"No sound becomes old more quickly than a new sound."

PRELUDES

Musicians have been tinkering with electricity since at least 1897, when the Canadian Thaddeus Cahill demonstrated his sounding stave, an electric device for the control of timbre. While the orchestras of his day were concerned with Berlioz or Rossini, Cahill was applying for a franchise to lay wires in the streets of New York for the purpose of distributing music electrically.

By 1906, when Cahill demonstrated his 200-ton telharmonium—which generated sounds by rotating toothed wheels in an electromagnetic field—composers had begun a search for an alternative to the classical tradition of tonal thought. In 1907 composer Ferruccio Busoni cited Cahill's work as a hope for a future of "abstract sound, unhampered technique, and unlimited tonal material." Arnold Schoenberg's further break with diatonic harmonies in 1908 made any combination of pitches permissible. Composers began to explore timbral relations and tonal qualities.

In 1917 Edgar Varese wrote:

"Music, which should be alive and vibrating, needs new means of expression and science alone can infuse it with youthful sap. . . . I dream of instruments obedient to thought—and which, supported by a flowering of undreamed-of timbres, will lend themselves to any combination I choose to impose and will submit to the exigencies of my inner rhythm."

Technological advances in the period around the First World War granted musicians the opportunity to move in this direction. The Italian Futurist Luigi Russolo (who referred to the traditional concert hall as a "hospital for anemic sound") produced his *intonarumori* in 1913. These were elaborate and bulky noisemaking mechanisms, which Russolo operated on stage in Paris and London. Russolo was intrigued with the rhythmic quality of machine sounds, and defiantly described his work as "noise music." Not surprisingly, noise music was never widely appreciated, but Russolo does prefigure much of later 20th century music.

American inventor Lee DeForest perfected the first oscillator (a source of periodic changes in voltage for the production of pitch and timbre) in 1915. New instruments, such as Leon Theremin's etherophone (1923), Maurice Martenot's ondes martenot (1928) and Friedrich Trautwein's trautonium (1928), were introduced in quick succession. In 1929 A. Givelet and E.E. Coupleux devised a musical synthesizer that used four oscillators controlled by a punched paper roll. Laurens Hammond produced the first electronic organ in 1929, which allowed the performer to control timbre, pitch, and volume.

Edison's and Berliner's invention of the phonograph in 1878, along with Valdemar Poulsen's invention of the wire recorder in 1898, had made possible the storage of electronic sound; in 1935 the invention of the first tape recorder, the magnetophone, enabled the composer to move beyond rudimentary sound manipulation. It became possible to vary speed during playback, to play sound backwards, to alternate between sounds by splicing or montaging, or to augment sound further by overdubbing. The plasticity of sound had been extended. "Everything which was limited," writes music historian Paul Griffiths, "became unlimited; everything which was imponderable could then be subjected to precise measurement."

The serial techniques of Schoenberg, as furthered by his students Alban Berg and Anton von Webern, had a direct effect on the shape of modern composition. The serial principle assured a coherency to atonal music by applying a 12-note series to a piece. This series—known as a tone row—is then maintained in strict order throughout the composition. A new objective musical language could thus be achieved. At first, serial techniques were applied only to pitch. Later, serial control was extended to rhythm, dynamics, texture, and register, which resulted in an often rarefied atmosphere of disjunct melodies. This total serial technique was considered in keeping with the tenets of technological advance, scientific thought, and modernity.

In 1948 Pierre Schaeffer, in collaboration with Pierre Henry at Radiodiffusion et Télévision Francaise in Paris, introduced tape-recorded sound objects freed from association to the natural world. By altering and rearranging natural or manmade sounds stored on magnetic tape, Schaeffer composed what he defined as musique concrete.

The commercial availability of the tape recorder around 1950 furthered efforts toward dealing with found noises and pure sound. By 1953 the field of electronic music was flourishing. Karlheinz Stockhausen, with Herbert Eimert and Werner Meyer-Eppler, had established the Elektronische Musik studio in Cologne, where they used sounds made by sine wave generators for manipulation by tape recorder. Their work, along with the efforts of Vladimir Ussachevsky and Otto Luening at Columbia University in the 1950s, typified the music that emerged from the so-called classical electronic music studio.

