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PARALLELS IN THE DEVELOPMENT OF ELECTRONIC AND PERCUSSION  
MUSIC AND AN EXAMINATION OF PERFORMANCE PROBLEMS IN  
LEJAREN HILLER'S MACHINE MUSIC FOR PIANO, PERCUSSION  
AND TWO-CHANNEL TAPE RECORDER WITH THREE RECITALS  
OF SELECTED WORKS OF ROLNICK, KESSNER, XENAKIS,  
WINSOR, NIIMI, AND OTHERS

DISSERTATION

Presented to the Graduate Council of the  
University of North Texas in Partial  
Fulfillment of the Requirements

For the Degree of

DOCTOR OF MUSICAL ARTS

By

Jeffrey B. Smith, B.M.E, M.M.

Denton, Texas

May, 1992

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Smith, Jeffrey B., Parallels in the Development of Electronic and Percussion Music and an Examination of Performance Problems in Lejaren Hiller's Machine Music for Piano, Percussion and Two-Channel Tape Recorder with Three Recitals of Selected Works of Rolnick, Kessner, Xenakis, Winsor, Niimi, and Others. Doctor of Musical Arts (University of North Texas), May, 1992, 105 pp., 22 illustrations, bibliography, 49 titles.

This study traces the significant developments in the late nineteenth and early twentieth centuries which led to the development of electronic music and increased writing for percussion. Whether by coincidence or premeditation, the field of percussion in Western culture and electronic music share many parallel aspects in their history. As the twentieth century progressed, percussion solos, chamber ensembles and percussion parts in large ensembles became increasingly demanding. In fact, the entire concept of percussion evolved to a level previously unknown in Western music. At the same point in history, techniques for producing music by electronic means were developing. Carlos Chavez, Edgard Varese and John Cage foresaw a time when electronic music would allow composers to realize compositions with ease, provide new sounds to the spectrum of possible material for pieces and aid in the conception of works. Significantly, these same composers were important figures in the development of percussion composition.

Obviously, the common link between the two areas are the numerous sonorities each medium makes available for the composer to use. There is also a striking correspondence in the timing of the major developments in each field. This dissertation will illustrate this is by chronologically comparing their near simultaneous strides from the end of the 19th century to the 1960s.

In many ways, Lejaren Hiller's Machine Music can be seen as a culmination of the developments which had been taking place in the history of electronic music and percussion music. A product of the innovations in both fields, it poses some formidable problems for the performers. This study will give some background into its composition, examine its structure and deal with its performance problems.

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## CHAPTER 1

### SIGNIFICANT DEVELOPMENTS IN THE LATE NINETEENTH AND EARLY TWENTIETH CENTURIES WHICH LED TO THE DEVELOPMENT OF ELECTRONIC MUSIC AND INCREASED WRITING FOR PERCUSSION

Whether by coincidence or premeditation, percussion music in Western culture and electronic music share many parallel aspects in their development. Percussion music of the twentieth century is more technically complicated, is more involved musically, calls for the use of diverse instruments drawn from a variety of sources, and is more complex notationally than ever before. During the same time in history, techniques for producing music electronically developed.

The origins of new compositional techniques for both percussion and electronic instruments can be found in the remarks of composers earlier in the century. Edgard Varèse said in 1936, "I am sure that the time will come when the composer, after he has graphically realized his score, will see this score automatically put on a machine that will faithfully transmit the musical content to the listener."<sup>1</sup> The next year John Cage wrote, "To make music . . . will continue to

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<sup>1</sup>Edgard Varese, from a lecture given at Mary Austin House, Santa Fe, New Mexico, 1936.

increase until we reach a music produced from the aid of electrical instruments."<sup>2</sup> Carlos Chavez also foresaw the use of electronic means to producing music in his 1937 book Toward a New Music: Music and Electricity. Significantly, these same composers were important figures in the development of percussion composition. In fact, Cage considered the percussion orchestra one of the most significant performing mediums of the century. He said that the percussion orchestra provided composers with the opportunity to explore new sounds and reach out to the cultures of the world which concentrate on the sounds of percussion instruments.<sup>3</sup> With electronic instruments, composers were able to set aside the customary approaches to writing for traditional instruments and explore new methods of composition. These two mediums--percussion and electronics--enriched the voices of twentieth century composers.

One link between the two areas is the timbral variety each medium makes available to composers. During the 20th century, the timbral palette of percussion expanded enormously. Ethnic and found instruments, sound effects, subtle shading by use of different sticks and mallets, and unusual manipulations of the instruments were utilized. In the field of electronics, instruments were built

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<sup>2</sup>John Cage, Silence (Middleton, Conn.: Wesleyan University Press, 1961), p. 3.

<sup>3</sup>*Ibid.*, p. 5.

which allowed composers to design entirely new sounds and gave them a means of controlling the sounds with precision.

There is a striking correspondence in the timing of the major developments in each field. Socio-political changes, redirection in the arts, technical developments and the intermingling of world cultures affected each similarly. Three periods of time will be studied in order to illustrate the trends which led to the composition of works such as Lejaren Hiller's Machine Music for Piano, Percussion and Two-Channel Tape. The first period begins in the 1870s with the innovative use of percussion by Richard Wagner, Peter Ilyitch Tchaikovsky, Giuseppe Verdi, Camille St. Sæens, the invention of the phonograph by Thomas Edison, and the wire recorder by Vladimir Poulsen. The second period begins at the turn of the century when Claude Debussy, Gustav Mahler, Charles Ives, and Arnold Schoenberg were active, and when the first electronic musical instruments appeared. The third period begins around 1930 when the first significant works for percussion ensemble and solo percussionist were written and the first tape recorders were built.

### 1870s-1900

The transition from traditional thought to twentieth-century temperament accelerated with the late romantic composers of the nineteenth century. It was during this transition period that the number of percussion instruments used in orchestral scores

increased significantly. Much of the influx was due to the addition of extramusical associations and novelty effects percussion instruments provided. Sound effects produced by percussion instruments are found in many opera scores. Richard Wagner used a tam-tam to simulate an anchor splash and a mechanical device to simulate wind in Der Fliegende Hollander, had an 18 anvil chorus depict the laboring dwarfs in Der Rheingold, used a sheet of metal to create a thunder effect in Parsifal, and had timpani simulate the sluggish heartbeat of the dragon in Siegfried. Pitched percussion instruments also became prominent during this time. Camille St. Sæens' Danse Macabre (1874) is the first example of xylophone writing in an orchestral setting.

Gustav Mahler is credited with raising the percussion section above the "orchestral kitchen department,"<sup>4</sup> writing much for percussion in his ten symphonies. He often used percussion instruments to make environmental and cultural associations. The idiomatic sound of the snare drum, bass drum and cymbals, common in Austrian military bands, was used in his Third, Fifth, Sixth, and Ninth Symphonies. In addition to the timpani, bass drum, suspended cymbal, tam-tam, triangle, glockenspiel, tubular bells, switch and whip in his Sixth Symphony, a wooden hammer is used to create the sound of an axe and the impression of a mountain landscape is produced by random strokes of Swiss cowbells. To impress the

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<sup>4</sup>Charles L. Seiler, "Gustav Mahler and Percussion," The Percussionist 13 (Winter 1976), p. 68.

image onto one of the percussionists performing the work, Mahler had him hang a large bell around his neck to demonstrate the "natural" sound he wanted.<sup>5</sup>

Instrument innovations also contributed to the expansion of literature for percussion. A foot-operated tuning system for the timpani was developed by Pittrich in 1872. With the timpanist's feet activating the tuning mechanism, fast changes and glissandi were possible. J.C. Deagan started the Deagan Co. in 1880 to manufacture keyboard percussion instruments with dependable, accurate tuning. He perfected the orchestra bells and tubular bells first, then, in 1893, he began manufacturing diatonic, resonatorless xylophones and in 1903 began building chromatic instruments with resonators. The first chromatic marimba was built by Sebastian Hurtado of Guatemala in 1894, and was popularized by the Hurtado Brothers' Royal Marimba Band. It was heard in the United States as early as 1908.<sup>6</sup>

Associations with other cultures and traditions greatly expanded the percussion section in the orchestra. Claude Debussy abandoned traditional tonality, developed new rhythmic complexity, recognized the essential role of color in music and created unique

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<sup>5</sup> *Ibid.*, p. 67.

<sup>6</sup>Vida Chenoweth, The Marimbas of Guatemala. (Louisville, Kentucky: University of Kentucky Press, 1974), p.76.

forms for each work.<sup>7</sup> Most noted for his journey away from the hierarchical prominence of melodic line and functional harmony, Debussy's was an unprecedented path. One of his significant contributions to music was the extensive use of the exotic. Following 1889, the year he heard Indonesian gamelan music performed at the Paris Exposition, Debussy incorporated oriental pentatonicism, pliant melodies and almost immobile harmonies into his music. Interest in Eastern music necessarily increased the interest in use of percussion instruments since they were vital to the serious music of the Far and Near East.<sup>8</sup> As a result, Western musical thought began to be entangled with musical traditions which relied heavily on the use of percussion instruments.

Like the percussion field, the field of electronics was also expanding during the end of the nineteenth century. The first electronic musical instrument was built by the American inventor Elisha Gray. Best known for his work with telephone inventor Alexander Graham Bell, Gray invented the "musical telegraph" in 1874. Predating the electronic organ by over 60 years, it consisted of a one octave keyboard which controlled several battery-powered, single-tone telegraph transmitters. It was a polyphonic instrument,

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<sup>7</sup> Paul Griffiths, A Concise History of Avant Garde Music. (New York: Oxford University Press, 1978), p. 13.

<sup>8</sup> Reginald Smith-Brindle, The New Music (London: Oxford University Press, 1975), p. 133.

that is, it was capable of producing chords, unlike many of the instruments which became popular in the early twentieth century.

The ability to record sound was also developed at the end of the nineteenth century. A year after establishing his research laboratory in 1876, Thomas Edison invented the cylinder phonograph. In 1887, Emile Berliner, a German-born U.S. inventor, introduced the flat phonograph which reduced the distortion associated with the Edison cylinder system. Magnetic recording was introduced in 1895 by Danish radio engineer Valdemar Poulsen (1869-1942). He invented the steel wire recorder (telegraphone) which can be described as an electromagnetic phonograph. Voltage from an audio line was converted into an electromagnetic field which was then "memorized" by the magnetization of a wire which passed by a recording head at 84 inches a second. The advantage of electromagnetic recording over disc recording was the ability to reuse the wire. Unlike the tape recorder, which developed in the 1930s and 1940s, editing by the use of splicing was not possible nor was there the capability to fast forward or rewind. The ability to store sound by use of a magnetic medium, however, became central to the compositional techniques of the electronic music pioneers.

### 1900-1930

The turn of the twentieth century was a period of great cultural, scientific and social change. During these years of turbulence profound and far-reaching changes occurred in music.

Some composers searched for new instruments and new means of writing to remold the traditional orchestra into a new medium of expression. Others, however, discarded musical tradition altogether and created works which coincided with their modern ideals. Musicians involved with Futurism, Dadaism and the Bauhaus movements departed radically from the musical aesthetics and approaches of the past and moved toward the new interest in electronic and percussion music.

