Sound Forms For Piano

by Charles Hamm

The pieces on this record have in common that they were written for piano--but for a piano altered in some way. Henry Cowell's pieces ask the pianist to produce tones inside the piano, rather than at the keyboard. Conlon Nancarrow's *Studies* are written for player piano. John Cage's *Sonatas and Interludes* are for prepared piano, an ordinary piano producing quite different sounds because various objects have been placed between some of the strings. Ben Johnston's *Sonata for Microtonal Piano* is performed on an instrument with radically altered tuning.

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It is not surprising that American composers have written music for piano from the beginning of serious composition in this country to the present day, for the piano has been a cornerstone of American culture since early in the nineteenth century, thanks to the inventiveness and talent of American piano makers.

The first mention of a piano in America is found in an announcement in the *Massachusetts Gazette* for March 21, 1771, of a musical program including "select pieces on the forte piano and guitar." In 1775, John Behrent of Philadelphia announced that he had constructed "an extraordinary instrument by the name of the pianoforte." Benjamin Crehore of Boston is reputed to have been making pianos by 1800, and he was soon followed by such men as James Stewart and Alpheus Babcock. Pianos were still being imported from England, and the earliest American pianos were copies of these, but by the second decade of the nineteenth century Americans were devising and patenting changes and improvements in the instrument that soon led to a distinctive American piano. Thomas Loud, born in London but an immigrant to Philadelphia, was probably the first to use overstringing, as early as 1816. Alpheus Babcock and Jonas Chickering of Boston made improvements in the action and in the frame; the latter patented a single metal casting for the entire frame that allowed greater tension to be put on the strings, with a resulting brighter tone.

By 1829, 2,500 pianos were being made annually in the United States, and the instrument was commonplace in the homes of the musically literate. New and important companies were established, such as Knabe and Sons in 1839, Lindeman and Sons in 1840, and the Emerson Piano Company of Boston in 1849.

American pianos received international exposure at the Great Exhibition at the Crystal Palace in London in 1851, which featured a large display of instruments from many countries. A number of American companies were represented, and the award of highest honors went to a Chickering piano, to the amazement of British and French firms. By this time, the number of pianos produced annually in the United States was up to 9,000. The firm of Steinway and Sons, founded in 1853, almost immediately produced pianos of superb quality; such Steinway technical innovations as bass overstringing were soon in universal use.

The 1876 Centennial International Exposition in Philadelphia witnessed the greatest international display of pianos ever, and there was no denying now that the United States was producing the best pianos in the world. When the Japanese government decided to purchase a supply of pianos in 1879

as part of its policy of modernizing and Westernizing the country, they turned to the American company of Knabe. The piano factory of Chickering and Sons in Boston was the largest of its kind in the world, and new companies began production almost every year. In 1883 Mason and Hamlin, which had been manufacturing organs for some years, began turning out pianos with a radical new method of stringing. These instruments worked very well and were soon used by some of the most famous piano virtuosos. The number of pianos made in America increased at an unprecedented rate, by 1910 reaching 360,000 a year. The success of American piano makers, the relatively low price of their instruments, the high standard of living achieved by millions of American families, and the almost universal musical literacy brought about by training in American schools and churches resulted in a piano in the home of almost every American family above the poverty level.

It is not surprising that American composers have written piano pieces that call in one way or another for alteration of the instrument, for American inventors have often attempted to change and improve various aspects of the piano ever since 1819, when Richard Bury of Albany patented a piano in which the hammers struck pieces of tuned glass rather than strings. George Ives, the father of the composer Charles Edward Ives, spent some years building a piano-like instrument that could play the notes "in the cracks between the piano keys"--intervals smaller than the half tones of the tempered scale to which all pianos were tuned by the nineteenth century. His instrument was made of 24 violin strings stretched across a clothespress, and even though it proved to be unusable for purposes other than his own, his son was later to write three piano pieces for quarter-tone piano. Nineteenth-century American inventors and tinkerers tried to modify every aspect of the piano, from its shape and striking mechanism to the method of tone production. Some sort of climax came with Thaddeus Cahill's Telharmonium, built in the first decade of the present century. It was played from a keyboard much like that of a piano, but the sounds were produced electrically, by some 200 tons of dynamos and other equipment hidden in the basement of Telharmonic Hall in New York, where the instrument was installed and played.

HENRY COWELL *and the Manipulation of the Piano*

The most characteristic feature of American music is its eclecticism.

Various waves of explorers, wanderers, and settlers came to this continent, bringing with them their music. As long as this music remained unchanged, there was no justification for calling it "American." It was Asian or English or Spanish or French or African music transported to a new location.

But almost from the discovery of America by Europeans there was contact among the different nationalities and races here--and this included musical contact. American music came about when the music of two or more cultures blended on this continent into a new musical style, obviously derived from others but unique to America because only here did these several cultures and their music come into contact.

It detracts nothing from the beauty--and Americanism--of Stephen Foster's songs to recognize that popular music in this country during his formative years consisted of Irish songs, songs arranged from the music of such Italian opera composers as Bellini and Donizetti, and English stage and concert songs; that Foster was familiar with these; and that elements of each can be traced in his

music. The shape-note music of the rural South and Midwest in the nineteenth century came about when Yankee singing masters brought the hymns, fuguing tunes, and anthems of William Billings and his contemporaries to regions where traditional English and Scottish ballads were still popular. Jazz has strong roots in both European and African music but it is American music, because it was only here that it developed, as a consequence of the unique blend of cultures in the South.

The music of Charles Ives is perhaps most remarkable--and most American--for its open and unabashed eclecticism. While other composers of his generation were laboring to achieve a personal style in their sonatas and symphonies (apparently unmindful that this style always turned out to be derivative of Germanic music of the later nineteenth century), Ives was willing to incorporate into his pieces any aspect of any kind of music that was part of his musical heritage. Melodies and other elements of hymns, popular songs and dances, patriotic songs, ragtime, classical music, and college songs turn up in his pieces. A melody might begin with a reference to Brahms and end up quoting Stephen Foster. It was this utter disregard for stylistic consistency that for decades blinded so many composers and theorists--particularly those associated with the academic study of music--to Ives's genius. But it was precisely this reckless eclecticism that made Ives the most American of all composers.

Henry Cowell continued Ives's tradition of eclecticism, but on a global scale.

Cowell was born in Menlo Park, California, on March 11, 1897. He was a prodigy on the violin, making his first public appearance at the age of six, and he gave piano recitals when he was in his early teens. Cowell came into contact with a wide range of music from his earliest days, and by no means only Western art music. As a boy he listened with great interest to Oriental music, including Chinese opera, in San Francisco. Extended visits to Kansas and Oklahoma during his childhood brought him into contact with the shape-note music of rural America. Of Irish descent, he heard and responded to all types of Irish music, vocal and instrumental. As a young man he made five extended trips to Europe, the first in 1923; he sought out folk music in the various countries he visited, and established professional contacts and friendships with musicians involved in research into traditional musics. In 1928, he went to Russia, the first American composer to be invited there after the Revolution. He studied non-Western music at the University of Berlin in 1932-33, and traveled to India, Japan, Iran, and other Eastern countries.

