Musique concrète and electronic music

By the early 1950s, two general tendencies had become preeminent. The first was based on the need for mathematical control of the various parameters in totally serialized contexts, the other motivated by an interest in new possibilities for radical expansion of timbre. Despite technological advancements in electronic instruments operated manually beginning in the 1920s and continued interest in music organized by noise since the pre-World War I experiments of the Italian futurists, both tendencies had remained unfulfilled for the most part until after World War II. A crucial factor that permitted great strides in these areas of mathematical control and timbral expansion after 1950 was the invention of magnetic tape.

Paris: Musique Concrète Without Tape

Just prior to the use of tape, early postwar timbral experiments in Paris had already laid the groundwork for developing new possibilities in the generation of musical sound. In 1948, Pierre Schaeffer, a composer and electronic engineer at the French National Radio, began to consider the use of natural sounds as the basis for musical composition, an interest which had developed from his research into musical acoustics since 1943 as head of the Studio d’Echantillons (entitled Club d’Echantillons in 1946). Schaeffer’s research has some historical precedent in the early experiments of the Italian futurists, who sought to create a musical idiom based on noises produced both naturally and mechanically. However, Schaeffer had the gramophone at his disposal, so available sounds could be transformed by means of mechanical manipulation of the recordings, such use of gramophones having been anticipated by the acoustical experiments of Hindemith and Toch in Berlin in the 1920s. Schaeffer’s first important product after his earliest experiments with the attack and decay of recorded bell tones was his Étude aux chemins de fer (1948), in which he made disc recordings of six steam engines straining and accelerating rhythmically over the rails. Together with Étude aux tourniquets and Étude aux sasroires, Étude aux chemins was broadcast as part of a “concert de bruits” in October 1948. While the possibilities of playing the recorded sounds backwards and changing their speed permitted some alteration of the natural sounds, reassembly of the original materials by means of available techniques could neither completely disguise their original identity nor integrate them into a unified musical medium.


Schaeffer’s use of several gramophones is canon and speed changes of ongoing problems in the creation of a new sound medium. For instance, the use of speed change led to radical modifications in pitch, duration, and in practical use in the early 1950s that each sound element in a recorded group could be modified individually and more drastically. Meanwhile, in collaboration with his colleague Pierre Henry, Schaeffer produced his first major work, Symphonie pour un homme seul (1948), which was originally public performance at the École Normale de Musique in an acoustical situation with an elaborate setting of gramophones and loudspeakers. Techniques employed in the Symphonie surpassed the earlier manipulations of gramophone recordings by a more systematic use of available sounds and techniques in both categories. In final form, the eleven sections of the different types of breathing, vocal fragments, shouting, humming, whistled prepared piano, and orchestral instruments.

In 1951, Schaeffer and Henry began to collaborate on the large musique concrète opera Orphée, the scoring of which produced formidable problems, so procedures, and part of the effort, indicating the musical structure and developed for the more successful performance at Darmstadt in 1953, and juxtaposition of explosive sonorities of noise against Gluck-like recitatives for solo violin. Some solutions to Schaeffer’s problems in the area of graphic Mole was.

In the early 1950s, controversy between German and French composers at Darmstadt over Schaeffer’s aesthetic approach led him to a defense centered at Darmstadt in 1951 on his experiments after a special studio, in which the Paris Broadcasting System. In 1952, he outlined a history of his early musique concrète developments and formulated the principles of concrète:

2 Schaeffer’s use of the prepared piano, based on alteration of the piano sounds by insertion of extraneous objects between the strings, was influenced by John Cage, whom he met in the same year.

3 See Peter Manning, Electronic and Computer Music, n.1, above, p. 29.
composition systematically, defining and describing the use of sound objects that included both human and nonhuman pitched sounds and noises and the use of the prepared piano. By the late 1950s, the aesthetics of both musique concrète and electronic music, often joined in single compositions, had found increasing mutual acceptance among composers in both areas. Significant among them were the German electronic composers and members of the "Groupe de Recherche de Musique Concrète" (renamed "Groupe de Recherches Musicales" in 1958), the latter composers of whom were connected intimately with Schaeffer's studio. Prominent members or associates of the Groupe, who represented wide-ranging approaches from pure concrete and indeterminacy to mathematical calculation in electronic and computerized idioms, were François Bayle (director of the Groupe since 1966), Pierre Henry, Luc Ferrari, François-Bernard Mache, Ivo Malec, Iannis Xenakis (Greek architect and composer Luciano Berio, Michel Philippot, André Boucourechliev (Bulgarian-French composer), Varèse, and others. Even Bayle, one of the staunchest advocates of musique concrète, began to incorporate electronically produced elements into his works after 1963. These more general developments within the musique concrète movement led to the adoption of the term expérience musielle in place of Schaeffer's designation, which was originally narrower.  