In 1909, the Italian Filippo Tommaso Marinetti published his Foundation and Manifesto of Futurism in the Paris newspaper Le Figaro. In it, he presented militant ideals of Futurist drama, literature, art and music. He urged artists to look no longer to the past for inspiration but to the present--the "Machine Age", as he called it--for true and meaningful expression. The Futurist musician Francesco Pratella echoed Marinetti's thoughts when he wrote: "Young musicians, once and for all, will stop being vile imitators of the past that no longer have a reason for existing and imitators of the venal flatterers of the public's base taste."<sup>9</sup>

Futurist composers concentrated on expanding the variety of timbres used in music. Bringing untraditional sounds into the concert hall required the building of new instruments and the innovative usage of conventional ones. The painter Luigi Russolo was the most renowned of the instrument builders. As Russolo said,

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<sup>9</sup> David Ernst, The Evolution of Electronic Music (New York: Schirmer Books, 1977), p. xxiv.



"Futurist musicians must constantly broaden and enrich the field of sound."<sup>10</sup> He constructed noise intoners, or *intonarumori*, which were wooden boxes containing motors and mechanisms that created a variety of clanking, hissing, buzzing and humming sounds. The sounds were amplified acoustically with megaphones protruding from the boxes. Russolo's contraptions were premiered in Milan in 1913 at the Concert of Noises. Another instrument, his *psofamoni*, built in 1926, was a keyboard-controlled instrument which imitated sounds of animals and nature. By composing for these instruments, music was being conceived and performed which was no longer based on a definite pitch system. As a result, the concepts of consonance and dissonance were deemed invalid; all sounds and their combinations with others were considered equally pertinent. The same attitude would be found at the heart of the electronic and percussion music movements of the twentieth century.

Although there is no direct link between Futurism and electronic music, late experiments and works produced by Marinetti foreshadow the work of Pierre Schaeffer, the developer of *musique concrete*. Marinetti used the phonograph to record his noise music and composers such as Paul Hindemith, Darius Milhaud and Ernst Toch experimented with the variable speed turntable and wrote music for it.<sup>11</sup> Schaeffer also would rely on the phonograph to

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<sup>10</sup>Luigi Russolo, "The Art of Noise," trans. by Stephen Somervall in Music Since 1900, ed. Nicolas Slonimsky (NY: Scribner's Sons, 1971), p. 1301.

<sup>11</sup>Ernst, p. xxiv.

produce his early works. Marinetti's I Silenzi Parlano fra di Loro was one of five works performed on the radio between 1930 and 1937. In it, isolated sounds of found objects (a motor, a baby's cry, "oooo's" from a small girl) and conventional instruments (flute trumpet, piano) were mixed with periods of silence up to forty seconds (pre-dating John Cage's 4'33" by 30 years). Other innovative ideas which later composers would use can be found in The Futurist Radiophonic Theatre (1933) written by Marinetti and Pina Masnata. In it, amplification of inaudible sounds and amplification of the "vibrations from living beings" were discussed as being possible sources for musical material.<sup>12</sup> The electro-acoustic composers of later decades would continue the search for new sounds begun by the Futurists.

During the first years of the First World War, a group of artists met at the Cabaret Voltaire in neutral Switzerland to begin an uprising in the arts. Calling themselves Dadaists, these artists devoted themselves to shocking the world into realizing the senselessness of the mass murdering taking place in Europe. "Form and sense, politics and morals, were to be razed to the ground; and something new, something pure and natural was to be created out of their basic elements."<sup>13</sup> Dadaism was not a movement but rather a outcry against all movements. The artists' sole means of battling the war machines was "nonsense--the weapon against sense imputed to

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<sup>12</sup>Ernst, p. xxv.

<sup>13</sup>Willy Verkauf, "Dada--Cause and Effect", Dada: Monograph of a Movement, Willy Verkauf, ed. (New York: St. Martin's Press, 1975), p. 7.

the war."<sup>14</sup> The Dadaists believed that their art would interrupt the social rhythms that had brought about wholesale murdering. Although painters and writers made up a majority of the Dadaists, the influence of Dadaism extended to music as well. The Dadaists' desire to do away with historical abstraction left only one concrete element in music: noise. Similar ideas appeared throughout Europe.

As with Futurist music, Dada music's emphasis was on timbral variety. Writer-poet-playwright Hugo Ball and his colleagues wrote incidental music to plays they had written which, ironically, resembled in many ways the music of the Futurists. The use of found objects and made instruments, a tendency towards primitivism (Bruitisme as it was called, an idea taken from the Futurists), and the rejection of traditional form and symmetry were characteristics of Dada music. Ball's poems exhibited his interest in timbre. They were made up of sequences of syllables "devoid of sense or content, freed from any symbolic meaning, nothing but audible material,"<sup>15</sup> as in the following example from "Flight from Time":

gadji beri bimba  
 glandridi lauli loni cadori  
 gadjama bim beri glassala  
 glandrid glasala tuffm i simbrabim

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<sup>14</sup>Verkauf, p. 8.

<sup>15</sup>Rudolf Klein and Kurt Blaukopf, "Dada and Music", Dada: Monograph of a Movement, Willy Verkauf, ed. (New York: St. Martin's Press, 1975), p. 54.

blass galassasa tuffm i simbrabim<sup>16</sup>

"Gadji beri bimba" (above) is an example of a "sound" poem, one of three types of poetry associated with Dadaism. The second, "simultaneous" poems, were multilingual readings of poems. Interestingly, "simultaneous" poems read at the Cabaret Voltaire were said to have been accompanied by whistles, drums and bells. "Chance" poems, the third type, were invented by the artist Tristan Tzara and first appeared in 1919. They consisted of random placement of words cut out of newspaper articles.<sup>17</sup> Years later, composers like Pierre Schaeffer, Pierre Henry, Luciano Berio, John Cage and Karlheinz Stockhausen would treat texts in similar ways. Cage would become famous for his use of chance operations in his music.

The Bauhaus was founded by the German architect Walter Gropius in 1919. Consisting mostly of visual artists, the Bauhaus nevertheless provided a testing ground for experimentation with music used in the group's theatrical productions. Significantly, percussion instruments and electronics were frequently used. Phonograph recorders and electronic instruments of some sort (probably a Theremin or other oscillator-based sound source) were used in Oskar Schlemmer's Man and Art Figure (1924). Mention is made of "technological equipment" which "by means of various kinds

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<sup>16</sup>*Op. cit.*

<sup>17</sup>Ernst, p. xxx.

. . . is now capable of replacing the sound of the musical instruments and the human or of detaching it from its source." Noisemakers, sound effects, sirens and modified conventional instruments were called for in Moholy-Nagy's Mechanized Eccentric of 1924. Music was used to accompany the 1925 reflected-light pieces of Ludwig Hirschfield-Mack. Schlemmer's Gesture Dance (1927) calls for piano, gong, timpani and a phonograph recording of a fanfare.

Compositional styles evolved from many of the ideas of the Futurists, Dadaists and Bauhaus artists. The infinite variety of everyday sounds, as well as newly discovered sounds, became musical material. Timbre took on unprecedented significance in compositions. Western harmonic traditions were avoided. Definite pitch was de-emphasized. Dance-derived rhythms were often avoided. New instruments to increase composers' and performers' versatility and control were discovered or designed and built. Electronic instruments began to appear. The climate of change led to great advances in the field of percussion and the creation of the electro-acoustic medium.

As a result of the increased interest in percussion, several orchestral works were written which required oversized percussion sections and highlighted instruments which had rarely been emphasized in a soloistic manner. In his ballet work Le Sacre du Printemps (1913), Igor Stravinsky found the percussion section to be useful in conjuring a primitive atmosphere for the work. Timpani, bass drum and tam-tam are used in a bombastic manner. Three

other dance works The Firebird (1910), Petrouchka (1911) and Les Noces (1917) (which calls for 4 performers on timpani, xylophone, 2 crotales, bells, side drum, 2 tambours, tambourine, bass drum, cymbal and triangle), and his opera Renard (1917) also have significant percussion parts. In a manner similar to that used by Stravinsky in Le Sacre du Printemps, Darius Milhaud created a primitive aura in his opera Les Choréophores (1915-1916) by writing for a huge percussion section: cymbals, triangle, metal castanets, wood castanets, ratchet, whip, tambour de basque, tambourin provençal, military drum, snare drum, tom-tom, two bass drums, wind machine, hammer, sleighbells and timpani. The section plays several solo passages and on three occasions alone provides the accompaniment for a solo voice.<sup>18</sup>

It was Stravinsky and Milhaud who also integrated American jazz into their music. About his encounter with Harlem jazz in 1922, Milhaud stated, "Its effect on me was so overwhelming that I could not tear myself away."<sup>19</sup> Consequently, the jazz drummer's instruments and melodic style of playing were incorporated into European compositions such as Stravinsky's L'histoire du Soldat (1918) and Milhaud's La Creation du Monde (1923). Their writing for the "complicated percussion section played by one man"<sup>20</sup>

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<sup>18</sup>Darius Milhaud, Notes Without Music (New York: Alfred a Knopf, 1953), pp. 66-67.

<sup>19</sup>Milhaud, p. 137.

<sup>20</sup>*Op. cit.*

introduced the multiple percussionist to the serious chamber ensemble. Stravinsky's work "is the first known work to include soloistic multi-percussion passages in which important musical material is scored for percussion alone and in combination with other players."<sup>21</sup> Using the same style and practically the same set-up, Milhaud would produce the first concerto for a solo percussionist: the Concerto for Percussion and Small Orchestra written in 1929-1930.

Another consideration in the development of compositional styles that lent themselves to increased use of percussion and electronics was the expansion of dissonance which took place at the beginning of the century. Composers such as Richard Strauss and Alexander Scriabin stretched the limits of functional harmony to an unprecedented level. The early work of Arnold Schoenberg, though rooted in a Germanic tradition of counterpoint and formal schemes, significantly increased the level of dissonance. Referred to as atonal writing (though he preferred the term "pantonal") he built his tonal plateaus on a foundation of dissonance. He was faced with the dilemma, however, of not having a system on which to build his musical structures. After years of development, he presented his first twelve-tone work Five Pieces for Piano, Opus 22 in 1923. The

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<sup>21</sup>Terry Lee Applebaum. "A Comprehensive Performance Project in Percussion Literature With An Essay Comprised of Multi-percussion performance Problems As Found In Selected Contemporary Works, With Original Etudes Relevant To Those Problems" (D.M.A. Thesis, University of Iowa, 1978), p. 6.

system allowed him to group the twelve pitches of the octave into rows which in turn were manipulated in a multitude of ways. The twelve-tone technique liberated composers from the tonal conventions of the past and allowed them to explore completely new ways of writing music.

An important outcome of the system was that it was ideally suited for instrumental music. Twelve-tone music " . . . offered the means by which a return to instrumental composition was possible, for it was an organization granting logic, coherence and unity."<sup>22</sup> Whereas his early atonal style was well suited for vocal music (due to the pre-existing structure of the text) the twelve-tone system allowed Schoenberg to concentrate on the instrumental medium. The significance to percussion of this new method of composing will be seen in the music of composers such as Anton Webern, Olivier Messiaen, Luciano Berio and Karlheinz Stockhausen who would adapt Schoenberg's pantonal style to their own compositional approaches.

During the early twentieth century many electronic musical instruments also began to appear. Thaddeus Cahill patented his Telharmonium in 1896. Four hundred eight rheotomes (elementary alternators) were to be integrated into a system which would create the fundamentals and partials of 84 chromatic notes (7 octaves). It was to be polyphonic, equipped with touch-sensitive keys, capable of controlling the envelope of each sound, and capable of transmitting

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<sup>22</sup>Griffiths, p. 91.



sound over telephone wires. A smaller version of the original plan was completed in 1906. Cahill incorporated his company, the Cahill Telharmonium Co., with the intent of providing an electronic music service for commercial subscribers. Stores along Broadway in New York City were recruited so that this early form of muzak could be provided for their customers. However, interference with normal telephone traffic and technical problems with the instrument itself led to the failure of his company in 1911.