When not traveling, Cowell was intensely active in America as a composer, performer, teacher, and promoter of contemporary music. From the early 1920s he toured as a composer-pianist, playing his own piano pieces, which explored radically new sonorities. A review in *The New York Times* of his first New York program, in 1921, was headed "Musical Bolshevism." In 1927 he founded the New Music Society to encourage the performance, publication, and recording of contemporary music. The *New Music Quarterly,* the Society's organ, which he edited until 1937, published pieces by Ives, Ruggles, Nancarrow, and many other composers at a time when commercial publishers were unwilling to handle them. Cowell also served as president of the American Composers Alliance. In 1928 he began teaching at the New School for Social Research in New York; he was director of musical activities there until 1963. Students in his classes in composition and non-Western music included George Gershwin and John Cage.

Just as Ives drew on the total range of music of his cultural background, so Cowell drew on his. But

Cowell's included not only folk and art music of America but music from most of the world. He did not hesitate to use melodic, rhythmic, harmonic, and timbral elements of folk and non-Western music in the context of Western art music, nor to combine Western and non-Western instruments. *Sound-form for Dance* (1936) is for three wind instruments and a percussion section containing both Western and Asian instruments. Many of his pieces, from piano and chamber music to compositions for full orchestra, use Irish songs and dances harmonized with simple chords or triads, dissonant chromatic chords, or tone clusters. *Persian Set* (1958), for orchestra, uses exotic scales and melodies in Western forms and harmonizes them with triadic chords foreign to Persian music. The severally numbered *Hymn and Fuguing Tune* pieces, written between 1944 and 1964 for a variety of instrumental and vocal combinations, use melodies and compositional techniques characteristic of this folk-choral music. In 1962 and 1965 Cowell wrote two concertos for koto (a Japanese stringed instrument) and Western symphony orchestra.

In his piano pieces, his eclecticism is seen most obviously in his willingness to use all types of chords and sonorities. Where traditional sonorities were not adequate for his purposes, he invented new ones.

Cowell was fascinated with tone clusters from early in his career as a pianist and composer. He says in his book *New Musical Resources:*

> The use of chords based on clusters of seconds, built as they are on the next reaches of the overtones after thirds, would seem inevitable in the development of music. There is no reason to suppose that the progress along the overtones, which has been made from early musical times to the present, will suddenly stop.

In a series of piano pieces, the first dating from 1912, Cowell elicits remarkable new sounds from the instrument--not by altering the mechanism, but by requiring the performer to produce sounds in a variety of ways.

The Tides of Manaunaun (1912) is a piece of program music based on a passage from the writing of John Varian:

> Manaunaun was the god of motion, and long before the creation, he sent forth tremendous tides, which swept to and fro through the universe, and rhythmically moved the particles and materials of which the gods were later to make the suns and worlds.

The music begins with immense masses of sound in the lowest register of the piano, representing the surging of tides over bottomless seas. The sounds are produced by tone clusters including every note in a two-octave range. There is no way a pianist using traditional piano technique can make such sounds; there are not enough fingers. But Cowell directs the pianist to use his left forearm. These clusters continue in the left "hand" throughout the piece, as accompaniment to a pentatonic melody in the right hand reminiscent of an Irish tune. The clusters are sometimes chromatic; at other times they encompass only the white notes or the black notes of a two-octave range. Sometimes they are played as a simultaneous mass of sound; sometimes they are rolled from bottom to top in a massive arpeggio. Cowell has invented new notational symbols to instruct the pianist in

these manipulations of the instrument. Critics have pointed out the stylistic inconsistency of using clusters to accompany a melody based on a five-tone scale. But the most important aspect of the piece is that it achieves sounds never before heard from a piano.

Advertisement, written in 1914 and revised in 1959, has clusters of three and four notes in the right hand shortly after the beginning. As the dynamic tempo increases, the pianist is directed to play tone clusters with his right fist. "The tone quality produced by the fists is different from that produced by the fingers" is Cowell's understatement in his explanatory notes. The left arm first plays tone clusters with the forearm, then as the tempo increases it too is directed to play with the fist. To startled audiences of the 1920s, it appeared that the young composer-pianist had gone berserk and was simply pounding the instrument at random with both fists. With historical perspective in our favor and even wilder things in our ears, we can appreciate that this piece represents a breakthrough in piano sonorities.

Charles Ives used tone clusters in several piano pieces, and in his song *Charlie Rutlage,* written probably in 1921, he has the pianist strike the keys with the fist. These devices have been used occasionally by later composers. In Cowell's *Aeolian Harp* (1923) the pianist must produce sounds directly on the strings of the instrument, rather than the keyboard. In opening the piano lid to the performer and letting him play directly on the strings, however, Cowell opened a gold mine. The list of later pieces--particularly those written in the 1960s--in which the pianist is asked to strike, stroke, and pluck the piano strings with his hands or other objects is enormous.

JOHN CAGE *and the Prepared Piano*

John Cage has been at the center of the American avant-garde for so long, and some of his more outrageous activities have received so much publicity, that in order to deal with such a piece as *Sonatas and Interludes* it is useful and perhaps necessary to see it as the crowning work of any early stage of his development as a composer, very different in structure, content, and intent from many of the pieces he has created in the almost thirty years since he wrote it.

Cage was born in Los Angeles in 1912, the son of an inventor. He spent two years at Pomona College, then traveled in Europe for a year, drawn there by his love for art, architecture, and music. When he returned to this country, he studied privately with Richard Buhlig in California, Henry Cowell and Adolph Weiss in New York, and Arnold Schoenberg back in Los Angeles. His earliest preserved compositions, dating from these years of study, show Schoenberg's influence. Such pieces as *Six Short Inventions* (1933) and *Music for Wind Instruments* (1937) reveal a preoccupation with systematic organization of the twelve tones of the chromatic scale. Only Henry Cowell showed him music from traditions other than that of Western Europe, and there is little trace of his experiences with Cowell in these early compositions.

Cage held various part-time jobs in Los Angeles in the mid-1930s; one of these was as rehearsal pianist for a dance class. This experience proved so sympathetic that he moved to Seattle in 1937, to be composer-accompanist for Bonnie Bird's dance classes at the Cornish School. By this time, partly as a result of his exposure by Cowell to various non-Western musics, Cage was writing music for percussion instruments. He organized and directed a percussion ensemble, programming his own Quartet, a three-movement piece for any four percussion instruments, in late 1937. His Trio for

percussion (1936) was performed at the Cornish School on December 9, 1938.

In "The Future of Music: Credo," a talk delivered before a meeting of a Seattle arts society in 1937, Cage said:

> Wherever we are, what we hear is mostly noise....When we listen to it, we find it fascinating. The sound of a truck at fifty miles an hour. Static between the stations. Rain. We want to capture and control these sounds, to use them not as sound effects but as musical instruments....Whereas, in the past, the point of disagreement has been between dissonance and consonance, it will be, in the immediate future, between noise and so-called musical sounds.