Such early efforts were hindered by the rudimentary technology of the analog synthesizer, and constrained by the manual difficulties presented by tape splicing. Modulators and waveform generators had a certain acoustic sameness, which allowed for no harmonics but only a single frequency of even dynamics. Harry Olson's and Herbert Belar's invention of the RCA Mark I synthesizer in 1954 offered the first variety in timbre and shape that permitted the composer to explore new sounds. With this, the stage was set for the introduction of the computer into the world of music.

—L.F.

ews has been called the father of computer music and a man as important to the development of music as the inventor of the pianoforte. It was Mathews who in 1957 first used the DAC to translate binary voltage fluctuations into sounds.

Mathews' accomplishments are legion. While finding the act of playing a violin attendant with obstacles, he saw in the computer a performance instrument capable of "breaking the shackles of mechanical virtuosity." Mathews sought to make the computer accessible to composers and performers without imposing his "tastes and ideas about instruments on musicans."

His Music IV and Music V programs were of great significance to computer music because they let musicians work with the computer without being overwhelmed by technical concerns. Mathews' GROOVE program, developed with F.R. Moore, allowed for "edited improvisation" between machine and performer, thus freeing computer music from the barren rigidity of unchanging performance.

Mathews' more current endeavors include the completion of further musical programs as well as the invention of the intelligent instrument (like the sequential drum, sequential piano, and sequential violin). These instruments permit interaction between score, instrument, and performer in a manner hitherto impossible. Mathews was dissatisfied with conventional instruments because "one had the freedom to play wrong notes when one didn't want that freedom. Intelligent instruments take away that freedom to play wrong notes."

Mathews is also responsible for what has been called the greatest conceptual advance in computer music, unit generators. These are distinct subprograms that stimulate electronic signal-generating devices—instruments, you might say—which the composer can use as sonic building blocks. An executive source of voltage control makes possible the generation of sounds in real time; by pushing a button, the composer can create sounds

Push Button Bertha, in 1956, generated some 4,000 pop tunes.

of astounding complexity.

Mathews is modest about his work as a composer, and has even described certain of his pieces as "musically nauseating." Certainly his compositional efforts are overshadowed by his achievements as instrument builder and musical analyst. But his engineer's ability to hear sounds in an objective fashion has not betrayed his essential love of music. His importance to computer music is not likely to be surpassed by any of his contemporaries.

BOULEZ FOUNDS IRCAM

At Paris' Institut de Recherche et de Coordination Acoustique/Musique (IRCAM), director Pierre Boulez, who until 1977 was musical director of the New York Philharmonic, works on a digital sound synthesizer developed by H.G. Alles of Bell Labs. Having once renounced electronic music, Boulez has gone on to found IRCAM, and now plans to unveil a computer-aided composition at Donaueschingen this month.

Some modern composers have worked in the spirit of Edgar Varèse, who, while expressing interest in new musical resources, insisted that they enhance expression as well as technique. By using advances made in sound analysis and synthesis by Xavier Rodet and Gerald Bennett, these composers have managed exemplary compositions: John Chowning at Stanford, Conrad Cummings at Oberlin, Charles Dodge at Brooklyn College, Paul Lansky at Princeton, Roger Reynolds at San Diego, and Jean Claude Risset at IRCAM, to name a few.

But a lot of computer music has been a parade of complexity for its own sake. Lars-Gunnar Bodin has written: "In spite of great efforts in time and money, relatively little of artistic significance has been produced in computer music." In some cases, compositions have been downright tedious. Ezra Pound pointed out that "170 pages of mathematics are of less value than a little curiosity and a willingness to listen to the sound that actually proceeds from an instrument." Nevertheless, many computer composers, perhaps finding music to be minatory, have sought refuge in their calculations.

One is reminded of Charles Babbage's hatred of street music, particularly that of organ grinders, and the ends to which his neighbors went to annoy him with tin whistles, kitchen pots, and "worn-out or damaged wind instruments." Babbage proposed a sort of steam-driven musical calculator with which, one supposes, he would have supplanted his tormentors. Judging from his journals, Babbage envisioned a music that was mechanized and controllable, and consequently less of a nuisance. Certain computer programmers cum composers seem to have followed his lead.