A significant development during this time was the invention of the vacuum tube by Lee De Forest in 1906, the same year that Mahler's Symphony No. 6, a landmark work in the symphonic literature for percussion, was premiered. The vacuum tube allowed for precise control of an electrical current. It could be used for generation, modulation, amplification and detection of current and would become the main component of music-producing devices until the introduction of solid state circuitry in 1948. In 1915, De Forest invented what would become the main sound producing element of the classical electronic studio and the synthesizer: the oscillator. Oscillators were used by the Russian scientist Leon Theremin in developing his electronic instrument, the theremin, in 1920. It used oscillators as sound sources with frequency and amplitude controlled by the proximity of the operator's hand to an antenna protruding from the instrument. As the operator's hand entered the electromagnetic field of the antenna the frequency of the oscillator would vary. A secondary loop antenna or foot pedal was later

incorporated to control the volume. The first public performances of the theremin in the West were given in 1927.

A similar instrument was developed by Maurice Martenot in 1928. Called the ondes martenot, it used a metal ribbon instead of an antenna as a pitch controller. A metal ring attached to the player's index finger was run across the ribbon to change the frequency of a variable capacitor. The left hand controlled volume with a pressure-sensitive key and timbre by depression of expression keys which controlled a filtering device. It was monophonic, had a seven octave range and was portable. Martenot's intent was to build an instrument which could join the ranks of the traditional instruments of the concert hall. Many pieces would be written for the ondes martenot such as Dimitri Levidis' Symphonic Poem for Solo Ondes Martenot and Orchestra of 1928 (which Stokowski brought to the United States for a performance the same year) and works by Darius Milhaud, Arthur Honegger, and Olivier Messiaen.

1930-1960

Although Schoenberg can be considered the composer who took the first significant step towards a new music, he left one foot firmly planted in the past. He emphasized that his music was the continuance of an old tradition, not the beginnings of a new one. He emphasized that " . . . one uses the series and composes as before . . .

as the great Austro-German composers have always done."<sup>23</sup> The composer who would take Schoenberg's theories and use them as a catalyst toward the development of a totally new musical approach was his student Anton Webern. In his work, Webern used twelve-tone technique in a very clear, economical way resulting in a compositional style of thin texture and clear structure. He developed the concept of klangfarbenmelodie in which the coloristic qualities of the instruments would be used in a melodic way, that is to say, the concept of melody was expanded to include a parameter other than pitch. The increased interest in timbral capabilities and experimentation with combinations of new sounds led to increased interest in percussion.

Some of the significant percussion composers of the middle twentieth century have a background in the study of an instrument which also exemplified a vast repertoire of coloristic possibilities: the organ. Edgard Varése and Olivier Messiaen, two composers who would have significant impacts on the repertoire of percussion, had studied with organists--Varése with Charles Marie Widor and Messiaen with Marcel Dupré. It can be conjectured that the emphasis placed on the coloristic aspect of composing for organ influenced their instrumental writing. Varése would later write the first percussion ensemble and become an electronic music pioneer

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<sup>23</sup>Griffiths, p. 89.

while Messiaen would elevate timbre to a status equal to that of the other parameters.

Many ideas were spawned in the 1930s which led to the development and use of new instruments, increased expectations of percussionists and increased interest in electronic music. Edgard Varèse wrote Ionisation for thirteen percussionists in 1931. He was one of the first composers to isolate the percussion section from the western orchestra and give it its own medium: the percussion ensemble. He blended traditional instruments with the unusual. Along with the typical bass drum, snare drum, cymbals, tambourine and triangle he included parts for lion's roar, sirens, guiro, cowbells and slapstick. He utilized non-pitched instruments of the percussion family to create a wash of rhythm--a meshing of contrasting material in a polyphonic style with the emphasis placed on rhythmic ideas rather than melodic ones. Ionisation marks the beginning of the literature for percussion ensemble. The work exemplifies the compositional focus on restructuring the musical hierarchy, or more precisely, tearing away the confines of traditional hierarchies and redefining the aesthetic principles of music. Instrument innovations and technological advances encouraged this attitude.

In no one's music can this be more clearly seen than in that of John Cage. During the period from 1935 to 1942 Cage wrote numerous works for percussion. Quartet (1935) and Trio (1936) are two of his earliest. First Construction in Metal from 1937 uses rhythm ideas similar to Indian tala. Imaginary Landscape No. 1

(1939) can be considered the first piece written specifically for the recorded medium using a variable speed phonograph playing two RCA Victor test records, the interior of a piano and a large Chinese cymbal. Imaginary Landscape No. 2 (1942) is written for percussion quintet and calls for instruments such as an amplified wire coil. Imaginary Landscape No. 3 (1942) is scored for instruments such as an electric oscillator, tin cans, buzzers of various frequencies, a Balinese gong, generator whine, amplified wire coil, and amplified marimbula. Amores (1943) is scored for percussion trio and prepared piano, another of Cage's innovations.

Many other composers were also looking for new sounds in their percussion works. William Russell's Fugue for Eight Percussion Instruments (1933) calls for striking on the timpani bowls, glissandi on the xylophone resonators and rubbing a resined glove over a snare stick held on center of the bass drum. Innovations can also be seen in his Three Dance Movements (1933) which calls for ginger ale bottle, dinner bells, dinner fork pizzicato on piano strings, sFFFz bottle break, saw drawn across a Turkish cymbal, rim strike on bass drum, and a board used to play black and white keys on the piano. Amadeo Roldan's Ritmicas No. 4 and No. 5 were written the same year as Varése's Ionisation. Orchestrated for traditional Cuban instruments, Roldan created a thick texture of Latin derived rhythms. As with much of the early music of Cage and his colleague Lou Harrison, Henry Cowell's Ostinato Pianissimo from 1935, with the exception of the fast-moving xylophone part, was written for

amateurs. Other significant composers of percussion ensemble pieces from the thirties were José Ardéval, John Becker and Johanna M. Beyer.<sup>24</sup>

Innovative use of percussion also appeared in orchestral and chamber music settings during the thirties. Not only did Alban Berg introduce the marimba to the orchestra, he was the first composer to call for the vibraphone, in Lulu written in 1935. Orchestral works such as Carl Orff's Carmina Burana (1936) appeared with oversized percussion sections. Bela Bartok's massive Sonata for Two Pianos and Percussion (1937) requires two percussionists to participate in a mixed chamber setting in an unprecedented way. Each percussionist must play numerous instruments. The timpani are treated in a melodic manner and are required to change pitches constantly. Lejaren Hiller would draw material from this work in Machine Music.

The 1930s were also important for the development of electronic music. In 1931, Henry Cowell, a composer who had a great influence on the percussion field, asked Leon Theremin to build a keyboard device which allowed the continuous repetition of any selected note. Pitch, duration and tempo of the selected notes were variable. By depressing more than one key, multiple notes and rhythms could be played. Like a modern sequencer, a series of notes could be programmed. Called a rhythmicon, Cowell used it in several pieces during the 1930s. He used it to illustrate the relationship of

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<sup>24</sup>Larry Vanlandingham, The Percussion Ensemble: 1930-1945 (Ph.D. Thesis, Florida State University, 1971) pp. 37-41.

pitch intervals with their rhythmic equivalent. For example, an interval of a fifth having a relationship of 3:2 would be articulated with a polyrhythm of the same ratio, the upper note of the interval being repeated at a 3:2 rate faster than the lower note. Lou Harrison would use the same relationships to determine the speed of theme restatements in his percussion ensemble work Fugue (1942).

Edgard Varése also asked Theremin to build an electronic instrument for him in the early 1930s. Varése wanted two extended range keyboard activated instruments for his chamber work Equatorial. They were obviously never built since ondes martenot are asked for in the published score.<sup>25</sup> Varése's and Cowell's interest in both percussion and electronics illustrates the growing influence both mediums were having on compositional output in the early twentieth century.

In 1931, Fred Troutwein expanded on the ondes martenot concept with his Trautonium. It consisted of an electronic keyboard made of touch sensitive plates. It was similar in design to the ondes martenot but produced a rich sawtooth wave which could be filtered. It allowed for programming of timbre and pitch making it ideal for tone row compositions and the use of microtones. Paul Hindemith learned how to play the instrument and wrote his Concertino for Trautonium and String Orchestra in 1931. Trautwein would later

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<sup>25</sup>Thomas Holmes, Electronic and Experimental Music. (New York: Charles Scribner's Sons, 1985), pp. 44-45.

design the monochord for the Cologne electronic music studio in the 1950s.

The first tape recorder, called the magnetophone, was invented in 1935. The German scientist Pfleumer experimented with iron-oxide-coated paper and plastic tape as a recording medium in the early 1930s. The Allgemeine Electricitäts Gesellschaft (AEG) bought all the rights to Pfleumer's work and introduced the magnetophone at the German Annual Radio Exposition in Berlin in 1935. The same year, Bell Laboratories introduced the mirrorphone which used steel tape as the recording medium. Following World War II the magnetophone design became very popular due to the enormous savings made using oxide-coated tape rather than solid steel wire or tape. All rights to the design were transferred to the United States as a result of alien property custodial rights. The American companies Magnecord, Rangertone and Ampex adapted the design and produced tape recorders which would become widely available by the end of the 1940s. At the same time, Minnesota Mining and Manufacturing (3M) began manufacturing a higher quality recording tape.

The 1930s produced many revolutionary instruments and compositional styles: the first percussion ensemble, early use of a recorded medium in performance, production of several electronic musical instruments, the infusion of large percussion sections into orchestral works and demanding parts written for percussionists in chamber settings. Advances continued in the 1940s and 50s.



In 1948, Pierre Schaeffer and Pierre Henry began using tape recorders, instead of phonographs, to produce their musique concrete works. Three years later, French National Radio sponsored the development of an electronic studio for them to produce their music. Percussion instruments were involved from the beginning. Because percussion instruments offered a wide spectrum of timbral variations and were separated from the cultural connotations associated with other instruments, Schaeffer and Henry used recordings of percussion instruments as source material for many of their compositions. Schaeffer's first experiment at the French National Radio studios used a bell as a sound source which was subsequently manipulated. "He divided a prerecorded bell sound into two parts . . . the first was recognizable as a bell, while the second sounded more like an organ or wind instrument."<sup>26</sup> Schaeffer's Etude aux tourniquets used recorded xylophone, bells, toy whistling tops and variable speed phonographs. Pierre Henry's Tam-Tam IV used wooden and metallic sounds along with a piano and his Antiphoniae used metallic percussion instruments as sources. Otto Luening and Vladimir Ussachevsky would also rely on percussion instruments for sound sources at the Columbia-Princeton studio in the fifties in works such as Piece for Tape Recorder (1956) and Metamorphosis (1957). Also in 1948, Bell Laboratories introduced the transistor. These miniature, solid-state components could more

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<sup>26</sup>Ernst, p. 19.

efficiently do all the things the vacuum tube had done. The transistor would be at the heart of the synthesizer systems which would become popular in the 1960s.