PARIS: MUSIQUE CONCRÈTE WITH TAPE

Radical developments in musique concrète composition were permitted by the use of the tape recorder in the early 1950s. Schaeffer introduced the term musique concrète to designate this new musical concept, in which natural sounds are recorded directly on tape, in contrast to the use of the abstract notational signs of the score for tones produced by instruments. Various kinds of recorded natural sounds and noises from vocal and instrumental sources to wind, motor, and other machine-produced sounds could now be modified and transformed by manipulations of the magnetic tape, including speed change resulting in frequency and duration modulations, retrograde of tape, greater control and extension of dynamic range, ostinato patterns produced by the use of tape loops, multiple tapes employed in overlap, isolation of the core of a given sound or noise by elimination of its attack and/or decay, use of echo chambers, and other techniques. The earliest concrete works to use such tape techniques were Henry’s Concerto des ambiguités and Schaeffer’s and Henry’s Bidule en ut (1950). Many other works after 1950 were to be based on the synthesis of both concrete and electronically generated sounds and may, therefore, be subsumed under the heading of electronic music.

FIRST POSTWAR ELECTRONIC DEVELOPMENTS IN EUROPE: COLOGNE

Few works have adhered strictly to either purely concrete or electronic principles from even the early 1950s, such compositions having been referred to more accurately as tape recorder music. The basic difference between the techniques of musique concrète and electronic music is the source of the sounds themselves. The purely electronic idiom, in which musical sounds are generated exclusively from electronic devices and recorded on magnetic tape, had its inception at the Studio for Electronic Music of the West German Radio in Cologne in 1951. The two main figures associated with this studio were its founder Dr. Herbert Eimert, a composer, musicologist, and critic who explored the aesthetics of electronic music and its technical similarities with musique concrète, and the ultrasonist Karlheinz Stockhausen, who became the director of the studio in 1963. While their earliest electronic experiments owed much to the serial principles of Webern, Eimert had already discussed systematically the aesthetics and techniques of twelve-tone composition in the 1920s, further developing them in his Lehrbuch der Zwölffonotechnik (1950) and his Grundlagen der musikalisches Reihentechnik (1965). These studies influenced Stockhausen and others in dealing with the possibilities inherent in the serial principle. Among Eimert’s earliest important electronic experiments were his Four Pieces (1952–1953), in which electronically synthesized tones were recorded on tape. In these early years, pure electronic sounds, or sine tones (i.e., tones without overtones), which are produced by an alternating electric current, or oscillators, were the primordial elements of the new medium. The production, manipulation, and synthesis of these elements by means of electronic generators and the use of the magnetic tape have resulted in radical expansion and transformation of our musical sound world and may be seen as a fulfillment of Boulez’s pre–World War II prophetic assertions regarding the need for an entirely scientific music. The new electronic technology has led to almost unlimited possibilities for the exploitation of the freedoms available within the range of the human ear and also expanded the spectrum of durations, timbres, and dynamics. From the outset, Eimert linked the serial concept to all levels of the process of electronic composition and to the aesthetic basis of the music.


music, but is serial music. . . . Today the physical magnification of a sound is known, quite apart from any musical, expressionist psychology, as exact scientific data.8

Although there are basic procedural connections between electronic and concrete techniques discussed by Eimert—including the superposition of sound, multiple tapes in canon, cutting, splicing, and reassembling of the tape, speed change, retrograde, ostinato produced by tape loop, durational values determined by tape length, dynamic change, multiple loudspeakers, etc.—his attitude has suggested a fundamental philosophical difference from the assumptions of musique concrète, the latter by its very connections with the world of natural sounds lying closer to human sources. In contrast, pure electronic serialism paved the way for use of the computer by the late 1950s and a greater removal from the human performer/interpreter. From the beginning, the electronic composer was able to generate the raw materials directly from the electronic sources and then to work directly with the tape.

The first complete electronic composition to be based entirely on pure (sine-wave) tones was Stockhausen's totally serialized Elektronische Studie I (summer of 1953), and the first such score to be published was his Elektronische Studie II (Universal Edition, 1954), both works produced at the West German Radio in Cologne. While the sine-wave generator served as the exclusive sound source for both pieces, the electronic sounds of Studie II were based on the separation of "white noise" into "coloured noise," rather than on the addition of sine-wave frequencies to "stationary sounds and note-mixtures."9 Thus, the noise spectrum was introduced systematically into electronic composition.

The first step in the composition of Studie II was a tape recording of the raw materials comprising 193 tone mixtures, of which the individual frequencies were derived serially (mathematically).6 Selection was then made from this "scale" of mixtures and recorded according to a notational, or graphic scheme (Ex. 18-1).7 The degree of noise that was introduced into the composition was determined both by the use of harmonically unrelated partials of the overtone series and the density, or closeness in the adjacency of these superimposed sine-wave oscillations. Control of the ratios between the sine waves thereby permitted graded sound transformations along the continuum between notes and noise. In contrast to Studie I, the use of a reverberation chamber in Studie II contributed to the systematic introduction of noise into the composition by creating greater density through the distortion of the superimposed sine tones.