Bacchanale, written in 1938 for a dance by Syvilla Fort, was Cage's first piece for prepared piano. He wanted to accompany the dance with percussion, but economic and practical considerations dictated that the dance be accompanied by piano alone. Cage discovered that if various small objects were placed between the strings of the piano, a wide range of percussive sounds would come from the single instrument. The dance was performed in the theater of the Cornish School on April 28, 1940, with Cage as accompanist.

Some of the sounds in Cage's early percussion pieces had specific pitches (musical sounds), some were nonpitched (noise). It was the same in his pieces for prepared piano--the insertion of various metal, rubber, and plastic objects in the strings of the piano produced a mixture of "musical sounds" and "noises." This posed a dilemma for Cage, who felt that a musical composition should be made up of organized sounds. Pitch organization had served him in his early pieces, but his determination to use nonpitched sounds made this method obsolete. His solution was to organize his new pieces according to rhythmic rather than pitch patterns. His earliest percussion pieces used recurring rhythmic patterns that gave shape and a sense of unity to the composition. His *First Construction (in Metal)* (1939), for six percussionists playing a wide variety of pitched and nonpitched instruments, is organized according to a sixteen-bar rhythmic structure (4+3+2+3+4) that occurs sixteen times in the course of the piece. This is a macrostructure, probably not perceptible to a casual listener; more clearly perceived unity comes from the frequently repeated rhythmic motives. Whether or not the large rhythmic organization can be heard, it at least served to shape the piece in some way that satisfied the composer, who was still much concerned with rational structure in music. As he says in his "Credo" of 1937:

> The principle of form will be our only constant connection with the past. Although the great form of the future will not be as it was in the past, at one time the fugue and at another the sonata, it will be related to these as they are to each other: through the principle of organization or man's common ability to think.

In 1939 Cage went back to Los Angeles, where he collaborated with Lou Harrison in organizing programs of percussion music. Dating from this period are *Imaginary Landscape No. 1* (1939), *Second Construction* (1940), and *Third Construction* (1941). The first is of special note in that it uses two variable-speed phonograph turntables and several frequency recordings as sources of sound and is thus one of the first pieces to use electrically produced sound.

In 1941 Cage taught a class in new music at the Chicago Institute of Design and directed another percussion ensemble. James Pence wrote in the *Chicago Daily News* of March 19, 1942, what was probably the first criticism of any of Cage's music in a major journal, titling his article "People Call It Noise--But He Calls It Music."

In the spring of 1942 Cage went to New York, which remained his home. A program of percussion music at the Museum of Modern Art early in 1943 that included three of his works brought him wide attention and acclaim for the first time. *Bacchanale* had remained his only piece for prepared piano for some years, but he turned to the instrument again in his first years in New York. *Totem Ancestor* (1943) was the first of many pieces for prepared piano written for the choreographer and dancer Merce Cunningham, whom Cage had first known in Seattle and who was establishing a wide following in New York for his sensitive and innovative work. *Amores* (1943) is made up partly of two pieces for prepared piano that attempt to "express in combination the erotic and the tranquil, two of the permanent emotions of Indian tradition." The year 1944 brought *Root of an Unfocus* for Merce Cunningham; *The Perilous Night,* a twelve-minute suite of six pieces played in its first performance by Cage himself; *Prelude for Meditation,* which uses only four different tones; and his most extended piece for prepared piano to that date, *A Book of Music,* a thirty-minute piece for the duo pianists Robert Fizdale and Arthur Gold. The following year saw more music for prepared piano: *Daughters of the Lonesome Isle* and *Mysterious Adventure,* both for dance, and *Three Dances,* a virtuosic piece for Gold and Fizdale.

These first New York years were a time of achievement and recognition. In addition to writing the pieces mentioned above, Cage began his long, successful collaboration with Merce Cunningham, writing music for Cunningham and his company, touring with them as accompanist, and becoming musical director. In 1949 Cage received awards from the Guggenheim Foundation and the National Institute of Arts and Letters.

Sonatas and Interludes was completed in March 1948, and almost immediately Cage's music took quite different paths. By 1950 Cage was studying the *I Ching,* the oracular Chinese *Book of Changes. Music of Changes* (1951), for piano, is made up of pitches obtained by tossing three coins, then consulting charts derived from the *I Ching. Imaginary Landscape No. 4* (1951) is a composition for twelve radios; two performers at each radio, one manipulating the volume-control knob and the other the knob that changes frequencies, follow a carefully written score. But the resulting collage of sounds is determined by an examination of imperfections on the paper on which the piece is printed. In *4'33"* the performer sits on the stage, in front of the score, without producing a sound and leaves when the time is up; the piece consists of whatever noises occur in the audience or outside the hall during the time frame of the work. *Williams Mix* (1952) was composed directly on magnetic tape from bits selected from tapes of musical and nonmusical sounds, the length of each segment and its position in the collage determined by chance operations. Cage's determination to "make a musical composition the continuity of which is free of individual taste and memory...and also of the literature and 'traditions' of the art" led him to relinquish more and more control over his compositions until he was specifying little more than the time frame and physical setting within which the piece was to take place. Even that control was given up with his *0'0"* of 1962 and subsequent pieces of the mid-1960s. All distinctions between art and life had vanished.

None of this has to do with *Sonatas and Interludes,* nor does Cage's later involvement with the ideas of

Thoreau, Mao, and Buckminster Fuller, which was unsuspected when his pieces for prepared piano were written.

BEN JOHNSTON ***and the Microtonal Piano***

Ben Johnston was born in Macon, Georgia, in 1926. He received an undergraduate degree at the College of William and Mary and a Master's degree at the Cincinnati College Conservatory of Music and also studied at Mills College, the University of California at Berkeley, and the University of Illinois. His teachers included Darius Milhaud, Burrill Phillips, Robert Palmer, Harry Partch, and John Cage in composition and John Powell and Claire Richards in piano. He taught from 1951-1986 at the University of Illinois at Urbana-Champaign, where he was a professor of theory and composition. He was a Guggenheim Fellow in composition in 1959-60 and received a grant from the National Foundation on the Arts and the Humanities in 1966. Among his major compositions are his String Quartet No. 2 (1964), commissioned by the La Salle Quartet; *Quintet for Groups* (1966), commissioned by the Saint Louis Symphony and premiered by that organization in March 1967; *Ci-Gît Satie* (1966-67), written for the Swingle Singers; Duo for Flute and String Bass (1963), written for and recorded by Bertram Turetzky; the opera *Carmilla* (1970), performed and recorded by the La Mama Company of New York; String Quartet No. 4 (1973), written for the Fine Arts Quartet; Mass (1972), for mixed voices, eight trombones, and rhythm; and *Knocking Piece* (1962), for two percussionists and piano. His most recent compositions include *In Memory, Harry Partch* (1975), for soprano, computer tape, tape, string quartet, eight percussionists, and slide show, and String Quartet No. 5 (1975), written for the Concord Quartet.