Much of the music that grew out of Mathews' early undertakings was overly concerned with timbre—the shape of a sound. The computer work of J.K. Randall, Barry Vercoe, Godfrey Winham, or G.M. Koenig seems beguiled with the psycho-acoustics of sound, much to the detriment of the compositions, which are often little more than successions of glossy timbres.

In dealing with taped sound objects, Pierre Schaeffer found that if a sound is to be considered music, it cannot be recognizable to the listener—that is, it cannot be an evocative symbolic representation of natural sound. By Schaeffer's definition a mimetic tape is not music but literature, a kind of drama of sound effects. A fair portion of computer music is literature in this sense: gong noises evoke the cathedral, bird sounds suggest the aviary, the catlike howlings of a modulator recall the back alley, and the faked viola sounds almost like a real one. The listener identifies these sounds. Beyond that there is commonly not much more.

A lot of this music has also been hardwired into its epoch: by paying too much attention to the novelty of the sound and not enough to the sound itself, the composer has stamped a date on his composition. "No sound," said the composer Milton Babbitt, "becomes old more quickly than a *new* sound." Sound cannot progress by a change in the field of action from instruments to electronics because, as composer Paul Lansky notes, "C Major itself is a neutral quality." There is an aesthetic decrepitude to this process of ceaseless technical change, a frenzied epidemic of ever-novel sound with each new wave washing away previous fixations. Music can change both conceptually and technically, but it does not necessarily progress.

INTUITIVE ELEMENTS LACKING

Gamelan gong music from Bali, like the music of Mahler, has a certain intuitive structure to it that computer music has chiefly lacked. The acoustician Hermann Helmholtz has written of this mysterious something:

"There arises in our mind a feeling that the work of art is the product of a design which far exceeds anything we can conceive at the moment, and which hence partakes of the illimitable."

This sense of the illimitable, present in Balinese and Viennese music but absent from computer music, has intrigued artificial intelligence researchers, who have moved music closer to psychology and engineering.

In working with the computer for the generation of music, one finds that nothing is indicated, i.e., left to the performer, as in the instruction "adagio." Instead, everything must be realized by the composer. To understand music, one must investigate the mental processes through which it comes into existence. "You have to make a little composer," Marvin Minsky is quoted in the *New York Times*. "That means your attention is drawn not so much to the rules of the surface [of music], but to the rules of how the perceptual process proceeds, or how the composer decides what to do next." Music is a mental process assembled from cooperating procedures that pursues a goal-determined course of action. It can be perceived procedurally and not analytically. If the mental process involved in comprehending a sound for musical purposes could be objectified, an intelligent machine might truly compose music.

It is this interest—not bound to musical objects but concerned with their making—that has become of seminal concern to certain computer-composers. Otto Laske, a proponent of a procedural theory of music, has written: "Music is in existence only when it is being made or remade." This realization has offered a different approach for music composition by computer.

"In 1967," says composer Charles Dodge in his studio in Flatbush, "there were probably no great works of computer music. I think today there are." As a result of work at Stanford's Center for Computer Research in Music and Acoustics (CCRMA), Bell Labs, and IRCAM, composers have been given a new vocabulary of sound in the last decade. It has only recently become possible to assemble a wide range of compositional and sound-synthesis techniques for the purpose of making music.

"I may be one of the first composers in the history of music for whom the speed of sound is something that I must figure on as I write my music," says Paul Lansky in his office at Princeton. Lansky is a composer who has become more sensitive to the complexity of human performance. Lansky's "Six Fantasies on a Poem by Thomas Campion" (1978-79) is an elegant treatment of classical quantitative verse, where the composer has observed spoken cadence from a musical perspective. The sound of the human speaker's voice is transformed into a musical response. Using linear predictive coding for speech synthesis on an IBM 360/90 and 3033, Lansky alters and modifies the sound of a female voice reading Campion's "Rose-cheekt Lawra." The result is at once ethereal and concrete.

"Composers in the past," says Lansky, "were more like playwrights. They wrote the plays and the plays were performed. Now composers are more like sculptors. We have to create strings of numbers to represent sound."

