but intense use of live electronics, and the adaptability of technologies to the work and to the scenic space. In this sense, the electronics function to enrich a sound organism that, albeit moving with relatively traditional characteristics, is enhanced by continuous mobility and variability over time, with the result of constantly drawing the listener's attention back to the musical dimension of the work, making sound, more than the other parameters of musical theatre, the true protagonist of the long and complex dramaturgical process (Giomi 2000).

The Live Electronics “da Camera” of *Altra voce*

*Altra voce* for contralto flute, mezzo-soprano, and live electronics is an example of Berio’s use of electronic techniques within a chamber music context. This composition, however, is derived from a work of musical theater:

In one episode, namely *Il Campo* (*The Field*), from my *azione musicale*, *Cronaca del luogo*, there is a virtual love duet. Two voices and several instruments “fall in love” and follow one another in a constantly renewing relationship. . . . As we all know, in true polyphony each voice contributes to the whole, yet retains its own identity, if not complete autonomy. In *Altra voce*, I have liberated one voice (mezzo-soprano) and one instrument (alto flute) from the whole and developed their respective autonomies and harmonic premises by, among other means, using live electronics. (Berio 2001)

The choir, the orchestra, and the loudspeakers of *Cronaca del Luogo* are placed behind the stage at various heights, forming a kind of “wall” of sound. In *Altra voce*, this idea of a wall is translated into a configuration with two diverging diagonal lines of loudspeakers that, adapting themselves to the performance space, are positioned at the farthest possible distances (see Figure 11, groups 1–6). To the diagonals are then added two groups of loudspeakers positioned at the performers’s feet for sound reinforcement (see Figure 11, groups L–R).

In this composition, the electronics play a crucial structural role and are characterized by three types
of processing: the live sampling of various fragments, spatialization, and the use of harmonizers.

From the formal diagram of the electronics part (see Figure 12), it is immediately apparent that the various kinds of processing do not take place one after another but tend to overlap and interweave. The first sample, a single $F$ for voice and flute, is actually held from the third beat (see Figure 13) to the last. Regarding the function of this continuous note, Berio speaks of a sort of “tonic,” an always-present element that gives a common perspective to all other events. This $F$ is accompanied at various times by other samples falling into two categories: fragments of held notes, which played in a loop create continuous events (#1, #2, #3, and #6); and entire musical phrases (#4, #5, #7, and #8), which appear instead as repeated musical structures. This creates various reference elements that could be described as “attraction poles,” compared to the precise delimiting of the traditional tonic. The musical discourse moves within the gap that opens between these poles.

Following the formal scheme it can be seen how the first category of samples has an almost symmetrical distribution (#1-#2-#3-#3-#6-#2-#3-#2-#1), while those with phrasing (#4, #5, and #7) mark the beginning or the end of formal accumulations. Sample #8 should be considered a special case, as it consists of a structure recorded “off-line,” that is, not during the performance, and enriches the final zone in which, in general, continuous rarifying of the sound layers occurs.

The sound spatialization is characterized by a process of expansion of the loudspeakers closest to the performers (1 and 2) up to the ensemble of all of the loudspeakers, reached at beat 49. From this moment on, various differentiations in the use of space take place based on the type of movements (speed and regularity) and on the use of pairs of loudspeakers alternating with individual loudspeakers.

In addition to these ideas of movement, Altra voce is undoubtedly an important example of how Berio operates with electronics on degrees of affinity between different sonorities: initially, with the long $F$ held on the loudspeakers closest to the performers, the already intense fusion between the timbre of the mezzo-soprano and the contralto flute is reinforced still further, while subsequently, with the accumulation of layers of samples (freeze) and of harmonizers, the various signals are increasingly separated in space, thus rendering transparent an ensemble of layers so homogeneous as to be otherwise almost impenetrable to the ear. Concerning the harmonizers, the formal diagram demonstrates the progressive augmentation of the intervals and of the number of intervals per sequence. In beats 94–109, the degree of parallelism of the harmonizers also increases, up to a maximum of three on the flute and two on the voice. In the final part of the

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**Figure 12.** Formal diagram of electronics in Altra voce. For sampling, an index and an approximate duration of the fragment recorded and reproduced in loop are indicated (for example: #1 ||:4\(^{\text{H11033}}\):||). For the spatialization, the loudspeakers are denoted by Roman numerals. For the harmonizers, the intervals used are shown (e.g., 0, 2–\(\frac{2}{3}\) with the sequences which work on permutations of these intervals).
composition, the harmonizations progressively disappear in favor of the exclusive presence of spatialization alone.

The overall form can be described as two arches, with the first climax underlined predominantly by progressive spatial expansion and the second, thanks to the harmonic stratification, achieved by the augmenting of intervals, the length of the harmonizer’s transposition sequences, and their degree of parallelism. The superimposition of freeze techniques on these elements creates for the listener a texture that extends and develops throughout the entire composition, a “harmonic wall” in ceaseless evolution. All of these aspects of Altra voce may be viewed within the light of the initial perspective: the simple metaphor of “falling in love” leads to a complex polyphony and to a surprising interaction among the three dimensions of sound: vocal, instrumental, and electronic music, which, while retaining their individual autonomy, seem almost to abandon themselves to each other, creating hybrid situations of striking intensity.

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