Johnston first encountered the theory and practice of microtonal music during his study with Harry Partch (1950-51), in Gualala, California. Partch used microtonal intervals in many of his works, devising new scales based on the expansion of chains of intervals derived from just intonation. He gave a generalized theory of this procedure in his book *Genesis of a Music* (New York, Da Capo Press, 1973), and used scales derived from this theory in such works as *Cloud Chamber Music* (1949-50). While Johnston was at the Columbia-Princeton Electronic Music Center in 1959-60, he began computing ratio patterns resulting from variations of extensions of tuning based on triadic tuning. At first this was merely theoretical work, but in such pieces as *Five Fragments* (1960), for alto, oboe, bassoon, and cello, and *A Sea Dirge* (1962), for mezzo-soprano, flute, violin, and oboe, he began asking performers to alter certain pitches microtonally to achieve chords in just intonation, which caused the pitch to rise and fall as in Renaissance choral music, and devised notational symbols to indicate these intervals.

In 1963 Johnston began exploiting his new ideas about tuning in music that would include a piano, tuned microtonally. With the aid of Arnold Brewe, a piano technician at the University of Illinois, he experimented with various tunings on a piano made available to him for this purpose by Duane Branigan, director of the School of Music. After some experimentation with transferring pitch-proportional schemes to metrical proportions--which had resulted in his *Knocking Piece,* composed the previous year--he undertook the composition of a piano sonata at the urging of Claire Richards, his former teacher, who had undertaken a comprehensive study of the twentieth-century piano sonata and performance of many major works of the genre.

Richards first played the *Sonata for Microtonal Piano* in 1965 at one of a series of "Roundhouse

Concerts" of contemporary music in the Urbana home of composer Salvatore Martirano. It was later performed in Austin, Texas, by Neely Bruce and in California by Virginia Gaburo. Preparing the piece for Smith Publications, Johnston made minor changes and corrected a few errors with the aid of his copyist, Mark Behm.

CONLON NANCARROW *and the Player Piano*

Although many inventors and instrument makers of the mid-nineteenth century had the idea of activating a mechanical musical instrument by means of a perforated roll of paper, it was a Frenchman named Fourneaux who built the first mechanism based on pneumatic principles that played the piano mechanically. His Pianista, patented in 1863, consisted of a machine, larger than the piano itself, operated by a hand crank that created a vacuum; a perforated sheet of paper passing over this vacuum caused a set of wooden fingers to depress certain keys of an ordinary piano. The device, wholly exterior to the piano itself, was first exhibited in America at the Centennial International Exposition in Philadelphia in 1876.

Despite this beginning in France, the main chapters of the history of what came to be known as the player piano were written in America. Inventors in this country were working on similar instruments before the Pianista was shown. John McTammany of Boston was producing mechanical organs, limited to a range of sixteen notes activated by rolls of perforated paper, by the early 1870s. Elias Parkman Needham and Merritt Gally patented devices that were later essential to the construction of more complex instruments.

R. W. Pain may have been the first to construct a workable pneumatic automatic piano, a thirty-nine-note instrument built in 1880. But William B. Tremaine and his son devised and marketed the first commercially successful player pianos. They first built and sold mechanical organs, Orguinettes, thousands of them. When H. B. Tremaine, the son, took over the company in 1899, a certain Mr. Votey had perfected a successful and reliable mechanical piano mechanism. This Pianola was a compact pedal-operated unit that could be positioned at the keyboard of any piano, upright or grand. The owner could select from a catalogue of many thousands of piano rolls. By merely purchasing his choice of these, inserting one in the instrument and operating the pedals, he could enjoy—“ unhappy Schubert speaking...in the sweet tones of Rosamunde, or Chopin bemoaning the fate of Poland in his Nocturnes, or Wagner lifting [him] aloft above the clouds to the mighty Halls of old Walhalla” --in the words of advertisements of the day.

For other tastes, there were songs, rags, and Sousa marches. All this music was "at his call, always fresh, not needing practice." "Before the Pianola came," concluded the sales pitch, “how very few there were who even caught a glimpse into the grand world of harmony. Toiling laboriously to reproduce a small part of the great compositions of the masters, even the best pianists were sadly limited. To all the rest of human kind the masterpieces of the grandest art that is known to man were buried treasures. This is what the Pianola does for man.”

The instrument was so successful that its name became synonymous with the player piano. The word lingers in the language even today: at bridge, when dummy lays down his hand and declarer sees that the play will be simple, he calls it a "Pianola"--it plays itself.

The Aeolian Company, as the Tremaines called their organization, produced thousands of units to meet the demand, and soon they set up subsidiary companies in London, Berlin, Paris, and Australia. Despite this success, there were lingering difficulties with the Pianola. It was large and clumsy, the wooden fingers sometimes snapped off, and it used only sixty-five of the piano's eighty-eight notes.

Melville Clark was one of the first to market an instrument with the automatic mechanism built inside the piano, forming a single unit. The Aeolian Company was quick to follow with its New Pianola Piano. Instead of exterior wooden fingers striking the keys, there was now an interior mechanism activating the hammers. The performer sat directly at the keyboard, operating pedals, rather than at an attached unit. The instrument also functioned perfectly well as an ordinary piano once the player mechanism was switched off.

The Welte organization of Freiburg, Germany, brought out the first "reproducing piano," which made it possible for nuances of touch, dynamics, and even phrasing to be captured and replayed on the mechanical piano. Marginal perforations on the piano rolls controlled the force with which the hammers struck the strings. Such composer-pianists as Rachmaninoff, Busoni, Paderewski, and Gershwin made piano rolls that captured their individual style of playing. Aeolian brought out the Duo-Art instrument, and the American Piano Company introduced the Ampico, the most successful reproducing piano.

The essence of the operation of all player pianos is that a perforated paper roll passes over a vacuum; each perforation activates a mechanism that depresses a hammer, which strikes a string and thus produces a note. The perforations on the horizontal axis of the roll determine which notes are to be struck; the vertical arrangement controls the timing--the sequence in which the notes are to be struck and the time intervals between notes. Thus it is possible to create music--compose--directly on the piano roll. Once a measurement is made to determine the precise point on the horizontal axis where a perforation will cause the piano to sound the note middle C, for instance, a perforation made here on a blank roll will cause that note to sound when the roll is run through the piano. A measurement on the vertical axis will yield the distance necessary for two notes to sound one second apart, for instance, and two perforations made according to this measurement will sound two notes at this time interval. Thus pitch and rhythm can be reduced to measurement, and it is theoretically possible for someone to create directly on a piano roll any sequence of pitches and rhythms, a sequence that can even bypass the capabilities of the human performer.

The first person to grasp this fact and use it to create new music directly on piano rolls was the composer Conlon Nancarrow, a mysterious, shadowy player in the drama of twentieth-century music, as little known to most of his contemporaries as was Charles Ives to his.