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Other parameters are also indicated in the three layers of the score. The volume envelopes, measured in decibels, are indicated at the bottom of the score in correspondence with each note mixture in the frequency/timbre section at the top. The duration of a note-mixture is indicated by tape length, measured in centimeters, in correspondence to the length of the pitch and volume lines. The piece opens with several successive and overlapping note-mixtures, the first with a range of five frequencies (650 to 2500 Hz) forming mixture number 67.\footnote{Ibid.}

By the mid-1950s, Stockhausen made further advances in the generation of electronic sounds and the exploitation of expanded timbral possibilities.\footnote{See Wörner, Stockhausen, n.7, above, p. 127.} In Gesang der Jägerlinge (1955–1956), he went beyond Studie II by filtering “white noise” more completely into different noise bands and continuing the filtration process until the single note reemerged. Through further superimposition of the noise bands, he was able to arrive at possibilities still more expanded for timbral invention. Another development in this work was the use of electrical impulse generators, in which the specific sequences of impulses were filtered to produce a still greater variety of sound mixtures. The increased importance of musical space in Gesang was manifested both in the juxtaposition of extreme sounds along the continuum between pitch and noise and their dimensional projection by means of five loudspeaker groups. The distribution of these groups around the listener was calculated to heighten spatial perception—i.e., by the use of the loudspeakers in a wide variety of combinations and in varying degrees of spatial movement.

The sound source is derived from a single untransformed boy’s voice reading from the Book of Daniel, the sung sounds of which are combined with ones produced electronically including “vowel-type sounds, consonant noises” and “a scale of the intermediary forms of tone-mixtures.”\footnote{See Stockhausen’s commentary to the Deutsche Grammophon Gesellschaft recording (DGG 138 811).} Special means are employed for the interaction between the electronic and vocal spheres. Words such as “Blitz” (lightning) and “Scharen” (host) are divided into their syllabic components as well as into smaller consonant and vowel articulations, between which electronic sounds of varying lengths are interpolated, the longer interpolations disrupting the written meanings more than the shorter ones (Ex. 18–2).\footnote{David Ernst, The Evolution of Electronic Music (New York: Schirmer Books, 1977), p. 89.} Synthetic words may also be produced by the rearrangement of the word components themselves. More direct connections between vocal and electronic sources are created by the interchangeability of their functions; sine tones were used to represent vowels, noise bands for consonants, and electronic impulses for certain speech sounds produced by

the stoppage and sudden release of the breath for consonants such as “k,” “p,” and “t.”\footnote{Ibid., p. 90.} As summarized by Stockhausen, “Sung noises are individual ‘organic’ members of the more comprehensive ‘synthetic’ sound family. At certain points in the composition, the sung sounds become comprehensible speech momentarily emerges from the sound-symbols in the music; it is to praise God (Daniel 3: ‘Song of the Men in the Fiery Furnace’). This work is the first to use the direction of the sounds and their movement in space as aspects of form.” Thus, Gesang represents a historical landmark in the tendency toward the fusion of natural (in this case, live vocal) sounds and ones generated electronically, their juxtapositions, iterations, and electronic manipulations resulting in the dissolution of the traditional distinctions between linear projection, and other differences between aspects that had been so essential to the definition and perception of traditional structural organization.

Stockhausen’s sound technology and aesthetics, stemming from his enriched experience with Gesang der Jägerlinge, were expanded radically in other electronic works beginning in the late 1950s, from Kontakt (1959/1960), based on “contacts” between mobile sound forms in space and, in the Mantra (1970), for two pianists, taped shortwave sounds, two ring modulators, two oscillators, wood-blocks, antique symbols, and sound projection works, Stockhausen explores the relation of known sounds with what he referred to as the “unknown world of electronic sounds,” like “finding an apple, perhaps even an asteroid, on a distant star.”\footnote{See Wörner, Stockhausen, n.7, above, p. 67.}
Within two years of Stockhausen’s Gesang der Jünglinge, the Austro-Hungarian composer György Ligeti also realized his L’ecume (1957) and Artikulation (1958) at the Cologne studio. In Artikulation, based on tape manipulations of sound generated electronically and recorded on four-track tape, Ligeti exploited special techniques that initiated his own use of an invented “language.” Many of Ligeti’s techniques, including the invention of synthetic words produced by the rearrangement of the word components themselves and the use of additive electronic synthesis, were similar to those used by Stockhausen. In the complex form of this electronic work, Ligeti was to exploit the results of his research in phonetics, in which he attempted to establish correlations between speech and musical sound.16 The gamut of forty-two basic sounds included sine tones, harmonic combinations formed above and subharmonic combinations formed below a fundamental pitch, and the use of noise. They were then grouped according to degree of sonic-relatedness and subjected to stages of splicing and electronic manipulation to form words and, ultimately, “languages.” The musical structure is based on a process moving from abstract conversation to reorganization of the sonic details. The entire procedure is outlined in Ex. 18-4.17

By the mid-1950s in Cologne, both concrète and electronic sources and techniques were integral to the field of electronic music.