Lansky is currently working with Kenneth Stieglitz on a series of pentatonic folk song syntheses using synthetic violins

"In 1967 there were probably no great works of computer music. Today there are."

and cellos. He is also studying the synthesis of choirs and orchestras ("There's a C chord here that sounds just like the Philharmonic," he says of a taped synthesis).

Taking the timbre and phrase inflection of the violin and adding his own pitch and rhythm, Lansky functions as a skilled interpreter of acoustic sound. "In 1976," he says, "I would have imagined that this was not an appropriate thing to do on a computer, since it's the kind of thing you can easily get people to play." But now Lansky is concerned with spatial acoustics—hence the awareness of the speed of sound—as well as intonation, pitch-bending, and transforming the sound of violins to that of the cello or double bass.

"You can listen to some sound," Lansky adds, "and have the computer give it to you to play with. I'm working with the difference between what is perceived as a complex electronic sound and what somebody perceives as a simple human sound. In reality, the complexities are reversed in many cases." Computer music, for Lansky, has no specific characteristic. It is of little interest as a thing in itself. Computer capabilities offer the liberation, not of music, but of the composer.

Charles Dodge has also used signal processing and speech synthesis in his compositons. His "In Celebration" (1975) is a remarkable piece using a system designed by Joseph Olive at Bell Labs. His "Speech Songs" (1973) consists of a catarrhal voice reading lyrics by Mark Strand. By altering the natural resonance, pitch, contour, and speed of the voice, Dodge realizes the great richness of sound-synthesis technique and uses it in an aesthetically convincing fashion. The synthetic voice is capable of sounds no human voice can make. The effect is alternately humorous, frightening, and giddy. "The field is opening up in a lot of fascinating ways," says Dodge, "offering an entirely new set of tools for the composer."

Dodge's "Cascando" (1978) for three characters—Voice, Music and Opener—is taken from Samuel Beckett's radio drama. It is an unusually expressive piece in which the composer has established the rules the computer will use to produce sounds. Using linear predictive coding to disassemble, alter, and reconstruct the sound of a human voice, "Cascando" is a work that merges the opposite processes of intuition and analysis.

CARUSO SINGS AGAIN

Dodge has also completed some amazing work with a recording of Enrico Caruso singing "Vesti la giubba," a recording that was originally influential in popularizing the gramophone. Caruso made this recording by singing into an acoustic horn connected to a stylus. In the process, the horn transmitted certain frequencies with special emphasis while attenuating others. This caused the grainy tone of gramophone recording. Thomas Stockham of the University of Utah determined the acoustic characteristics of the type of horn Caruso used and digitally constructed a filter with the inverse frequency response. This resulted in a more lifelike recording. Subsequent work by Neal Miller removed most of the remaining scratchiness from Stockham's modification, but also filtered out the accompaniment.

Working with this tape of an isolated Caruso, then altering it in assorted ways, Dodge composed a work for live piano and recorded Caruso. The voice of Caruso, strangely disembodied and mutated, is manipulated by the composer to strong effect. The singer meanders through the song, losing track, breaking into sobs, hurrying to catch up. Dodge has called this piece his way of "putting Caruso to rest." It is a fine example of the multeity of perspectives that a composer may bring to any acoustical information.

Works that use voice analysis and synthesis can be strikingly eerie. As Conrad Cummings has written of his "Beast Songs," which uses voice synthesis and live voice: "The more lifelike the synthesized voice, the more powerfully one feels its slightly abstracted, cool quality." To hear a disembodied computer-synthesized voice enunciating human emotion is to better understand the intricacy of musical expression itself.

The most rewarding work in computer music has probably only begun. Other composers have taken other paths. John Chowning's "Stria" is based on mathematical Fibonacci series. Jean Claude Risset's "Songe" is an example of how sound images can be manipulated to fascinating effect. Laurie Spiegel's dronelike work is in its stark quality reminiscent of Erik Satie's *musique d'ameublement* (furniture music).

Although the aesthetically satisfying work may never drown out the epigonal efforts of lesser composers, it does seem possible that computers will someday force a reevaluation of music. "There's a whole uncharted universe of sound that we are just beginning to get in touch with," says Charles Dodge, "one that has a profound effect upon those who hear it." ●