Nancarrow was born on October 27, 1912, in Texarkana, Arkansas. As a young man he drifted to various parts of the country, studying composition and playing the trumpet in jazz bands. He attended the Cincinnati College Conservatory of Music for several years, then went to Boston, where he studied briefly with Nicolas Slonimsky, Walter Piston, and Roger Sessions. He found his way to Europe in 1936 and in May 1937 enlisted in the Abraham Lincoln Brigade in Spain, joining other Americans in the fight against fascist domination of that country. When he returned to the United States he found that his own government, uncertain at the moment as to what its policy toward Spain should be, regarded him as undesirable and revoked his passport. Nancarrow went to

Mexico, where he has lived since in virtual isolation.

Three of Nancarrow's early compositions, written before he went to Europe, were printed in January 1938, issue of *New Music Quarterly*. They are most notable for their rhythmic complexity. It was after he went to Mexico, apparently, that Nancarrow thought of creating pieces for player piano, an idea well suited to his situation--living in virtual isolation from other musicians, and desiring to compose pieces of great rhythmic complexity. He acquired an Ampico instrument and made charts of correspondences between each of the eighty-eight notes on the piano and the precise spot on the piano roll that must be perforated in order to have the piano play this note, and also of measurement-time equivalences on the vertical axis. Perforating the roll by hand was tedious and imprecise, so he went to New York to attempt to purchase a mechanical perforator. When the owner refused to sell the device, Nancarrow made photographs and sketches of it and supervised the building of his own mechanism when he returned to Mexico. It resembled a huge typewriter, with horizontal and vertical tabulators. Even with this machine, the perforation of a roll is a long and exacting business.

Nancarrow executed thirty player-piano studies by 1960. He now owned two Ampico pianos, one with metal hammers and the other with hammers of leather and metal. Both had their action tightened for greater hammer speed and precision. At this point Nancarrow decided to put all his pieces into conventional notation, a task that took some five years. At this time he also received his first public exposure. John Cage arranged six of Nancarrow's studies to accompany Merce Cunningham's dance *Crises,* performed first in 1960 and kept in the repertory for five years. Nancarrow began composing again in 1965.

THE RECORDING

Henry Cowell

In *Aeolian Harp* (1923), the pianist is asked to produce sounds directly on the strings of the instrument rather than at the keyboard. The score gives a succession of three- and four-note chords. Standing, the performer depresses the notes of the chord on the keyboard with his right hand, gently so as not to activate the hammer mechanism, and with his left hand sweeps the strings encompassing the chord. The effect is of a chromatic glissando out of which the chord being held down by the right hand emerges, because depressing the keys releases the damper action on these notes, which sustains them as the others die away. Some of the glissandi are swept upward, some downward; the performer sometimes uses the fleshy part of his finger to produce a gentle sound, sometimes his thumbnail for a harsher sound. The musical structure of the piece is simple: a series of chromatic--almost Wagnerian--chords moves four times to a final triad, successively on E flat, A, G, and E flat, with a following arpeggio on this chord plucked on the strings without depressing the keys.

The aeolian harp, incidentally, was an instrument popular in ancient China and India and in nineteenth-century Europe. Strings stretched at varying degrees of tension over a resonating box gave off gently changing mysterious sounds, rich in overtones, when set in vibration by the wind.

The Banshee (1925) goes even further in the creation of sounds that have almost nothing to do with

what usually happens in a piano piece. Like *Aeolian Harp,* it is played on the strings of the instrument. The performer stands in the crook of a grand piano, with an assistant depressing the damper pedal throughout. The first sounds are produced by sweeping the fleshy part of the finger from the lowest string up to the B flat just below middle C; once this note is reached, it is sustained by drawing the finger back and forth along the string. Other notes are produced this way, then other effects give different sounds. Glissandi are played on the strings with both hands simultaneously, sometimes in parallel motion and sometimes in contrary. Chords are sustained by sweeping three or four fingers up and down the proper strings. Sometimes the palm of the hand is used to strike the strings, sometimes a fingernail. The result of all this is a series of muted and blurred eerie wailing sounds. Single notes and chords sometimes emerge, briefly. Sustained notes in the first six bars outline a whole-tone scale: B flat, A flat, G flat, E, D, C. After this there are diminished triads, then some sustained tone clusters, and movement back through diminished triads to final hints of the whole-tone scale.

This recording follows Cowell's performance practice of omitting eight measures of the published score.

The *Piano Piece (Paris 1924)* is doubtless one of Cowell's most extended and complex piano works. It begins quietly, with low, soft two-octave clusters giving dense, blurred clouds of sound. The tempo and the dynamic level increase, and deep tone clusters played with the left forearm accompany a *marcato* pattern in the right hand. A presto section is reached, with both arms playing fortissimo two-octave clusters on the first beat of each measure. In the slower and quieter section that follows, the pianist plays glissandi and other effects on the strings. A sudden allegro tempo leads to the dynamic climax of the piece, with the right fist pounding in the upper register and the left forearm playing massive tone clusters in the lower. A quiet ending has more low clusters and two final glissandi on the strings. The piece is a virtual catalogue of Cowell's new piano sonorities.

John Cage
From *Sonatas and Interludes*

Sonatas and Interludes climaxed a ten-year line of development in Cage's music, a period when he was concerned with integrating pitched and nonpitched sounds into coherent musical structures based on durational rather than pitch patterns. In view of certain directions his music was soon to take, it might be well to emphasize that in this work all notes and rhythmic patterns were chosen by the composer and fixed in precise, traditional notation. There is no element of chance here.

Cage composed this, his most successful work up to that time, in New York between February 1946 and March 1948. It is dedicated to the pianist Maro Ajemian, who played four of the pieces in Town Hall on April 14, 1946. The first performances of the entire set were by Cage himself in the spring of 1948 at Black Mountain College in North Carolina and at Stephens College in Missouri. Miss Ajemian's performances in Carnegie Recital Hall in New York on January 12 and 13, 1949, met with both public and critical acclaim. Cecil Smith wrote in *Musical America* of January 15:

> The tone of the prepared piano, gentle almost to the point of gentility, is quite enchanting, for Mr. Cage's fabulous ear for timbre and texture has enabled him to achieve gleaming combinations of overtones such as have never been heard in western

music.

Sonatas and Interludes was written when Cage was first seriously studying Eastern philosophies with Gita Sarabhai and Zen Buddhism with Dr. Daisetz T. Suzuki of Columbia University, attending lectures by Alan Watts, and reading the works of Ananda K. Coomaraswamy. The last prompted him to attempt to express in his major work for prepared piano "the `permanent emotions' of Indian tradition: the heroic, the erotic, the wondrous, the mirthful, sorrow, fear, anger, the odious, and their common tendency toward tranquillity."

There are sixteen Sonatas, in four groups of four separated by the Interludes; Interludes II and III occur together at the midpoint of the set, after Sonata VIII. According to Cage's "Table of Preparations" at the beginning of the score, forty-five of the eighty-eight notes of the piano are prepared by the insertion of various types of bolts and screws and pieces of hard rubber and plastic between the strings at specified distances. The Table of Preparations explains: "mutes of various materials are placed between the strings of the keys used, thus effecting transformations of the piano sounds with respect to all of their characteristics." Their effect on the sound differs with the type of material, its position, and whether or not the soft pedal is used. Some of the strings thus prepared give nonpitched thumps and thuds when struck by the hammer of the piano; some give tones altered in pitch and timbre; others produce two or more pitches simultaneously. As Cage puts it, the effect is of a "gamut of sounds moving from lower to higher without the correspondences of pitch characteristic of scales and modes." Specific materials and precise measurements are given; it is a matter of several hours to prepare a piano for a performance of the piece. In this recording the piano was prepared by Robert Miller.