**ELECTRONIC STUDIO IN MILAN**

While Stockhausen was expanding his electronic and natural sound spectra in the mid-1950s and Hermann Scherchen was experimenting with electronic filtration in his new studio at Gravesano in 1957, developments were also taking place at the Studio di Fonologia Musicale at the Italian Radio (RAI) in Milan, which was initiated in June 1955 by Luciano Berio (director until 1969) and Bruno Maderna. This studio, which drew the interest of such diverse international figures as Pousseur and Cage, also sparked activity in the public sonic intentions further by use of an electronic elaboration of sound material Joyce’s Ulysses. The complete text is presented in unaltered form, after which overtones. Other tape manipulations also contribute to the transformation of the original text sounds into new ones, thereby divorcing the sounds from meaning gradually as a means of creating his own expressive idiom in homage to Joyce.20 Berio investigated the possibilities of using electronically

16 A somewhat more detailed discussion is provided by Ernst, The Evolution of Electronic Music, n. 11, above, pp. 18-41.

17 Ibid., p. 40.

20 A magazine of the same title, published between 1956 and 1960, was also initiated by this studio.


elaborated words more fully for both their expressive and sonic capabilities in *Quento voudre dire che*, for voices, instruments, and tape (1960).

As the most advanced electronic technical facility in Europe in the mid-1950s, the Milan studio was significant not only in contributing to the breakdown of the distinction between natural and synthesized electronic sounds by means of manipulations, transformations, and juxtapositions of diverse sound sources, but also in serving as a kind of intermediary among the relatively separate, isolated studios such as those in Cologne and Paris. However, the Milan studio was only part of the proliferation of electronic studios that were becoming involved increasingly in a larger international context of aesthetic and technical cross-fertilization.  

**ELECTRONIC MUSIC IN PARIS, BRUSSELS, AND THE NETHERLANDS**

Edgard Varèse began, in the 1940s, to explore the possibilities of juxtaposing taped sounds with live instrumental performance after his work with percussion and sirens, as in *Imitazion* (1931), a landmark in his experiments with sounds as objects in spatial music. As early as 1933, while he was in Paris, Varèse was interested in developing a center for electric-instrument research, which did not come to fruition. He already had some experience with electronic instruments operated manually, having replaced the siren by the onions undercrown for the French premiere of *Amphitruon* in 1929 and having used two theremin parts in *Resonance* (1932–1934). Only when he was given an Ampex tape recorder in 1953 could he begin to employ those techniques that would fulfill his interest in the radical transformation of sound.

In 1954, about four years after his initial instrumental sketch of *Déserts*, Varèse visited Schaeffer's studio in Paris, where he worked on the tape part for the first version of the work. It was then presented as the first live stereo broadcast by the French Radio. *Déserts* is scored for two basic sound groups, the first consisting of instruments (winds, piano, and percussion), the changing relations of the juxtaposed sound masses which are intended to produce a sense of spatial movement and association with the human realm, the second consisting of two-channel stereo tape of electronically organized sound suggesting distance and nonhuman elements. For Varèse, the tape implied not only the physical deserts of the earth and outer space, but also the deserts at the depths of the human mind, "that remote inner space no telescope can reach, where man is alone, a world of mystery and essential loneliness.

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21 Some of these studios included, in addition to those in Cologne, Paris, and Milan, the Columbia-Princeton Electronic Music Center in New York (1944), the Electronic Music Studio at the Japanese Radio in Tokyo (1953), Philips Research Laboratories in Eindhoven (1956), Studio für Elektronische Musik in Siemens and Munich (1955); Studio Eksperymentalne of the Polish Radio in Warsaw (1955); Studio de Musique Électro-Électrique in Brussels, and San Francisco Tape Music Center (1949), moved to Oakland in 1960.

transforming, and juxtaposing electronic and concrète elements as a means of liberating sound from the tempered scale and mechanical (instrumental) sources. The work was also performed at the Philips pavilion in 1958 after it was realized at the Philips studio at Eindhoven on three-channel tape. The pavilion resembled a three-peaked circus tent externally, while simulating "the shape of a cow's stomach" internally. Along the architectural curves were placed over 400 loudspeakers grouped in what he called sound routes, the sonic arcs of which were accompanied by lighting and slide projections, though no special synchronization of these multimedia sources was intended. Mixed and transposed sine waves were produced by the electronic oscillator and generated as combined with electronically treated natural sounds (including feet and finger tapping, voices, etc.), the most recognizable of which are the female voice, male chorus, gong, bell, organ, piano, and percussion, some remaining in their original form, others modified electronically. Filters, loops, and reverberation units, which comprise two of the three channels, were used for mixing, separating, and transforming the contrasting sound components. An elaborate network was set up (Ex. 18-4), in which the 3-track taped sounds were distributed by way of amplifiers and telephone relays through the loudspeakers, a 15-track control tape regulating the sound paths and the multiple visual sources.

The cumulative form of the work is determined primarily by the temporal rate of sonic interaction, resulting in varying degrees of spatial density as well. Varèse stated that "one of the most valuable possibilities that electronics has added to musical composition... is that of metric simultaneity. My music being based on unrelated sound masses, I have long felt the need and anticipated the effect of having them move simultaneously at different speeds..." At the same time, recurrent motif fragments contribute to what may be perceived as a two-part form, in which each part is initiated similarly by a gong and cadenced by a siren. However, the basic formal conception is that of contrast and accumulation rather than recapitulation and is determined for the most part by the direction of the sound movement, in which the vocal and organ passages are reserved for the latter half of the work. Although a program was not intended, Varèse suggested an expression of "tragedy—and inquisition," which is evident in the vocal excerpts especially. This mood is further supported by the accumulation of tension resulting from the rate of interaction and length of the sonic events. This cumulative process culminates in the gradual shortening of an organ passage to two chords, leading to an intensification in the final upward surge of the siren. Thus, radical expansion of timbral and metric/rhythmic means of electronic generation and manipulation permitted Varèse a greater freedom in the realization of spatial form according to his own personal expressive conception.