In the early 1950s a new genre of electronic music was developed in Germany. Engineer Robert Beyer, composer H. Eimert and physicist W. Meyer-Eppler relied entirely on electronic means to create their music rather than using the musique concrete approach of manipulation of acoustic sounds. Following a concert of their music given on Oct. 18, 1951, they received funding to build a studio at the West German Radio station in Cologne. The studio consisted of audio testing equipment adapted for use as sound sources and processing devices, a monochord which was an updated version of Fred Trautwein's trautionium, a double keyboard instrument called a melochord which allowed for two notes to sound simultaneously, a mixing console, and tape recorders including a four-track machine. By 1957, four-channel works were being produced at the Cologne studio while many studios were still integrating the two-track machines into their systems. Many composers in Cologne were devoted to a high order of organization and the electronic medium made it possible to achieve a high quality performance. Composers accurately realized serially-controlled parameters such as dynamics, articulation and rhythm. In 1953, Eimert stepped down and Karlheinz Stockhausen became director of the Cologne studio. He, too, would have a great impact on the percussion field.

In contrast to the European activities were the musical endeavors of several composers in New York. In 1951, John Cage along with Earle Brown, Morton Feldman, Christian Wolff and David Tudor organized the Project of Music for Magnetic Tape. Using chance operations resembling the techniques used by Dada poets such as Tristan Tzara, Cage constructed pieces which combined material from a variety of sources. Imaginary Landscape No. 5, which drew sounds from 42 phonograph records, and Williams Mix, which took nine months to assemble, date from 1952. Also in 1952, Cage began using chance operations to form multi-media compositions. Precursors to the "happenings" of the 1960s were presented at Black Mountain College. Live music, phonograph recordings, poetry reading, dance, lectures, films and slides were simultaneously presented without apparent coordination. Cage's work exemplifies the expanded interest in percussion and electronics.

Further expansion of the percussion field during the 1940s and 50s can be seen in orchestral works such as Paul Hindemith's Symphonic Metamorphoses (1943) and Darius Milhaud's Concerto for Marimba and Vibraphone (transcribed in 1947 from his Suite for Piano and Orchestra). The literature for percussion ensemble expanded with the composition of works such as Carlos Chavez's Toccatà (1942) and Tambuco (1964). Significantly, Chavez was one of the composers who had made prophesies regarding the future of electronic music. The fact that he was also important to the area of

percussion shows a connection between the two genres and their compatibility with the new approaches to music.

Other significant percussion composers of the 1950s were Warren Benson who wrote Trio for Percussion, Three Pieces for Percussion Quartet, Variations on Handmade Theme and Streams, and Ginastera, whose massive work Cantata para America Magica calls for a dramatic soprano to be accompanied by 53 percussion instruments. In Ginastera's work, serial techniques were employed to determine pitches, intensities, dynamics, rhythms and densities. Similar approaches by Karlheinz Stockhausen and Luciano Berio led to the writing of significant works for both percussion and electronics.

Based on scientific theory and his studies with Olivier Messiaen, Karlheinz Stockhausen developed an approach to composition which resulted in extensive use of percussion. Messiaen is credited with being the first composer to utilize serial technique to control multiple parameter in his 1949 piano work Mode de valeurs et d'intensities. Rows of pitch, duration, attack and intensity values were serially manipulated. No hierarchy of musical elements exists in this piece as each element's role is calculated and then combined with the others.

Stockhausen also experimented with independent control of musical parameters. He approached the four constituents of music--pitch, timbre, rhythm and form--as derivatives of the same phenomena: vibration. Two of the basic ideas of his time-duration

theory are that a pitch is a series of impulses lasting from one-sixteenth to one-six thousandth of a second while a duration is a series of impulses lasting from eight seconds to one-sixteenth of a second. As a consequence, he was able to create timbres, pitches and rhythms using only a pulse generator. The reliance on series of pulses as source material for his electronic piece Kontakte (1959-60) made the use of percussion and piano for the second version appropriate. The addition of "known" sounds gives the listener an orientation to the aural experience.<sup>27</sup> His writing for the combination of piano and percussion comes from his research of Bartok's Sonata for Two Pianos and Percussion (1937). In studying the work at the Musikhochschule in Cologne (writing over a hundred pages) he examined Bartok's use of the various percussion sonorities. Furthermore, Stockhausen analyzed the acoustical properties of the different instruments giving him a basis on which to relate the percussion sounds to the sounds he produced in the electronic studio. He divided the instruments in Kontakte into six categories: metal sound, metal noise, skin sound, skin noise, wood sound and wood noise. Throughout the work, the instrumental sounds are transformed by the tape, that is, the tape frequently provides a bridge from one instrumental sonority to the next. Each category of

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<sup>27</sup>Jonathan Harvey, The Music of Stockhausen (Berkeley: University of California, 1975), p. 13.

instrumental sound is transformed into the other and each known sound is transformed into previously unknown sounds.<sup>28</sup>

As did his percussion solo Zyklus written in 1955, Kontakte became a landmark in the literature for percussion. Through careful analysis of the timbral characteristics of the percussion instruments, electronic tape and acoustic instruments were integrated into a coherent whole. This is far removed from the extramusical sound effects which had been the main function for the percussionist up to the twentieth century.

The practice of combining taped electronic music and live performers began in the 1950s. Many of these works involved percussion. The first use of electronic sounds and live performers actually dates to the time of the phonograph recordings in orchestral settings, the Bauhaus productions and the work of Boisselot who used ondes martenot and oscillators along with conventional ensembles beginning in 1944. The first piece for electronic tape and live performers was Bruno Maderna's Musica su due dimensioni for flute, cymbals and tape (1952). Cymbals, gongs and tam-tams were frequently used by musique concrete composers since many of the sounds created by electronic means resembled those percussion instruments. Ring modulation can create sounds which resemble the enharmonic overtones of gongs and cymbals. Filtered white noise can be manipulated to resemble the sound of cymbals and tam-tams.

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<sup>28</sup>Storm Bull, questionnaire answered by Karlheinz Stockhausen (University of Colorado, 1962).

Varèse's Deserts (1949-54) was another early piece to involve live performers and electronic tape. In this work, the ensemble and tape do not interact, but alternate sections. Otto Luening's Theatre Piece No. 2 from 1956 calls for soprano, narrator, percussion and wind instruments to be accompanied by tape.

The University of Illinois at Urbana-Champaign was a significant center for percussion and electronic music in the fifties. It was the first school in the United States to offer credit for a percussion ensemble class. Under the direction of Paul Price, the program prospered with recordings, commissions and numerous performances of works written for the percussion solo and ensemble mediums. Resident composers, such as Michael Colgrass, Harold Farberman, Salvatore Martirano and Herbert Brün, wrote many of the works Illinois percussion students performed. Colgrass wrote Three Brothers, Percussion Music and Chamber Piece for Percussion Quintet. He is noted for his emphasis on the exploitation of timbral possibilities of the various instruments, including use of differing mallets, fingers, wire brushes and playing on different areas of the instrument such as the center and edge of the snare drum head. Farberman wrote works such as Evolution and Music for Percussion. Salvatore Martirano's landmark work Underworld (1965) is scored for tenor saxophone, two string basses, four percussionists and tape. Herbert Brün also wrote significant parts for percussion in his chamber works. Price was responsible for significantly expanding the percussion literature and creating a college curriculum which

allowed students to major in percussion performance--one of the first state university programs in the United States to do so.

Another innovative program which began at the University of Illinois in the 1950s was the electronic music studio. Developed by Lejaren Hiller beginning in 1957, the electronic music studio was the first to be recognized by a university and the first to produce compositions as a university studio. The correspondence of circumstances at the University of Illinois brought the two mediums together; an active percussion program and young electronic music program interacted to create works that included both.

As has been seen, electronic music and the percussion media interacted throughout the twentieth century. Several circumstances account for this:

- 1) Both mediums were relatively new in the twentieth century. Although percussion instruments had been a part of western musical heritage for hundreds of years, most of their uses were reflective of associations with non-symphonic traditions and extramusical elements (i.e., military band connotations, sound effects, novelty). The need for sonorities which defied historical association led composers to use electronic techniques and instruments, as well as percussion. The unusual percussion instruments which began to appear at the beginning of the twentieth century especially lent themselves to this purpose, for no historical context existed for them.
- 2) Percussionists had at their disposal a vast array of timbral possibilities as did electronic composers. The number of available



sonorities continues to expand in both areas. No other instrumental family can be said to have as broad a timbral spectrum.

3) The complex timbre of many percussion instruments allowed composers to draw from them numerous sonorities. Composers manipulated them using conventional tape techniques such as tape reversal, speed variation and filtering.

4) The percussion instrument family is the only one which includes non-pitched instruments. Sounds from cymbals, tam-tams, snare drums, scrapers and shakers all consist of nonharmonic tones and bands of white noise which could be narrowed by use of filters to create a large library of potential "instruments" or could be used to match the white-noise-generated electronic sounds. Low frequency thuds could be mimicked by low drums. Similarly, percussive pitched sounds could be matched by the keyboard percussion instruments and timpani.

5) The natural resonance and nonhuman quality of percussion instruments made them similar to the early sounds being created by electronic means. Whereas the voice, wind, and stringed instruments make use of subtle pitch nuances and complex expressive adjustments, percussion and electronic sounds are purer in nature. As a result, imitation and adaptation was easier. "The innate resonant qualities of piano and percussion instruments, in addition to

the enharmonic overtone structure of gongs and cymbals, have attracted electronic composers since 1948."<sup>29</sup>

The areas of percussion composition and electronic music have run along seemingly parallel paths--pedal timpani and mallet keyboard instruments appeared around the time of Edison's invention of the phonograph, Cahill's Telharmonium was built around the same time that Stravinsky was writing his early orchestral works, the invention of the tape recorder coincide with the early percussion compositions of Edgard Varése and John Cage, college percussion programs started at the same time that electronic music studios did, the first computer music was being generated at the same time that Stockhausen and Berio were writing their works for multiple percussion. The interaction between the two mediums led to the composition of works which utilized the strengths of both. One example is Lejaren Hiller's Machine Music for Piano, Percussion and Tape Recorder which can be seen as a culmination of the developments taking place in electronic and percussion music.

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<sup>29</sup>Ernst, p. 136.

## CHAPTER 2

### LEJAREN HILLER

Lejaren Arthur Hiller was born on February 23, 1924 in New York City. At an early age he developed interests in both science and music. His music studies began with Harvey Officer who gave lessons in harmony, counterpoint and piano. One childhood experience which foreshadows his interest in musical automation was cutting designs in player piano rolls to produce compositions. He composed a few works in high school, even writing the graduation march for his class.

Hiller's main interest was chemistry, however, and this led him to Princeton as a chemistry major with minors in electrical engineering and music. He was enthusiastic about his music studies. As a freshman, Hiller entered into the sophomore class in strict counterpoint with Milton Babbitt. It was with Babbitt that he had his first serious musical training. He later moved into Roger Sessions' classes in elementary composition and analysis.

Hiller was very involved in the music program when Sessions left for Berkeley in 1945. Sessions urged him to follow but Hiller stayed at Princeton to continue his studies in chemistry. Following his work with Sessions, Hiller was basically self-taught. The only other teacher he had was Hubert Kessler at the University of Illinois

in the mid-1950s. As a graduate student at Princeton, he was a teaching assistant for one year and then a research assistant in the newly formed Textile Research Institute. It was then that he began working in cellulose chemistry which eventually led to his doctoral dissertation. He received his M.A. in 1946 and his Ph.D. in 1947.