Cage speaks of the formal structure in these words:

> The first eight, the twelfth, and the last four sonatas are written in AABB rhythmic structures of varying proportions, whereas the first two interludes have no structural repetitions. This difference is exchanged in the last two interludes and the sonatas nine through eleven, which have respectively a prelude, interlude, and postlude....The compositional opinions involved are the subject of an article, *Forerunners of Modern Music.*

The article mentioned is reprinted in Cage's book *Silence* (see Bibliography); it first appeared in *The Tiger's Eye* of March, 1949. The article begins with some philosophical statements:

> Music is edifying, for from time to time it sets the soul in operation. Structure in music is its divisibility into successive parts from phrases to long sections. Form is content, the continuity. Method is the means of controlling the continuity from note to note. The material of music is sound and silence. Integrating these is composition.

He continues by explaining that structure in music is usually approached from a harmonic basis, but that Oriental music, Western music "in our pre-Renaissance culture," and modern atonal music do not have a harmonic basis. Of the four characteristics of sound--pitch, timbre, loudness, and duration--only duration involves both sound and silence. Therefore, he concludes, only a structure based on duration is "correct," since only it corresponds with the nature of the material--the musical composition.

Cage is not concerned with the simultaneous sounding of pitches. This would be difficult in *Sonatas and Interludes* anyway, since so many of the sounds are nonpitched. He is concerned rather with rhythmic groupings of sounds and silences.

Sonata V will serve to illustrate Cage's method of structure. The piece is in two sections with different material, a simple AB form. Each section is to be repeated, thus the form is AABB, as Cage reported in the quote above. The A section is 18 measures long, the B 221/2, giving a ratio between the two sections of 4:5. The 18 measures of A divide in half, 9+9, the 221/2 measures of B are divided 9+9+41/2. Each of the four 9-measure segments of both A and B is further subdivided into 4+5 measures, a reflection at a lower level of the 4:5 ratio of the two large sections. At an even lower level, both the 4-measure and the 5-measure segments are divided in half, giving within each 9-measure segment a division of 2+2+21/2+21/2. Since there are 2 beats to each measure, these smaller segments take up 4+4+5+5 beats, giving a 4:5 ratio at a third level. The final 41/2 bars are also constructed of 4+5 beats.

Sonatas I and XII are also in AABB forms. The A and B sections of Sonata I are in a proportion of 4:3, with reflections of this ratio at smaller levels. Interlude II, though not written in a binary form, consists of 64 measures, broken into 32+32. The first 32 are further divided into 4+4+4+4+4+6+6.

But it is not necessary to count numbers in order to listen to these pieces. The structure is the business of the composer and the theorist. Cage chose the individual sounds and their combinations because they appealed to his ear. The light, high, bell-like sounds of Sonata I float by, separated by silences, following one another in mosaic-like patterns that follow no rules of harmonic progression or melodic development but are nevertheless satisfying and inevitable. The ostinato patterns of Sonata V thrum on and on, becoming fragmented and dislocated near the ends of the large sections, sounding almost jazz-like at times, pushing on to the ethereal, sustained ringing of the final four and a half measures. Interlude II is more complex, winding its way through delicate arabesques of sound to a steadier bass line, dying away from this, moving next to a repetitious strumming pattern, and dying away at the end to high, thin, almost unheard chimes. Sonata XII is broader, more spacious, in its ringing first section, moving in the second half to a delicate running figure in a high register against bell-like strokes in the left hand.

But words do no more than numbers. These are sound pieces, pieces to be listened to, made up of sounds conceived by the composer for the delight and pleasure of the listener. This is music that "sets the soul in operation."

BEN JOHNSTON

Sonata for Microtonal Piano

The Piano: Its Tuning and Temperament

Some knowledge of the complex subject of tuning and temperament is useful in approaching Ben Johnston's *Sonata for Microtonal Piano.*

It is an almost universal phenomenon among music cultures of the world that a note a certain

distance above or below another note is perceived as the same note as the first, but higher or lower in pitch; a note, a group of notes, or an entire melody performed this distance above or below the original note group, or melody, is understood as a duplication or doubling in a different register. In Western cultures this distance is called an octave.

The distance between two notes an octave apart may be thought of as a continuum along which a number of other notes are placed to form what is called a scale. The word "octave" was coined when a scale of seven notes was considered fundamental to music and music theory, and the eighth note (octave) of the scale began a duplication of the scale an octave higher. But division of the octave into a seven-note scale is by no means as common as the perception of the octave: some music is based on scales of four, five, six, eight, or more notes to the octave.

In cultures with no musical notation, the scales on which music is based are perceived and transmitted aurally. But in the fact-oriented and intellectually curious Greco-Roman-Western European culture, it was inevitable that the formation and structure of scales would be treated in an analytical way.

The seven notes of the Western scale have been given letter designations. Starting for convenience on C, these are C D E F G A B (C) (D)....The distance, or interval, between two consecutive notes is called a second, and though it is not apparent from the letter names, these seconds are two different sizes--half steps, or minor seconds; and whole steps, or major seconds.

The pitch of a string is determined by the number of vibrations per second once it is plucked or struck. The greater the number of vibrations, the higher the pitch. Science tell us that a note an octave higher than another note has a vibration rate twice that of the lower. If a vibrating string is divided precisely in half, the pitch will be an octave higher, since the vibration rate is twice that of the original string. If the string is divided where the ratio of lengths is 3:2 (and hence the vibration rate is also 3:2), a note a fifth above the second note will sound. Continuing this process, proportional string lengths--corresponding to proportional vibration rates--for the various notes of the seven-note scale can be computed. Exactly the same series of notes can be obtained on a brass instrument. A fundamental note can be played; a change in air pressure by the player will cause the vibrating air column inside the instrument to divide into halves; different air pressure will cause it to split in a ratio of 3:2; and so on.

The notes produced by these two methods might be called acoustically perfect intervals. There is a clear tendency for musicians to favor acoustically perfect tunings when playing and singing relatively simple music restricted to the notes found early in the above series. But problems arise when music becomes more complex.

Western musicians reached the point of no longer being willing to confine their music to a seven-note scale and introduced new notes a half step above or below certain notes. Eventually a twelve-note scale (in which each note is a half or minor second away from its neighbors) was accepted, first in theory and then in practice. Music was still based on the seven-note scale, but five additional notes were available for variety and tonal color. Also, Western music began accepting the idea of modulation (that a composition could move from one tonal center, or key, to one or more different tonal centers) and of transposition (that a melody or an entire composition could be performed at

another pitch level).

A scale built on acoustically perfect intervals has its various notes tuned to the fundamental or tonic note of that particular scale; if any other scale is played, using the notes of the first scale, the different notes of the new scale will not be acoustically perfect in reference to the new tonic note.