As early as 1952, Henk Badings was already working with tape pieces for the Nederlandsche Radi Unie at Hilversum, though the electronic facilities were more primitive than those in Cologne. The first result was his radio opera Orestes (1954), which employed electronic sound generators, filters, chorus and instrumental sections. Other manipulations resulted in the expansion of possibilities in pitch, rhythm, and timbre. A more important development took place at the Philips branch at Eindhoven in 1957, where Badings was able to advance his electronic techniques prior to Varèse’s work on Poéme Électrique at this studio. In his Corset (1958), Badings employed five oscillators as the basis for the purely electronic sources, but his approach was somewhat conventional in the formal organization of the sound sources. From the early 1960s, Badings moved toward greater mixing of electronic and instrumental sources.

TAPE RECORDER MUSIC, SYNTHESIZERS, AND COMPUTERS IN THE UNITED STATES

In the late 1950s, Vladimir Ussachevsky and Otto Luening at Columbia University, in collaboration with Milton Babbitt and Roger Sessions at

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Princeton, established the Columbia-Princeton Electronic Music Center. In contrast with the first realizations at the Paris and Cologne studios, the tendency in New York was toward combination of taped pure electronic and musique concrète sounds from the beginning, so the musical results were to be termed tape-recorder music more appropriately. Prior to his awareness of the pioneering concrete and electronic experiments developed separately at the Paris and Cologne studios, Ussachevsky had already embarked in 1951 on the first major tape experiments in the United States and, in collaboration with Luening beginning in 1952, combined both live and electronic sources involving the transformation of natural sounds (especially instrumental) rather than electronic synthesis. These efforts were preceded by some experiments with tape that were begun in 1948 in New York by Louis and Bebe Barron. From 1951 to 1953, John Cage drew together several composers, including Earle Brown, Morton Feldman, David Tudor, and Christian Wolff, at the Barron studio for further development of what was to be referred to as Music for Magnetic Tape. This group was more radical in its interest in producing new sounds, often tending toward aleatoric results unlike Ussachevsky and Luening, who remained closer to the traditional sound sources and the presentation of their musical ordering on tape. Ussachevsky’s first set of taped concrete pieces, produced between 1951 and 1953, were Transposition, Experiment, Reverberation, Composition, and Underwater Value, derived entirely from the sounds of the piano. These titles indicate the tape techniques used in the transformation and musical organization of the original sounds, including speed changes for pitch and duration modification, repetition by use of echo devices, etc., techniques of which were developed further in his Sonic Contours (1952) derived from piano and vocal sources. In Incantation (1952), by both Ussachevsky and Luening, the recorded sound sources were expanded for the first time to flute, clarinet, voice, bell, and gong. The first public concert of their tape music occurred on October 28, 1952, at the home of Henry Cowell at Woodstock, New York, a concert attended by Luciano Berio. Included on the program were Ussachevsky’s Sonic Contours and Luening’s Invention in 12 Notes, Low Speed, and Fantasy in Space. In subsequent compositions, they began to add prepared tape to the recorded instrumental materials. Through a grant from the Rockefeller Foundation in the mid-1950s, both composers were able to investigate various international studios, including those in Paris, Cologne, and Milan as well as Canada and the United States. While progress in the United States lagged behind that in Europe generally, they had observed a significant development at the University of Illinois, where Lejaren Hiller and Leonard Isaacson were exploring possible musical applications of the computer prior to the commercial availability of electronic synthesizers. Hiller and Isaacson programmed a table of numbers, which were then applied to pitch, duration, and orchestration to produce the first important work programmed digitally, the Illiac Suite for String Quartet (1955–1956), named after the computer. The function of the computer in this early example was to generate the data for an otherwise traditional score, the sounds of which were generated by the string quartet rather than an electronic source. Nevertheless, the computer, which no longer necessitated tape splicing and other manipulations associated with electronic techniques, served to remove the compositional process further from human sources. Similar approaches followed in Paris, England, and the Netherlands. However, the first true computer music, in which the computer itself was to serve as the sound source by means of digital-to-analog conversion (DAC), took hold in New Jersey, in 1957. These techniques were developed further in 1964 by Hubert Howe and Godfrey Winham at Princeton University, John Chowning at Stanford University, and at the more recently developed studio in Stockholm and elsewhere. In 1969, Hiller and Cage used computers to generate and electronically processed sounds in HPSCD for one to seven harnessed and one to fifty-one computer-generated tapes. Some of the most recent developments are based on hybrid systems, in which computers are used as control synthesizers. Others contributing to the development of the appears to have stemmed from his earlier work at the Cologne studio, and Kenneth Louis Gaburo, who showed similar synthetic speech influences of Berio.