After graduating from Princeton, Hiller worked for E. I. duPont de Nemours in Waynesboro, Virginia. From 1947 to 1952 he was a research chemist working in the areas of cellulose, polymer and dye chemistry. He published a number of research articles, a chemistry method book, and had some patents including a significant one which allowed for dyeing of acrylic materials like orlon.<sup>1</sup>

Hiller left duPont in 1952, travelled extensively in Europe, then took a position at the University of Illinois in Champaign-Urbana as a research associate in physical chemistry. He later became an assistant professor in inorganic chemistry. In 1955 he had his first exposure to computers while working at the graduate college's Digital Computer Laboratory. Computers were being used as research tools, well-suited for solving the theoretical problems in which the laboratory program was involved. That same year, he and fellow chemist Leonard Isaacson developed the notion of using a computer to compose music. The project fit into the objectives of the computer laboratory since research of all types was encouraged. The projects which ensued changed the course of Hiller's life.

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<sup>1</sup>Cole Gagne and Tracy Caras, Soundpieces: Interviews with American Composers. (Metuchen, N.J.: The Scarecrow Press, 1982), p. 234.

In order to write a music-writing program, the actual process of composition had to be defined in such a way that a computer could reproduce it. The work which was undertaken gives insight into Hiller's personal compositional approach: the treatment of music as a language, fascination with the analogies of mathematics and music, concentration on structure, struggle with the questions of aesthetics in contemporary music, and use of a variety of musical styles for source material in his work. In his book Experimental Music, co-written with collaborator Isaacson, the procedures undertaken in the research and the development of their music writing program are documented. In addition to the technical procedures involved with programming a computer to compose, fundamental questions regarding musical aesthetics and perceptions were addressed. They found that the computer could be used to compose because it could be instructed to operate in much the same way as a human composer. Since composition could be considered a task which creates order out of a multitude of possible choices, Hiller and Isaacson believed that if the codified rules of composition from various style periods were subject to computer generation, works could be produced which possessed the same qualities as those produced by a composer. Because the rules of well-known styles, such as cantus firmus technique and 16th century polyphony, were codified, they could be approached like a language, allowing them to be subjected to computer control.

The undertaking was complex on several levels. Fundamental questions arose concerning "the nature of musical communication and its relation to formal musical structures. Moreover, it also raised the question of how far it is possible to express musical and aesthetic principles in forms suitable for computer processing . . . .It also brings up the problem of what role automation of the type exemplified by high-speed digital computers can be expected to fulfill in the creative arts."<sup>2</sup> To create a working premise, Hiller and Isaacson researched the writings of music scholars and composers such as Hans Tischler, Susanne Langer, E. Hanslick, Leonard B. Meyer and Igor Stravinsky. Issues such as emotional versus intellectual content, literal versus symbolic meaning, internal versus external relationships and musical meaning and experience as they relate to form were addressed.

Also, two significant elements were distinguished: what does music communicate and how is it organized to be effective. A starting point for their work defined music as "the logical expression of inward mental and emotional states."<sup>3</sup> From there, Hiller and Isaacson set out to give the computer guidelines so that its choices were appropriate for the particular style of composition that was being produced. They also programmed the computer to produce

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<sup>2</sup>Lejaren Hiller and Leonard Isaacson. Experimental Music: Composition with an Electronic Computer, (New York: McGraw-Hill Co., Inc., 1959), p. 1.

<sup>3</sup>*Ibid.*, p. 16.

works of a completely different nature using contemporary methods such as twelve-tone technique and probability and information theories.

To further define the computer's role in the music composing process, they cited Tischler's definitions of the two types of relationships: internal and external. Internal relationships deal with the medium itself. In music, rhythm, melody, counterpoint, tone color, expression and form (or contour) are the basic parameters used. The computer is well-suited for the manufacturing and manipulation of these internal relationships. The data can be treated as self-contained, that is, independent from external relationships, allowing a computer to deal with the internal parameters apart from their traditional relationship to the musical experience. Tischler describes external relationships as those which are "true of all arts: gesture, program, ethics, technical mastery, psychological drives of the artist, function, relevant historical and sociological data and performance . . . . Separation of internal relationships from external relationships is extremely useful because it separates what we can find explicitly in a musical score from what we must read into a score in order to become aware of its more general referential significance."<sup>4</sup> Hiller would successfully integrate the technical with the musical in his work.

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<sup>4</sup>*Ibid.*, p. 15.

Furthermore, Hiller and Isaacson concluded that musical memory and instantaneous perception were significant aspects of musical experience. Both are required to understand musical structure.<sup>5</sup> Memory recall is at the root of the concepts of thematic repetition, thematic development, rhythmic repetition, and systematic structures such as sonata form, fugue and variation form. Hiller and Isaacson also referred to the concept of tonality as being a result of pitch recall. ". . . Specific pitches acquire significance because they are related, through specific intervals over a span of time, to a specific tonal center. It is these long-range intervallic relationships that require memory for their recognition and which are used to build up both small- and large-scale musical structures depending upon tonal coherence as an organizational principle."<sup>6</sup>

Hiller's concern with the perception of small and large structures is obvious in Machine Music. Palindrome and symmetry are used at the smallest and largest levels. "Musical coherence in a musical structure depends on the exploitation of memory as well as immediate sense perception. Recognition of this principle is essential in the understanding of how proper articulation is achieved in setting up musical structures."<sup>7</sup>

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<sup>5</sup>*Ibid.*, p. 20.

<sup>6</sup>*Ibid.*, p. 21.

<sup>7</sup>*Ibid.*, p. 22.



In their definitions of music, Hiller and Isaacson make three main observations. 1) Form is codifiable. Claims have even been made that "musical content is nothing but its form."<sup>8</sup> 2) Ordered sets of information are derived from vast possibilities using rules. Because choice from a chaotic wealth of material is involved, music can be studied using probability theory and information theory. The computer is well-suited for these types of operations. 3) The aural sensibility of a composer goes beyond technical rules; a computer must therefore be guided in its choices. Hiller and Isaacson used a generate-and-test procedure to produce music which complied with the established rules.

After their definitions were input into the ILLIAC I computer, the Illiac Suite for string quartet was produced in 1957. It was the first substantial work written with the assistance of a computer.<sup>9</sup> The work's four movements parallel the four experiments which were undertaken in their project. In fact, Hiller and Isaacson describe the work as a research record, not a work of art (though Hiller admitted in 1980 that even the Illiac Suite possessed a good

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<sup>8</sup>*Ibid.*, p. 2.

<sup>9</sup>Klein and Bolitho at the ElectroData Division of the Burroughs Corporation wrote Push-Button Bertha in 1956 using a random generation and test system similar to the one Hiller and Isaacson used on the Illiac, simple melodies were produced by a computer program developed by the team of Brooks, Hopkins, Neumann and Wright at Harvard University in 1957, and R. C. Pinkerton suggested the use of probability tables to write simple melodies in 1956. Hiller and Isaacson, p. 55-56.

deal of expressive content.<sup>10)</sup> All of the experiments utilized generate-and-test procedures to produce data. In the generate-and-test procedure, an integer is first randomly selected then tested against the rules of the musical style that was being used as a model. The integer chosen could be kept and used to build up a composition, or, it could be rejected requiring the generation of new data. If no integer chosen fulfilled the rules' requirements, the composition process had to start over. Once completed, the computer's alphanumeric printout was translated into musical notation and then scored for string quartet.

The first experiment used first-species counterpoint as a basis for a polyphonic setting. Hiller and Isaacson modelled the program on the style of Palestrina as described by Fux in his Gradus ad Parnassum of 1725. Choices had to conform to the sixteenth century rules of melodic succession and harmonic consonance. The second set out to produce cantus firmus settings that were technically proper. The movement begins with random orderings of seven tones which are then successively restrained to create four-part, note-against-note counterpoint. The third experiment applied contemporary techniques of chance operations and twelve-tone technique to determine pitch, rhythm and dynamic data. Interestingly, neither Babbitt or Sessions taught serial techniques in the classes Hiller

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<sup>10</sup>Gagne and Caras, p. 238.

attended at Princeton.<sup>11</sup> Contemporary music was not discussed in their classes. Hiller believed that the unpopularity of twelve-tone technique was responsible. More popular at that time was neo-classicism. As a result, he had to teach himself about serial composition techniques.

The fourth experiment departed from traditional compositional practice. Hiller and Isaacson describe the technique as one which makes use of ". . . sequences of events in which the choice of each new event can be made dependent on previous events, or, in musical terms, the choice of each new note or interval in a given melodic line can be dependent upon previous notes or intervals in the same melodic line."<sup>12</sup> Harmonic, intervallic and structural material was derived from a program which utilized theories described by Heinrich Schenker and Paul Hindemith. Both theories recognized the dependence of vertical structure on the harmonic series and of melody on stepwise motion. Hiller and Isaacson applied these theories by relating structurally important notes to previous pitches using a probability formula. The tonal texture varied as the probability weights were shifted, creating movement from chromatic to consonant textures. Markov chains were used to determine interval relationships between rhythmically strong notes,

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<sup>11</sup>"Almost everything I was told about dealt with Mozart or Beethoven" Contemporary music was not discussed in their classes. Hiller believed that the unpopularity of twelve-tone technique was responsible. More popular at that time was neo-classicism. Gagne and Caras, p. 233.

<sup>12</sup>Hiller and Isaacson, pp. 132-133.

rhythmically weak notes, and short- and long-range harmonic relationships.<sup>13</sup> The use of operations such as Markov chains and the concern with structure became characteristics of Hiller's later work. "In works of all types, Hiller lays out and applies a rigid structural principle, then overlays and even obscures it with unpredictable and fascinating detail."<sup>14</sup>

Hiller was introduced to analytical approaches of Schenker and Hindemith in the mid-1950s. While still a faculty member in the Illinois chemistry department, Hiller was studying music with Hubert Kessler who, in addition to composition, taught Schenkerian analysis. The exposure proved to be significant.

"I certainly was helped a great deal by being introduced to the Schenker theory of hierarchy in music. That clarified a lot of muddled thinking on my part. It permitted me to see beyond the tonal context of prolongation of the tonic chord, and made me aware of generative grammars (in terms of language structures) and eventually of information theory. I could see that the question of moving from order to disorder, back and forth, was really what a composer deals with. When you talk about such things as Leonard Meyers's theories of musical affect, you are really talking about order and disorder in the most broad and general sense: a person becomes more disturbed when the number of possibilities increase; disorder increases and you build tension, and then resolutions come when one arrives at more organized, more static situations. This is what

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<sup>13</sup>*Ibid.*, pp. 132-135.

<sup>14</sup>Charles Hamm, "Lejaren Hiller", Dictionary of Contemporary Music, ed., John Vinton, (New York: E. P. Dutton, 1974), p. 318.

causes the ebb and flow of drama in a piece. So I think that any element that can cause this to happen is fine."<sup>15</sup>

Hiller drew from many musical traditions to derive the basic material from which to work on a single composition. Whereas many composers are bound to a single stylistic approach, Hiller was not restrictive in his use of traditional styles. An example of his stylistic disunity can be seen in several works which have sections which hedge on tonality in an otherwise chromatic environment. He did not attempt to evaluate tonality as being good or bad but rather treated it as a controllable parameter, as one means of expressing order or disorder. The main use of order and disorder was to articulate structure. ". . . The degree of imposed order is itself a significant variable . . . . The . . . principle recognizes the contribution to a musical structure not only of order, but also the relative lack thereof, and even, in certain extreme cases, of the absence thereof, namely, chaos . . . ." <sup>16</sup> Disorder can be expressed with weak, indistinct shapes or unarticulated progression. Desires for and expectations of clarification are subsequently aroused. Hiller created order and disorder in numerous ways, such as tension and release schemes in a tonal setting and mathematically derived algorithms.