Musicians were plagued by this problem for many centuries, and new scales were proposed and tried. Different methods of tuning were tried; however, in practice this tuning yields some pitches even in its first twelve notes that are noticeably sharper or flatter than acoustic intervals. Then there was just intonation, a system in which tuning is based on acoustic thirds and fifths. The solution was the eventual adoption of equal temperament, in which the twelve notes of the chromatic scale are divided into twelve absolutely equal half steps. Any interval or chord in any key is precisely the same in tuning as that interval or chord in any other key. This system permits the composer complete freedom in his choice of chords and keys.

Something is lost, though, in achieving this equality. Only the octave is acoustically perfect. All other intervals differ to a greater or lesser degree from acoustic ones. Fifths are very slightly smaller, and fourths are slightly larger, the differences too little to be heard by most ears. Whole tones are smaller, minor thirds are considerably smaller, and major thirds are quite a bit larger. These latter deviations are great enough to be perceived by most people when the two sizes of intervals are played one after the other, but Western musicians and audiences have been conditioned by more than two hundred years of listening to equal temperament, and they accept this tuning without question. Only some string players and an occasional choral director will produce acoustic intervals, usually thirds and sixths, and such efforts usually pass unnoticed by listeners.

Ben Johnston, in his *Sonata for Microtonal Piano* and other pieces, has "been concerned to reopen doors closed by the acceptance of the twelve-tone equal-tempered scale as the norm of pitch usage." His use of intervals smaller than the half-steps of equal temperament is quite different from the quarter-tone music of Alois Hába, Hans Barth, and Julian Carrillo, who divided the twelve-note chromatic tempered scale into twenty-four equal steps in order to have a wider range of pitches to draw upon in their compositions, with no concern for the reestablishment of acoustic pitches.

The Work

Concerning his *Sonata,* the composer has furnished the following remarks:

> My *Sonata for Microtonal Piano* deploys chains of just-tuned (untempered) triadic intervals over the whole piano range in interlocked consonant patterns. Only seven of the eighty-eight white and black keys of the piano have octave equivalents, one pair encompassing the distance of a double octave and the remaining six pairs separated by almost the entire length of the keyboard. Thus there are eighty-one different pitches, providing a piano with almost no consonant octaves.
>
> Effectively, for the listener, there are three main gradations of consonance/dissonance: 1) smooth untempered thirds and fifths, which have the least amount of harshness caused by acoustical beats, 2) compounds of these such as sevenths, ninths, elevenths, thirteenths, and fifteenths (which turn out to be slightly sharp double octaves), and 3) chromatic or

enharmonic intervals comprising all the even-numbered keyboard distances such as seconds, fourths, sixths, octaves, tenths, twelfths, and fourteenths, and which sound "out of tune."

This suggested to me the possibility of two opposite systems for the deployment of pitches: one that synchronizes pitch choices with the layout of consonant and dissonant intervals on the keyboard, and a violently contrasting one in which the system for choosing pitches, a twelve-tone row procedure derived largely from certain practices of Berg and late Schoenberg, either ignores or flouts the consonance/dissonance keyboard layout. There are two contrasting movements of each of these types.

This makes possible a Janus-faced work, in which, with only the third movement similarly located in both versions, permutation of the placement of the other three movements creates an alter-ego relationship between the two versions, called respectively *Sonata for Microtonal Piano* and *Grindlemusic.* In the *Sonata* version here recorded, the movements correspond to the classical sonata scheme: the "sonata-allegro," the "scherzo," the songlike "slow movement," and the "finale," which is in this case a meditative adagio. All movements, however, are cast in the common ballad mold, AABA, as is each of the two entire versions, the *Sonata* and *Grindlemusic.*

All tempos, all phrase and section lengths, and in certain parts of the finale (which opens *Grindlemusic,* the sequence closing with the scherzo) even note-to-note timings conform to a proportional scheme derived from a single patter of changes in AABA form. This pattern is associated with two distinct motivic groups at different points in the work.

Tempo and time period normally relate inversely in a proportional system, but in this composition these two sets of time proportions relate *without* inversion, resulting in an enormously complex rhythmic shape involving elaborate metrical modulation, interrupted bars and beats, and rapid passages of enormous virtuosity.

The *Sonata,* whether presented as beauty or as the beast, is a monstrous parody-enigma, elusive, referential, sometimes derisive, distorted, a tissue of familiarity in radically strange garb. In the *Grindlemusic* sequence the movements (arranged in the order finale, sonata-allegro, slow movement, scherzo) have these titles: "Premises," "Questions," "Soul Music," "Mood Music." Whatever the closing mood brings to mind, it is overlaid with irony and derision. The *Sonata* sequence poses the challenge: fast, faster, slow, slower. When, in the *Sonata's* finale, the knots are finally untied, will it be clear from what Houdini has escaped?

Sonata, what do you want? Candy?

CONLON NANCARROW
Studies for Player Piano

Rhythm Study #1 for Player Piano, done in 1948, was published in *New Music Quarterly* for October, 1951, with a footnote explaining that the score,

> like all the recent music of Conlon Nancarrow written for player piano, has been

recorded by him on a piano roll by punching accurately spaced holes. In this way he is able to achieve rhythmic combinations that otherwise would be practically unplayable.

The piece was first sketched, then punched on the roll. Only afterward did he make the transcription in traditional notation published in *New Music*--a transcription of almost unbelievable rhythmic complexity, but in some places still only an approximation of the actual rhythms. The easiest thing for the ear to pick up, on first hearing, is the series of ostinato (a figure repeated over and over throughout a composition) chords in the middle register of the piano. These begin as apparently random combinations of major triads on E, C, and G, move to a regular pattern of E G E C, E G E C, then expand to a sequence of triads marching up and down the scale from C to G: C D E F G F E D, repeated over and over, giving an apparent rhythmic stability to most of the middle of the piece before moving back to a simpler C E G E C pattern in the final seconds.

The piece begins simply, builds slowly to a climax, then quiets back down to sonorities and rhythms similar to those at the beginning. The climax is achieved by a gradually accumulating complexity. At the beginning, the marching triads are accompanied only by a lower, more slowly moving series of bass chords built of two fifths. Bits of rapid running passages appear, first in the treble, then in the bass. These become longer and more rapid and are joined by other patterns in other rhythms. At the peak of complexity, Nancarrow found it necessary to use five staves to notate everything that is going on. Needless to say, no human pianist--or even two or three of them together--could play such complex patterns accurately. Nor can most human ears sort out these different rhythmic threads. But the effect is of a tremendously exciting piece moving to increasingly complex and dynamic combinations of rhythms and sonorities.

The other two works on this disc illustrate Nancarrow's later methods of composing. Beginning with *Study #15,* he made a series of canons with each voice moving at its own tempo. The first of these was relatively simple, with two voices in a rhythmic ratio of 3:4. *Study #19* has three voices, in ratios of 12:15:20. *Study #36,* recorded here, has four voices in 17:18:19:20. It is unlikely that many ears can hear these relationships with precision. But that is not necessary--the rhythmic tension and excitement of the piece, the totally new piano sonorities, are there for all to hear.