Based on the recommendation of Ussachevsky and Luening in the mid-1950s for financial support to develop electronic music in the United States, in the universities most beneficially, the Radio Corporation of America (RCA) developed an electronic sound synthesizer, and this led to its creation. RCA developed the principle of voltage control in 1954, all aspects of the sounds generated electronically—frequency, envelope (growth and decay characteristics), amplitude, timbre, reverberation, modulation, etc.—could be controlled independently by automatic devices and manipulated by computer. 24

24 For a more detailed history of the developments of these two independent early groups in New York, see Manning, Electronic and Computer Music, n. 1, pp. 68–88.


26 See Ernst, The Evolution of Electronic Music, n. 13, above, p. 59, for a technical discussion of this process.

27 Ibid., p. 60.

hand techniques, an advantage the synthesizer had in common with the computer. Among the first to work with the new facilities at the Columbia-Princeton studio were the Argentinian Mario Davidovsky (present director of the Columbia studio) and Turkish Bülent Årab. Electronic pieces of both composers were performed at the first concerts of the Center, given on May 9 and 10, 1961, at the McMillin Theater at Columbia University, along with those of Usachevsky, Luening, Babbitt, and Halim El-Dabh. In his works after Electronic Study No. 1 (1960), Davidovsky has shown a continuing inclination towards combining recorded electronic sounds with live instruments, among his most important products of which are his set of Synchromy, No. 1 (1962) for flute and tape, No. 2 (1964) for flute, clarinet, violin, cello, and tape, No. 3 (1964) for cello and tape, No. 4 (1966) for chorus and tape, No. 5 (1969) for percussion and tape, No. 6 (1970) for piano and tape, No. 7 (1974) for orchestra and tape, and No. 8 (1974) for wind quintet and tape. The first three are characterized primarily by juxtaposition of the contrasting live and electronic materials, while the last three tend toward free mixture and fusion of these sonic sources. In these works, Davidovsky exploits all possible electronic techniques to produce an extraordinary range of sonic possibilities and textural combinations, so that true instrumental virtuosity is required for producing sonic and timbral flexibility in the interactions of the live and electronic resources.

Synchromy No. 1 is exemplary of such wide contrasts of articulations, dynamics, and registers both within the sonic range and technique of the flute and within the gamut of the electronic sounds, which range from some pitch elements to noise. Both textural spheres always remain distinct and transparent even in the sectioned overlapping of the two spectra, because of the sonic and rhythmic divergency between them. The main difficulty in the compositional process and in the performance of the work was to synchronize both rhythm and pitch. Vertical control of the timing between flute and tape is maintained in the overlapping shorter sections, while in the longer overlapping ones, a degree of vertical flexibility is introduced to accommodate the inevitable time discrepancies that result between the live performer and the constant speed of the tape recorder. The rate of figural and textural activity and of interaction (relative lengths of sections) between the flute and tape as well as the changing degrees of density appear to be the basic structural determinants, the form tending to peak at the fourth of the five taped sections in combination with the longest and freest flute passage (Ex. 1B-5). While the work is aperiodic, each section appears to be organized internally by a specific motivic gesture and its variants, which are defined by contour, timbre, and rhythmic direction.

As a mathematician and composer, Babbitt’s interest in working with the electronic equipment at the Center since the late 1950s has been motivated primarily by his inclination toward serialized control of all aspects of the musical structure. He was to work extensively with the special Mark II RCA Synthesizer, the most advanced electronic instrument of the period, after it was given to the Center in the late 1950s by its builders Herbert Belar and Harry Olsen. With this electronic instrument, Babbitt’s ongoing concerns with formal and temporal organization, based on rate of timbral and textural change, were now able to be realized more precisely. Composition for Synthesizer (1961) and the more complex Ensembles for Synthesizer (1962–1964), both for four-track tape, represent two of his earliest pieces synthesized entirely, and in which the new synthesizer facilitated the difficult task of reproducing the instrumental (piano and woodwind) timbres electronically and controlling them in more complex textures.

These works reveal varying degrees of distinction and integration of the vocal and electronic materials. In *Vision*, there is no attempt to integrate the intact text and conventional timbral character of the voice with the instrumental-like electronic sounds. Babbitt’s concern is focused rather on the possibilities of producing calculated correspondences, in terms of duration, tempo, length of phrases, stanzaic organization, and large-scale form, between the musical parameters and formalized, arithmetically expanding and contracting syllabic structure of the poetic text. However, a tendency toward vocal and electronic integration is manifested in *Philomel*, where certain timbral transformations of the recorded vocal sounds, as permitted by the synthesizer, are necessary due to the requirements of the text. In the Greek legend, the gods take pity on the tongueless maiden by turning her into a nightingale. While the live vocal part includes singing and speech-like sounds in a more percussive and atra styles, recorded vocal segments as well as the synthesized sounds (ranging from the distinct pitches of simulated instrumental sonorities to percussive sounds and filtered noise) are modified by means of reverberation and other electronic techniques. The resources of the synthesizer and the flexible live vocal style of this work are essential in the transformational flow between music and language.