A characteristic of Hiller's compositional style is his free use of a variety of compositional approaches, sometimes combining them in a single work.

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<sup>15</sup>Gagne and Caras, pp. 243-44.

<sup>16</sup>Hiller and Isaacson, p. 16.

"My general approach is empirical and eclectic. Of course I don't mean that in the pejorative sense. I just assume that everything and anything can go into a piece if it is appropriate. So, for example, I'll write tonal music if I want to; I'll even insert key signatures if it is useful, something which some people regard as provocative . . . . I will use tonal elements when I think they're appropriate and embed them in a more general structure . . . . I . . . use tonal methods, serial methods, . . . chance methods, charts, mathematical formulas like Fibonacci series, eye music--you name it. And all of this with or without computers and electronics . . . . I try all of them in what you might call a total matrix of possibilities"<sup>17</sup>

He continued to compose while a member of the chemistry department but was frustrated with his isolation from the music mainstream and the lack of performances of his music. ". . . By the middle fifties I'd turned out quite a bit of music, but all as an avocation and none of it had ever been performed . . . . I became upset about the whole situation because music became more and more a compelling interest."<sup>18</sup> Even though he was over thirty years old at the time, the Illiac Suite would be Hiller's first complete work to be performed in public. "I wrote the Illiac Suite and that hit the headlines--quite literally. All of a sudden I went from a nobody to somebody who was actually on the front page of many newspapers--usually in the most absurd kind of news article, but nevertheless, it drew attention to me."

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<sup>17</sup>Gagne and Caras, p. 243.

<sup>18</sup>*Op. cit.*

The following year he went to the dean of the graduate school, Frederick Wall, expressed his displeasure with teaching chemistry, and proposed that he start an electronic music studio in the school of music. After discussions with the music director in the summer of 1958, Hiller was brought in to teach a course in musical acoustics. At the same time, relying on his background in electrical engineering, he began building an electronic music studio in a house across the street from the music building. It was only the second such studio to be built in the United States (Ussachevsky's and Luening's being the other). In the same year, Hiller completed his Masters degree in music.

Hiller went on to become director of the Experimental Music Studio and developed a cooperative research program in electronics, computers, music and acoustics. Significant works produced during this time were two Electronic Theater Fantasies (1959-60), Symphony No. 2 (1960), 7 Electronic Studies (1963) for electronic tape, Quartet No. 4 (1962), Computer Cantata (1963) for soprano, tape, and chamber ensemble composed in collaboration with A. Baker, Machine Music (1964) for piano, percussion and two-channel tape recorder, A Tryptich for Hieronymous (1966) for actors, dancers, acrobats, projections, tape, antiphonal instrumental groups, An Avalanche (1968) for pitchman, prima donna, player piano, percussionist and prerecorded tape with text by Frank Parman, HPSCHD (1968) for 1-7 harpsichords, 1-51 tapes, composed in collaboration with John Cage, and Computer Music (1968) for

percussion and tape written in collaboration with G. Allan O'Conner (a free transcription of strophes 1, 2 and 4 of Computer Cantata). In 1968, Hiller became the Frederick B. Slee Professor of Composition at the State University of New York at Buffalo and became co-director with Lukas Foss of the Center for Creative and Performing Arts in Buffalo. He was a senior Fulbright lecturer from 1973-74 in Poland and in Brazil in 1980.

Charles Hamm divides Hiller's output into three categories. The first he calls "abstract instrumental works" which date from his early years. Typically, these works are written in formal structures such as sonata-allegro, variation and passacaglia, reflecting Hiller's instruction with Babbitt and Sessions and "his own inclination toward logic and order."<sup>19</sup> Logic and order would be provided by the various computer programs he utilized in his later works.

The second category consists of works for the stage. Contact with the theater department at the University of Illinois led to the composition of incidental music for numerous plays and later theatrical multi-media works. Theatrical elements in Machine Music make it unique in the chamber literature for percussion. It was one of Hiller's first works to combine theatrical elements into a concert work. ". . . In all works written since Machine Music (1964), elements of stage and concert music are blended so that visual and

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<sup>19</sup>Vinton, p. 318.



dramatic elements become an intrinsic part of the composition itself."<sup>20</sup>

Hiller is best known for his work in the third category which consists of pieces which rely wholly or in part on computer and/or electronics. Hamm illustrates how Hiller's music can be approached from several levels. "The theorist may concern himself with the modified song form of the second movement of the Piano Sonata No. 1 or the passacaglia of the last movement of the Symphony No. 2 and the mathematician with the computer programs of Computer Cantata or HPSCHD. The listener responds to the rich and unpredictable detail, the vitality and virtuosity, the asymmetries and very often the aural and visual humor."<sup>21</sup>

An area which Hiller did not restrict himself in was instrumentation. By its nature, electronic music makes use of a vast timbral range but Hiller's acoustic music also makes use of an expanded timbral spectrum. Hiller commonly made use of unusual instruments and extended techniques on conventional instruments. He wrote works for folk instruments. Diabelskie Skrzypce (translated as "devil's fiddle") is written for the three-stringed Polish instrument of the same name and harpsichord. An Apotheosis of Archaeopterix is written for piccolo and berimbau, a Brazilian instrument which consists of a long piece of wood, a gourd resonator

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<sup>20</sup>*Op. cit.*

<sup>21</sup>*Op. cit.*

and a wire string which is struck with a small stick. The instrumentation of Machine Music also illustrates his tendency to use uncommon instruments calling for an ocarina (a ceramic flute), alarm clock, police whistle, polychord and a child's roller toy.

Elements from all three categories, abstract instrumental works, works for stage and works which rely on computers and/or electronics are exemplified in Machine Music. Although Machine Music did not involve computer assistance in its production, it uses tape and is typical of Hiller's approach to music composition programming on the Illiac computer exemplified in its use of a wide variety of musical materials and emphasis on structure as the foundation for musical experience. It is a significant work in the literature for both percussion and piano and is a landmark in electronic music, exhibiting a high degree of engineering quality and bringing the tape into a chamber ensemble as an equal partner. The virtuosic capabilities of percussionists, the availability of a wide variety of percussion instruments, and the advances made in electronics culminated in the composition of Machine Music.

## CHAPTER 3

### AN EXAMINATION OF LEJAREN HILLER'S MACHINE MUSIC FOR PIANO, PERCUSSION AND TWO-CHANNEL TAPE

Hiller composed Machine Music for Piano, Percussion and Two-Channel Tape Recorder in 1964 for percussionist Thomas Siwe, then a graduate student at the University of Illinois. It was premiered on February 27 of that year on Mr. Siwe's Masters degree recital in Smith Music Hall with pianist Phyllis Rappeport. Subsequently, the work was recorded by Siwe and Rappeport on Nonesuch records. Hiller's work was published by Theodore Presser Company of Bryn Mawr, Pennsylvania in 1967. A significant work in the percussion chamber music literature, it is illustrative of many of Hiller's compositional characteristics.

As noted in chapter one, music combining live performers with recorded electronics had been written since the early 1950s. Combining tape and live performers in Machine Music was therefore not unusual. However, integrating the tape into the ensemble as an equal partner was. The three parts--piano, percussion and tape--are closely related. Musical material is exchanged between them and they interact rhythmically throughout the work. "Machine Music is . . . very rhythmic and metrically laid out. I wrote it this way specifically because I had become frustrated with so seldom hearing

any sense of forward propulsion in most tape compositions whatever virtues they might otherwise possess."<sup>1</sup>

It is the rhythmic energy of the work from which the title of Machine Music is derived. "The title is meant perhaps to evoke images of machinery because of the motoristic flavor of the piece."<sup>2</sup> The title seems to imply that machines of some sort were used in its composition but none were. Although Hiller had become famous for his work with electronics and computers, he wrote many compositions without their aid. "I have discovered to my chagrin that once my name became associated with computer composition, it has been utterly impossible since to convince many people, including some critics, that I am capable of doing anything else musically."<sup>3</sup>

The similarities in the sonority and musical function of percussion and piano can be seen in the treatments to the piano in the compositions of Henry Cowell and John Cage. By manipulation of the strings inside the piano, the piano could be transformed into an entirely different instrument. Cowell was the first composer to ask the performer to activate the strings by means other than depressing the keys of the keyboard. Plucking, strumming and striking the strings with the hands is called for in pieces such as Aeolian Harp

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<sup>1</sup>Elliott Schwartz, Electronic Music: A Listener's Guide, (New York: Praeger, 1975), p. 226.

<sup>2</sup>*Ibid.*, p. 229.

<sup>3</sup>*Ibid.*

(1923) and The Banshee (1925). The prepared piano was introduced by Cage in the 1930s. By putting objects such as screws, washers, and coins on, around, or between the strings of the piano, an expanded repertoire of sonorities was created. Examples of Cage's prepared piano music are his Bacchanale (1938), Sonatas and Interludes (1946-48) and Amores (1943). Amores is also an example of the combination of piano and percussion. The first and fourth movements are written for prepared piano while a percussion trio plays the second and third. The modifications of the piano blend its timbre with that of the percussion instruments. In fact, the piano is made to produce a far greater variety of sonorities than the percussion instruments, the opposite effect normally encountered with piano and percussion music.

Piano preparations are also required in Hiller's Machine Music. This factor and its complex interaction with the tape, virtuosic parts for the players (the two solo movements being extremely demanding technically), humorous interjections, structural ingenuity, use of concrete and purely electronic sound sources for the tape, theatrical involvement of the players, use of a unique notational system, and use of unusual instruments all reflect Hiller's artistic style and originality.

## ANALYSIS

Machine Music consists of eleven movements which are symmetrically arranged by texture into six solos, three duets and two trios as follows:

Movement		Thematic Material Used			
I.	Trio 1	A			
II.	Solo 1 (Piano)		B		
III.	Duo 1 (Tape and Percussion)			C	
IV.	Solo 2 (Piano)				D
V.	Solo 3 (Tape)		B		
VI.	Duo 2 (Percussion and Piano)			C	
VII.	Solo 4 (Tape)				D
VIII.	Solo 5 (Percussion)				D
IX.	Duo 3 (Piano and Tape)			C	
X.	Solo 6 (Percussion)		B		
XI.	Trio 2	A			

The seven possible arrangements of the three sonorities are used: solo piano, solo percussion, solo tape, percussion and piano duo, piano and tape duo, percussion and tape duo, and trio. Hiller further groups the movements into five large sections consisting of the two trios and groups of three movements framed by the piano, tape and percussion solos. The tape is utilized in every other movement allowing time for the operator to cue up the tape for each section.

Not only is the texture used to articulate the form but also recurring musical material is used. The second trio derives its thematic material from the first trio. The three duos use the same four melodic ideas (though transposed). Solo movements II, V and X

use the same rhythmic organization. Solos IV, VII and VIII have the same structural plan applied to them. Each of the instruments presents the major thematic ideas. In fact, the parts are arranged so that each performer plays the main musical elements once and only once during the course of the entire work.