Study #27, subtitled "5%/6%/8%/11%," makes use of another of his techniques, rhythmic acceleration and deceleration in various voices. It has an ostinato figure in the middle range--described by the composer as "the ticking of an ontological clock"--surrounded by four voices, in canon, each speeding up and slowing down by the percentages given in the subtitle.

These pieces, like all Nancarrow's compositions for player piano, are hard, brittle, bright, spectacular. They do things with the piano that a human performer could never match. They are music for a machine, music for the Age of Machinery. Yet they were conceived, in every detail, by a human brain.

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Conlon Nancarrow

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A CENTURY OF AMERICAN INVENTION, 1852-1960

What occurred in the course of this century, through the application of new sources of power, chiefly electricity, was in fact a revolution in communication. The result was an enormous increase in our ability to exchange ideas, goods, and services. With this new energy came an acceleration in the pace of life and a necessary reorganization of ways of living. Some, like Dr. George Beard, argued as early as the 1880s that the basic personality of Americans was altered, that we were all becoming more "nervous" as a result of the new inventions. But all agreed that there had been a significant reorientation.

Obviously, the arts' basic means of communication were affected. Some artists enthusiastically adopted the new techniques and possibilities offered by the revolution in communication; others would resist and propose a return to more traditional modes of expression and behavior.

1852 Elisha G. Otis invented the first passenger elevator, a necessary prelude to the skyscraper.

1865-1875 William A. Bullock, Andrew Campbell, and Stephen D. Tucker significantly improved the printing press.

1865-1876 1867 Christopher Sholes invented the first practical typewriter. He later sold his rights to E. Remington and Sons.
Elias Howe's sewing machine won the gold medal at the Paris Exhibition.

1869 Thomas A. Edison invented the electric voting machine.
1873 Thaddeus Lowe invented the carbureted water-gas process.
1874 Stephen Dudley Field tested the first electrically powered streetcar in New York City.
1877 Bell Telephone Co. organized shortly after Alexander Graham Bell's invention of the telephone.
1878 Edison invented the phonograph.
1879 Edison invented the first electric light bulb.
1888 George Eastman marketed the first Kodak hand camera.
William S. Burroughs invented the first practical adding machine.
1891 Edison obtained the first radio patent in United States.
1895 J. Frank Duryea built the first gasoline-engine-driven motor.
1896 C. Francis Jenkins and Thomas Armat demonstrated Vitascope, a primitive motion-picture projector.
1903 Wilbur and Orville Wright made the first successful airplane flight at Kitty Hawk, North Carolina.
1904 Edison developed first movies with sound.
1909 Patent for plastic issued to Leo H. Baekeland.
1913 William D. Coolidge invented an improved X-ray tube.
1914 Robert H. Goddard patented the liquid fuel rocket.
1925 C. Francis Jenkins demonstrated the first television.
1927 A.T.& T. made first transmission of television signals, New York to Washington, D.C.
J. D. Rust and M. D. Rust invented the first mechanical cotton picker.
1928 First full-length sound film.
1930 Albert H. Taylor and Leo C. Young employed radar detection for United States Navy after inventing it in 1922.
1934 Diesel-motored trains perfected.
Invention of nylon by Wallace H. Carothers.
1940 First color television demonstrated by Columbia Broadcasting System (CBS).
1942 Jet plane tested for first time in United States.
1945 First atomic bomb exploded at Alamogordo, New Mexico, July 16.
1946 Radar signals were sent to the moon from Belmar, New Jersey.
Invention of the transistor by Walter Brattain, John Bardeen, and William Shockley of Bell Telephone Laboratories.
1952 Nuclear generator (cosmotron) at Brookhaven National Laboratory produced 2,250 million volts.
1954 U.S.S. *Nautilus* commissioned: the first atomic-powered submarine.
1956 Bell Telephone Co. and Air Research and Development Command developed the solar battery.
1958 "Explorer I," first United States earth satellite, sent into orbit.
1959 "Pioneer IV" satellite began orbit around the sun.
1960 "Tiros," a camera-bearing weather satellite, began orbit April 1.
A.T.&T. applied to Federal Communications Commission for permission to launch a communications satellite, October 21.
Donald A. Glaser received Nobel Prize for invention of a chamber for photographing atomic particles (bubble bath chamber) and Dr. Willard F. Libby for Atomic time clock, November 3.

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The piano used for the Ben Johnston composition was tuned microtonally using the Scalatron Tuner and Pitch Monitor. This equipment can establish any pitch progression both aurally and visually with extreme accuracy. We wish to extend our thanks to Richard J. Harasek and Motorola Scalatron, Inc. for their help and equipment for the microtonal tuning.

The Nancarrow "Studies" were recorded during an impromptu visit to the composer's home in Mexico City during March 1973. The recording equipment used was antiquated but well maintained. The studio in which Nancarrow's two Ampico upright player pianos are housed is approximately 20' X 50'. It is a resonant concrete-block structure lined with shelves containing music books and manuscripts. Considerable care was taken in microphone placement in an effort to achieve a representative sound quality. The volume fluctuations in *Study #27* are intentional.

ROBERT MILLER

Numerous works were expressly written for Robert Miller by such leading American composers as Milton Babbitt, George Crumb, Charles Wuorinen, and Mario Davidovsky (the Pulitzer Prize-winning *Synchronisms No. 6*). His concert appearances took him to the festivals of Tanglewood and Aspen, and to many other musical centers of North America. He recorded for Deutsche Grammophon (in conjunction with Acoustic Research), Columbia, Turnabout-Vox, and CRI. Robert Miller died November 30, 1981.

Producer: Sam Parkins
Recording engineers: Buddy Graham, Frank Laico, Roger Reynolds
Mixing engineer: Arthur Kendy

Digital mastering: Paul Zinman, SoundByte Productions, New York
Recorded at Columbia Recording Studios, 30th Street, New York, and Mexico City
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SOUND FORMS FOR PIANO 80203-2
Robert Miller, piano

Henry Cowell (1897-1965)
1 *The Banshee* (publ. Associated Music) 2:19
2 *Aeolian Harp* (publ. Associated Music) 1:28
3 *Piano Piece (Paris 1924)* (publ. Associated Music) 3:59
John Cage (1912-1992)
(from *Sonatas and Interludes*)
4 Sonata I (publ. C.F. Peters Corp.) 2:55
5 Sonata V (publ. C.F. Peters Corp.) 1:22
6 Second Interlude (publ. C.F. Peters Corp.) 4:23
7 Sonata X (publ. C. F. Peters Corp.) 3:45
8 Sonata XII (publ. C.F. Peters Corp.) 3:41
Ben Johnston (b. 1926)
Sonata for Microtonal Piano (publ. Smith Publications)
9 Movement I 2:44
10 Movement II 1:38
11 Movement III 3:56
12 Movement IV 2:43
Conlon Nancarrow (b. 1912)
Studies for Player Piano
13 Study #1 2:01

14 Study #27 5:31
15 Study #36 4:09

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