Others who have also made important use of the facilities at the Columbia-Princeton Center in widely varying and individual ways since the 1960s were Ilhan Mimaroglu, who was concerned primarily with the electronic generation of *onrile* rather than instrumental sounds, Andrés Lewin-Richter, Jacob Druckman, and Charles Wuorinen, whose *Time’s Encomium* (1966) reveals, like Babbitt’s works, an interest in the electronic synthesis of varied instrumental (piano, harpsichord, and organ) timbres and the achievement of control over complex temporal and rhythmic relations by means of the synthesizer. The proportional structural relations on all levels of the work are derived from the equal-tempered intervallic ratios of the basic twelve-note set, a basic characteristic of the RCA synthesizer. Here, “everything depends on the absolute, not the seeming, length of events and sections.” Being electronic, *Time’s Encomium* has no definite effect. 36 Thus, since the early 1960s, the RCA synthesizer has provided expanded possibilities for the realization of complex structural relations, increased control over the various parameters, and new compositional structural interrelations of the timbral and sonic events.

In addition to the developments at the Columbia-Princeton Center and at the University of Illinois, many other studios have emerged throughout the United States. Gordon Mumma and Robert Ashley established a private Cooperative Studio for Electronic Music in Ann Arbor, Michigan, as early as 1958. The private studio at the San Francisco Tape Music Center (SFTMC) was established in 1959 under the direction of Ramon Sender and Morton Subotnik, the facilities of which were moved to Oakland in 1966.

At Stony Point, New York, the collaboration of John Cage and David Tudor in the 1960s was significant especially in the development of live electronic music, their work influencing that of the Sonic Arts Union established by Mumma and others in 1966. In the last two decades, studios have been proliferating at various universities and colleges.

While many electronic composers have continued to work along the aesthetic and technical lines established at the Columbia-Princeton and Illinois studios originally, others have developed individual approaches to the composition of electronic and computer music. A variety of aesthetics, styles, Electronic Music Competition, held by the League of Composers-International Society for Contemporary Music, U.S. Section 37 For instance, Mael-chen Zür’s *Chants for Magnetic Tape* (1974) is based on a fusion of Gregorian chant style and serial principles, while Paul Lansky’s *Jade und leise* (1973/ 1974) uses the IBM 360/91 computer to compose and synthesize musical material from Wagner’s *Tristan*, Joel Gressel’s *Points in Time*, a title derived from a cliche used at the United States Senate Watergate Hearings, is based on principles of time similar to those used by Wuorinen in his *Time’s Encomium*. Overlapping and consecutive rhythmic blocks are determined by the mathematical ratios of the equal-tempered twelve-tone scale, producing rhythmically accelerating or decelerating patterns “approximating the sound pattern made by a freely bouncing ping-pong ball.” At certain points these patterns converge and, together with changing timbral combinations, serve to organize the large-scale structure. Furthermore, according to the composer, “Rhythms are derived from a set {F–F1–C–B–A–D4–E–G–G1–D–C1–A1}, the properties of which are derived from the tritone-related structures and long-term associations of pitch-class tetrachords (e.g., F–F1–C–B), trichords (D4–E–G), and dyads.” Thus, mathematical calculation, the contrapuntal and temporal accuracy of which relies on the use of the computer, is basic to the integration of the various parameters and structural levels of the composition.

Continued interest in either the electronic simulation of instrumental sounds or the combination of live instruments with tape is demonstrated in Donald Erb’s preoccupation beginning in the 1960s with experiments exploring the sonic and interactive possibilities of live instruments and tape, as in his *Strange Land* (1968), for trombone, string bass, and tape, and *Souvenir* (1970), for instruments, tape, and lighting. Morton Subotnik, founder and director of the San Francisco Tape Music Center from 1961 to 1966, often employs serial procedures, which are realized with the Buchla Synthesizer. In such mixed-media works as his *Luminations* (1970), for instrumental ensemble and tape, the interplay of corresponding sonorities is achieved by means of special

36 See Charles Wuorinen, note to the Nonesuch recording H–71285 (stereo).

37 These works, with commentary by the composers, are recorded on Columbia-Odessey Y 14139.
instrumental (e.g., flutter tonguing and muting) and electronic (e.g., modulating and filtering) techniques.

Three of the composers who have worked with the modern electronic facilities at the University of Texas at Austin in the 1970s and 1980s are Karl Korte, Barton McLean, and Russell Pinkston. Korte, in his *Remembrances* (1971), written for the flutist Samuel Baron, exploits the wide range of timbral and expressive possibilities of the alto flute, flute, and piccolo, respectively, in the three sections of the piece, in combination with taped electronic sounds. Tempered pitches generated electronically form the basis of the underlying twelve-tone series, the intervocal subsets often producing a sense of tonal priority. From the beginning, synthesized bell-like sounds produced by ring modulation interact with the flute’s more sustained line to produce a wide spectrum of sonic possibilities. These sonorities then interact with the improvisatory alto flute line, which slides with the ending of the series, the initially slow repeated notes of the solo developing into narrow-ranged glissandi, microtonal inflections, and embellishing flutter-tongue techniques as part of the gradual expansion of instrumental color. Increasingly rapid gestures in both flute and tape, based on the continual addition of new timbres in the latter, result in more complex contrapuntal and rhythmic interactions between the two spheres. While flute and tape generally remain distinct, they are linked by common serialized intervocal structures, of which tritones and larger octatonic segments are often prominent.