Regarding the tape part, a wide variety of sound sources are used: white noise generator, oscillators, sounds generated from the Harmonic Tone Generator built by University of Illinois colleague James Beauchamp, recorded percussion instruments, and speech. The sounds were then manipulated by use of tape techniques, such as reversal and speed variation, and through electronic means such as filtering, ring modulation, amplitude modulation and frequency modulation. High cutoff and low cutoff filtering is used with both electronic and concrete sources. Vibrato-like effects are achieved with the use of sub-audio frequency modulating signals. Beating tones are created by oscillators sounding together and separated by a few hertz. Gong-like timbres are created with the use of ring modulation. After the sounds were created and recorded, the master recording was assembled by splicing the numerous pieces of tape together. Every sound event and silence on the tape was put into place using a razor blade and splicing block.

## Trio 1

The first trio is a small-scale sonata allegro movement. The introduction is followed by an exposition section with first and second subject, development section, recapitulation of both subjects and a short coda. Hiller outlined the first movement as follows<sup>4</sup>:

Bars		Number of Beats at quarter=216
1-2	Introduction (grave; marcato)	--
3-16	Exposition (first subject and transition)	60
17-22	Exposition (second subject and close)	30
23-35	Development	60
36-49	Recapitulation (first subject and transition)	60
50-55	Recapitulation (second subject and close)	30
56-57	Coda (grave; marcato)	--

The first subject consists of two motivic ideas. Labelled Ia, the first subject's main feature is the rhythm of a dotted-eighth note followed by three sixteenths. It is made up of a four-note descending melodic line followed by a leap and is accompanied by chords on the first and last notes of the figure.

The second motive, labelled Ib, consists of two sets of four thirty-second notes which mirror each other's contour melodically, the top line descending then ascending, the bottom line doing the opposite. In both instances, the percussionist answers the piano statements of the motives with eighth-note figures which fill out the

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<sup>4</sup>*Ibid.*, p. 227.



measures (see example 1). At this point in the movement the tape provides non-rhythmic accompaniment.

**Furioso** (♩ = 216)

Example 1. Movement 1, measures 3 and 4.

In measures 5-7, the second motive is extended leading to an inversion of Ia in m. 8. This begins the transition to the second subject.

Hiller states in *Gagne* that any sort of disorder can be used to create structural tension. Tension in the transition between the first and second subjects is achieved through the use of a pointillistic environment in place of the homophonic style found in the opening.

In addition, 4:5 and 5:6 polyrhythms are used in the tape, providing further instability. A high degree of tension is created in m. 15 with a 10:4 polyrhythm in the piano juxtaposed against the 5:6 figure in the tape. In m. 15 transitional motive Ic closes the first section (see example 2).

The musical score for Example 2, Movement 1, measure 15, consists of five systems of staves:

- Pao. (Piano):** Two staves (treble and bass clef) in 6/8 time. A 10:4 polyrhythm is indicated above the treble staff. Dynamics range from *p* to *f*.
- Perc. (Percussion):** A single staff in 6/8 time. Dynamics range from *p* to *ff*.
- Lc. (Left Clarinet):** A single staff in 5/6 time, featuring a melodic line.
- Rct. (Right Clarinet):** A single staff with frequency specifications: *mp* HC: 4800, LC: 300, 9600 cps, and 600 cps.
- Rc. (Right Clarinet):** A single staff with frequency specifications: 9600 cps and 600 cps.

A label "HTG: melodic line" is located at the bottom right of the score.

Example 2. Movement 1, measure 15.

The second subject IIa is stated in m. 17. It consists of three elements, the piano right hand melody, the piano left hand repeated chords, and the timpani line with its distinctive glissandi on the 4th and 5th beats of each measure (see example 3). The tri-tone

glissando in the timpani is identical to the timpani part in the first movement of Bartok's Sonata for Two Pianos and Percussion during the transition to the second subject. The melody and glissando accompaniment are restated a fourth higher by the tape in m. 20 accompanied by Ib in the piano. The short second subject

The musical score for measures 17-20 consists of four systems. The first system, labeled 'Pno.', features a right-hand melody starting in measure 17 with a piano (*p*) dynamic, moving to a fortissimo (*sf*) dynamic by measure 20. The left hand plays a glissando accompaniment. The second system, labeled 'Perc.', shows a rhythmic pattern in the right hand and a glissando accompaniment in the left hand, with dynamics ranging from *sfz* to *mf*. The third system, labeled 'Lc.', shows a single note in the right hand. The fourth system, labeled 'Rc.', shows a single note in the right hand. The score includes dynamic markings such as *p*, *sf*, *sfz*, *p*, and *mf*, and articulation markings such as *crack* and *gliss*.

Example 3. Movement 1, measures 17-20.

area is closed in m. 22 with a modified version of the Ic transitional motive. It gives a clear illustration of some of the pitch manipulations Hiller uses throughout the movement. The twelve-

tone figure begins on the same pitch as the m. 15 statement, however, both lines are inverted (see example 4).

Example 4. Movement 1, measure 22.

The development begins in m. 23 with IIa material in stretto. This version of IIa also contains a quote from Bartok's Sonata. It is similar to a developed version of the opening theme in the first movement which appears near the end of the coda (see examples 5 and 6). The melody is played first by the piano a fifth below the original, then by the tape a minor third below that in m. 24, and finally by the xylophone a half-step above the tape statement.



Example 5. Bartok Sonata for Two Pianos and Percussion, first movement, measures 426-428, piano I part.

A musical score for measures 23-25, including Piano, Percussion, and Percussion/Chimes. The score is divided into three measures, labeled 23, 24, and 25. The Piano part (Pno.) is in treble clef and features a series of chords and single notes, with a dynamic marking of *sub. pp*. The Percussion part (Perc.) is in treble clef and features a series of notes and rests, with a dynamic marking of *subpp*. The Percussion/Chimes part (Perc./Chimes) is in bass clef and features a series of notes and rests, with a dynamic marking of *mp*. The Percussion/Chimes part also includes a section labeled "HTG. cones" and a dynamic marking of *p*. The Percussion/Chimes part also includes a section labeled "8va" and a dynamic marking of *gliss.*. The Percussion/Chimes part also includes a section labeled "Tomb." and a dynamic marking of *gliss.*.

Example 6. Movement 1, measures 23-25.

Before the completion of the xylophone statement, Ib returns in the piano in m. 27. Ia is also presented in stretto starting in m. 29 with the timpani. During the three statements by the timpani of Ib the piano states Ia in its original form in m. 30 (though it is transposed down a minor seventh). On the third beat of the measure the piano answers immediately with an inversion of Ia. The piano continues to develop the four-sixteenth-note idea from Ia through m. 35.

Similarly, the tape presents Ia in its original form (down a fifth) in m. 32 and in inversion in m. 33. At the same time, the piano and percussion return to the texture of the first subject transition with pointillistic and polyrhythmic tension.

The recapitulation uses material from the opening, though some of the measures are rearranged or modified. It begins in m. 36 with Ia presented by the xylophone in its original form with the original pitches. Reminiscent of the piano statement of Ia in m. 30, an inverted Ia is given immediately starting on the last note of the original statement. M. 37 is the same as m. 5, m. 38 is the same as m. 4, and m. 39 is the same as m. 7 transposed up a fifth. The chords in m. 40 and 41 are, similarly, a fifth higher than the same chords in m. 6 and 9 respectively. Inverted statements of Ia in 42 by the piano and xylophone lead into silent measure 43. Transitional material from m. 10-16 is used as a retransition in m. 44-49. Material is rearranged, reorchestrated, inverted and transposed.

The closing motive Ic is stated a half-step higher than the original in m. 48. The second subject area is recapitulated in a literal

manner starting in m. 50. Like the return of a second subject in a traditional sonata, it is a fourth higher than the original. The melody is given by the tape, the repeated chords are in the piano, and the timpani provide the glissando idea. The movement ends with a short coda using the material from the beginning. Much of the material from the first movement returns in the finale.

### Solos

The three solos in movements II, V, and X all use the same rhythmic material as do movements IV, VII and VIII. The piano plays 10 repeated chords in II, sustained and very soft. The length of each successive chord is lengthened by one beat creating the durational relationship of 1:2:3:4:5:6:7:8:9:10. In movement X the percussionist plays the same rhythm in retrograde with short and loud bursts on the bass drum and hi-hat. The tape in V plays the piano movement's (movement II) original rhythm in the the left channel and the percussion movement's (movement X) retrograde version in the right channel. The electronic sounds are random splices from the taped material used to create the cues for the first and seventh movements. Each sound lasts exactly one half second and is to be played back at mezzo forte. The relationship of the three movements to one another matches the overall progression of the work (see examples 7-9).

PIANO

1 Grave (♩ = 60) 2

15 ma

sempre *ppp*

15 ma una corda

Ped.

Example 7. Movement 2, measure 1 and 2.

1 Grave (♩ = 60) 2

Left channel

5/4

sempre *mf*

Right channel

5/4

Example 8. Movement 5, measures 1 and 2.

HI-HAT

BASS DRUM

Grave (♩ = 60)

1 2

5/4

sempre *fff*

Example 9. Movement 10, measures 1 and 2.

Subject material appears in the order A-B-C-D-B-C-D-D-C-B-A through the eleven movements. B-C-D appears twice followed by the retrograde appearance of D-C-B. Complimenting the overall scheme is the marriage between both the original rhythm and its retrograde in movement V and the retrograde alone in movement X. A similar connection to the overall form is made in movements IV, VII, and



VIII by the manipulation of the overall dynamic contour and the disbursement of thematic material within the structure.

In movements IV, VII and VIII a large scale rhythmic idea is controlled. Hiller uses a number scheme to illustrate the structure. The scheme controls both of the instrumental solos, in essence creating the same music using different material. In fact, Hiller refers to them as being the same music. He said, "Solo V is essentially the same music [as Solo II], however, reconceived for percussion."<sup>5</sup> Inspection of the manipulation of the four ideas used shows that information theory is a determining factor. The digits are taken out of the context of a numerical value and transferred into a series of symbols which can be manipulated. The scheme is outlined in table 1.

Each number represents one of the four-measure subjects used in both movements IV and VIII. Each subject is manipulated upon subsequent statements. The overall subject arrangement is a palindrome. The themes themselves, however, are altered continually through the movement, leading to drastically different

1234/4123/3412/2143/3214/4321

Table 1. Palindrome created by 12 measure retrograde.

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<sup>5</sup>*Ibid.*, p. 229.

versions by the end. The palindrome idea only effects the appearance of material, not its individual development.

Different developmental techniques are used simultaneously. In the piano movement, two of the subjects modulate in opposite directions with each statement and two are manipulated by the serial techniques of retrograde and inversion. Each subject consists of rhythm and pitch rows which are developed by retrograde, inversion and transposition of the original statement of the subject. Hiller also freely manipulates the rows themselves by rearranging segments of several of the subject appearances. This can be seen as another example of Hiller using different stylistic approaches in the same piece of music.

The method of variation is different for each subject creating independently developed lines of activity. In Solo IV, subject 1 transposes up in a scale-like progression moving up a major second, major third, perfect fifth, major sixth and major seventh away from the original pitches with each appearance. The second subject is a series of repeated eighth-note chords with a strong accent pattern. Through its six appearances, the accent pattern is shifted forward by a quarter note. The passage also transposes downward with each statement--the inversion of the first subject's direction.

Subject 3 in movement IV is manipulated using a variety of serial techniques. In m. 8, the rhythm is the retrograde and the pitch row is the inversion of the original. In m. 9, retrograde pitches are transposed down a major second with the original rhythm. In m.

16, each hand of the piano is manipulated independently. The right hand plays retrograde pitches and rhythm. The left hand has the rhythm in retrograde and inversion while the pitches are transposed up a major second. M. 17 uses retrograde pitches with the original rhythm. In m. 22, retrograde rhythm is used with the original pitches.