Barton McLean has performed extensively throughout the United States and Europe in collaboration with Priscilla McLean as part of a husband-wife electroacoustic duo called *The McLean Mix*. Their music retains classical structures and stylistic elements, but expands them by means of extended *musique concrète* techniques and performance virtuosity. Among their most recent works, the evocative set of five pieces *In Wilderness Is the Preservation of the World* often uses performance-gestural modes rather than specific pitch content. The work includes material for soprano, chorus, amplified bicycle wheel, digital electronics, percussion and woodwind instruments, audience singing, and various animal, bird, and other sounds of the wilderness on tape. Much use is made of other media, including multiple slide projections, lighting effects, and special light-performance patterns, which form intricate designs behind a screen while slides are projected on the front. The first composition in which Priscilla McLean exploit wilderness sounds directly is *Beneath the Horizon* (1978) for tuba quartet and taped whale ensemble, based on controlled improvisation.

Barton McLean’s *Dimensions I* (1977), for violin and tape, the first piece of his set of *Dimensions* based on various types of relations between instrument and tape part, bears certain external similarities to Davidovsky’s *Synchronisms*. Similarly, McLean has permitted total vertical freedom between the improvisatory violin part and more mechanical tape, except at the beginnings and endings of passages or sections, where these spheres, which are polarized stylistically, are synchronized by special cues. In Ex. 18–6, “the violin part, enclosed in solid boxes, is coordinated to the two tape channels enclosed in dotted lines, by means of arrows.” Most striking in the generation...
EXAMPLE 12-7. Harris McLean, Dimensions I, opening, arch-shaped phrases of violin conelites, structural occurrences of unordered transpositions of 0-1-6-7 tetrachord, with cyclic-interval fillings and extensions.
set appear as cadential punctuations, as in the soaring figures toward the center of the cadenza. As part of the cumulative process, 0:1-6-7 transpositions are combined to form larger octatonic collections. In the descending portions of the most rapid scale passages (marked “AFAP’), octatonic segment G-F-E-D-C3 is completed by G1-B3-A3-G1 to give G-F-E-D-C3-B1-A3-G1, which implies the presence of two 0:1-6-7 tetrachords, D3-G1-G1 and F-E-B1-A3. In the taped sections (see Ex. 18-6), 0:1-6-7 transpositions appear in tritone and interval-3/7 partitions, as at the opening of Section 2, tape a: for instance, G1-D1/A-D (upper staff) is followed by [ ] D1-G1-A and [ ] F1-B1-C, which form a larger octatonic segment together, D1-D1-F1-G1-A-B. Thus, divergent instrumental and electronically processed sonorities are absorbed into an integrated context by means of common intervallic sets, rhythmic configurations, and intermediary recorded violin timbres.

To some extent, Pinkston also follows the tradition of the early Columbia-Princeton products, especially those of his former teacher, Davidovsky. In certain respects, Pinkston’s Quarter for four horns with tape (1978) owes much to Davidovsky, in the tight interlocking of electronic and acoustic sounds, and the basic concept of using the electronic medium to “extend” and expand the timbral capabilities of the acoustic instruments. This concern is suggested in part by the composer’s indication: “Speakers should be placed on each side of the performers—a equal distance and preferably close enough to provide a feeling of ensemble between horns and tape while still allowing sufficient space for good stereo.” However, in his attempt to create a quasi-concerto for horns and electronic orchestra in this piece, in which he wanted a massive, weighty sound from the horns and a truly symphonic texture from the tape, the piece is antithetical in every respect to the ascetic, chamber-music-like style in most of Davidovsky’s Synchronisms. Pinkston conceived the form as being essentially symmetrical after the slow introduction (i.e., Introduction, A, B, A’, Coda), the A’ section of which is a nonliteral retrograde of the A section. As in the overall process of McLean’s Dimension I, where the lyrical violin style is transformed into the more savage and mechanical style of the tape, the horns and tape in the Quartet switch roles during the A’ section. Another unifying feature of the piece, in addition to the interlocking of electronic and acoustic sounds, is the extensive use of octatonic segments.

**DIRECTIONS FOR FUTURE ELECTRONIC RESEARCH AND COMPOSITION**

With advances in electronic and computer technology, the possibilities for both control and freedom as well as expansion of the musical sound world seems almost unlimited: from simulation of existing instrumental and vocal sounds through an infinite number of stages of transformation into varied types of invented musical sounds within the entire range of human perception. Such technological possibilities have not yet been exhausted as the basis of musical composition, nor does it seem likely that they ever will be. While

Some composers have not been inclined toward the electronic sound medium, others have continued to experiment with it at studios throughout the place in both private and public educational institutions. Among them are the 'Musique Concrète et sonorités' directed by Boulez in with the new possibilities of both sonic production and musical order is perhaps one of the most pressing aesthetic issues.

**SUGGESTED READINGS**