In subject 4, the pianist's parts are also treated separately. In m. 20, the left hand plays the right hand's original statement in retrograde while the right hand plays the left hand's original material (though with some octave displacement). In m. 15 both hands switch parts and play them in retrograde (also with some octave displacement). M. 5 has the left hand playing the original material while the right plays in retrograde. The original row of pitches is used throughout. M. 10 has both parts in retrograde while m. 21 is a restatement of the original form of M. 4. This is the only subject which is restated in its original form. As a result, Hiller has two subjects progressing strictly by pitch shifting (modulating) and two are being developed by row manipulations of retrograde and inversion without the use of modulation. He may have intended to use the more perceptible changes in the first and second subjects to allow the listener to comprehend the developmental features of the less obvious manipulations being used in the 3rd and 4th subjects.

Dynamics are also used to relate movements IV and VIII. Dynamics levels are given for every measure. The dynamic activity is independent of the four subjects' development. A dynamic row is

used in Solo 2. Symbolizing the dynamics as numbers, ppp=1, pp=2, p=3, mp=4, mf=5, f=6, ff=7 and fff=8, the row progresses 852/741/638/527/416/385/274/163. The three-event row 852 is "transposed" down a dynamic level every three bars. The three measure dynamic pattern contrasts with the four measure subject pattern.

The same formal outline is applied to the percussion solo in movement VIII but the subjects and their manipulations are different. Also, the dynamic pattern is reversed. Using the dynamic table above, the movement begins with 361 and is "transposed" up a dynamic level every three bars. Subject 1 is a sparse measure consisting of four events. However, each successive statement is embellished with more material. The final measure of the movement consists of 20 events.

The rhythmic second subject of movement VIII is reorchestrated for each statement. It begins with the triangle playing repeated quarter notes and the guiro playing a syncopated counterrhythm. In m. 7, the cymbal plays the repeated notes (though longer values are used due to the inarticulate nature of repeated notes on cymbals and tam tams) and the woodblock plays the syncopated part. Tam-tam, high hat, guiro and woodblock play the repeated notes in subsequent statements while the slit drum, bass drum, triangle, and cymbal play the syncopated lines. The reorchestration can be related to the modulation tactic used in the piano solo. It begins with a high metal and low wood sound and ends

with a high wood and low metal sound. The transformation can be thought of as a timbral modulation.

In the statements of the third subject, individual notes and groups of notes are freely rearranged. The nine xylophone notes and 3 timpani notes appear in a different order in every measure. The bass drum, slit drum, guiro and woodblock always appear in the same order with the same rhythmic relationship to a beat, but the placement within the rhythmic layout of the measure varies.

The fourth subject is developed by rearrangement of the figures associated with each beat. The beats are arranged in the following manner:

Measure	Quarter note beat placement							
M. 4	1	2	3	4	5	6	7	
M. 5	4	6	7	1	2	3	5	
M. 10	6	7	1	2	3	4	5	
M. 15*	1	2	6	7	4	5	3	
M. 20	1	2	3	6	7	4	5	
M. 21	6	4	5	1	2	3	7	

\* Beat 2 is divided into halves and split between the first half of the second beat and the last half of the sixth beat.

Table 2. Movement VIII outline.

No octave transposition or inversion techniques are used in the percussion movement as were used with the related piano solo. Both solo instrumental movements are developed in a manner appropriate to the instrument being used.

Of the tape solo VII Hiller states: "Solo IV . . . is more or less generally related to these two virtuosic soli in that it is dense and aggressive in texture. The sounds on the tape here are also reminiscent of the two trios." As with movements IV and VIII, four lines of activity progress simultaneously through VII. Brief descriptions of each are given in the published score. Pattern 1 consists of "Glissandi, glides and swooping sounds derived from a number of electronic and concrete sound sources modified by octave transpositions and reverberation." Pattern 2 is made of "scraping sounds of the type first presented in the last measure of the First Trio but much modified and extended." Pattern 3 is made up of pure electronic sounds: "amplitude modulated square wave tones of low frequency set in an accelerating rhythmic pattern with a descending pitch structure and with cross channel reverberation." The descending pitch structure corresponds to the gradually descending modulation of the second subject in movement IV. Pattern four consists of the "retrograde of pattern 1 with different reverberation."<sup>6</sup> Pattern 1 is in the left channel, 4 is in the right, and 2 and 3 are in both (The use of spatial location allows composers to better separate material for the listener). All patterns are independently developed as with the other two solos.

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<sup>6</sup>Hiller and Isaacson, p. 15.

## Duos

The three duos are closely related. Each use the same pitch, dynamic and rhythmic material. The melodic activity is grouped into two pairs of lines which are dispersed between the piano, percussion and tape in the successive movements. The top line consists of repeated pitches on the second and sixth beats of each measure. These two notes serve as pivots for two chromatically expanding lines which, throughout each movement, gradually expand to a minor sixth below and a major sixth above the pivot. In movement III the pivot is E, in VI it is A-flat and in IX there is a three note cluster B-C-D-flat which serves as a double pivot; the upper chromatic line moves away from the D flat and the lower line moves away from the B. Surrounding the chromatic lines are other chord tones which match the texture of the left hand and pivot clusters. Rhythmic placement of the chromatic pitches are identical in each of the three movements.

The second line of the four in movements III, VI and IV consists of a four-event palindrome rhythm with a repeating three-event pitch line. The rhythm progresses eighth note, quarter rest, eighth note, quarter rest, eighth note, quarter rest, eighth note.

The third line is a melodic idea which uses the remaining four notes of the chromatic scale. The first six measures of the melody are played in retrograde during the last six measures, and measures 7 and 8 are repeated in measures 14 and 15. The bottom line

consists of four pitches which progress through individual rhythm cycles. In movement VI, for example, the four pitches in the left hand of the piano D, E, A and B-flat repeat every 4, 5, 6 and 7 beats respectively.

Dynamics are also consistently applied to the four lines of activity. In movement III the tape has lines 1 and 2 with 1 diminishing throughout the movement from fortississimo to pianississimo and 2 doing the opposite gradually going from pianississimo to fortississimo. The percussion plays the third and fourth lines at a constant mezzo forte. In movement VI, the percussion has lines 1 and 2 with the same dynamic contour as the tape in movement III. The piano has lines 3 and 4 at mezzo forte as before. In movement IX, the piano has lines 1 and 2 again with the same dynamic relationship (the errata amendment included with the score corrects the reversed dynamics printed at the beginning of the movement). The tape has lines 3 and 4 once again at mezzo forte (see examples 10-12).

Pitch relationships also tie the three duo movements together. The sixth movement, which starts on a C, is a major third higher than the G# which starts the third movement. Movement IX is a major third above that starting on an E. Typical of Hiller, the three duos illustrate how he would independently develop multiple parameters.



1 Allegro moderato ( $\text{♩} = 105$ ) 2

High E frequency modulated by 3 cps sine wave + 5cps square wave

Left channel

TAPE RECORDER

LC: Harmonic tone generator tones frequency modulated by 5cps sine  
 RC: *ppp* *dim.* *cresc.* *poco a poco al fine* *poco a poco al fine*

Right channel

Tape loop of sine tones at notated pitches which are ring modulated by

GLOCKENSPIEL  
(or crotales)

PERCUSSION

4 Auto  
brake drums

Example 10. Movement 3, measures 1-2.

1 Allegro moderato ( $\text{♩} = 105$ ) 2

Tubular bells

PERCUSSION

Timpani

\* PIANO

Rubber band

Plucked

Plucked

*fff* *ppp* *dim.* *cresc.* *sempre mf* *8va*

Example 11. Movement 6, measures 1-2.

Allegro moderato (♩. 105)

Sine tone modified by 2<sup>nd</sup> low Freq. sine tone in amplitude modulator then AM again with B<sub>7</sub> (3951 cps) bring the modulated signal. Band-pass filtered at 150-3600 cps.

Example 12. Movement 9, measures 1-2.

With the dynamic and thematic relationships of the movements a clear arch form is created which hinges around the middle movement. Movement VII is loud and V is mezzo forte. Loud movement X contrasts to the sustained, soft Solo 1. Movement VIII uses a dynamic and phrase row which are the reverse rows used in movement IV. Movements VII through X are varied retrogrades of movements II through V. These are framed by two large movements which serve like traditional pillars in a multi-movement work.

## Trio 2

The last movement recalls many of the motivic ideas from the first movement. Of it Hiller states: "Trio II . . . serves as a traditional finale and climax. Remember that this is a piece meant to go somewhere dramatically and not just a chunk of soundscape."<sup>7</sup> It consists of two large sections articulated most obviously by the dynamic shape of the tape part. A single crescendo starts in m. 1 and climaxes in m. 17. The crescendo is countered in the piano with a peak in m. 9 followed by the subito fortissimo cadenza from m. 13 to 17. All three parts crescendo together from m. 31 to the end, climaxing with FFFF chords on the piano, chime note and a reverberated bass drum sound on the tape.

Manipulations of thematic material also takes place within the large dynamic structure. M. 1-4 are derived from the introduction. They are extended by repetition and pitch shifting. M. 5-8 are reminiscent of the repeated-chord accompaniment in IIa from the first movement and the 2nd subject in the fourth movement piano solo. In m. 9 the tempo changes to a brisk quarter note equalling 168 beats per minute. Strong downbeats in the piano are matched with tape accents. The eighth note flourish following the chords is similar to the quintuplet figures in the transitional closing theme Ic from the first movement. At m. 13, the piano plays four repetitions

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<sup>7</sup>Schwartz, p. 229.

of Ib followed by 6 chords which are repeated by increasingly shorter gaps. Decremental by eighth notes, they, in essence, accelerate to m. 18 in the relationship of 6:5:4:3:2:1 eighth notes in length.

Following a grand pause in m. 18, several theatrical/comical events occur in a suddenly thin texture. The pianist snaps a rubber band onto three strings in m. 19. Instructions are given on the errata amendment which state: "pull rubber band dramatically out of piano and release FFF." The percussionist runs excitedly in a circle with a child's roller toy for 5 measures starting in measure 20. The tape comes in at measure 23 with the title of the work recited backwards by the use of the musique concrete technique of tape reversal. The text is written in to the score as "'Redrocer epat lennahc owt dna noissucrep onaip rof cisum enihcam."<sup>8</sup> Ending the episode is a ratchet which sustains over the end of the text and overlaps the beginning of the coda. Ib material, which is introduced in measure 29, begins the crescendo to the end of the movement.

In the coda, material is given to the piano and percussion which is derived from Ib. It is first presented in a 12/8 version at measure 31. The length is subsequently shortened by one eighth note per measure. The amount of material is reduced but the accented chord at the beginning of the measure is retained creating a strong sense of accelerando to the end. This can be considered a

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<sup>8</sup>Hiller and Isaacson, p. 26.

development of the acceleration idea presented in the piano in measure 16-17 and also on larger scale with movements II, V and X. The downbeat chords modulate through all twelve pitch classes with the root of each moving from B to Gb, C, Eb, Bb, E, G, A, Db, F, Ab and ending on D, the root of the first chord in the opening of the first movement. The tape also draws from previous material. The part is described in the score as a "complex montage of rehearsal tapes . . . taken from the First Duo and Third Duo plus the First, Second, Fifth and Sixth Solos all forward and retrograde and processed [with a] variable speed tape recorder."<sup>9</sup> The work ends dramatically with the reverberation from simultaneous FFFF downbeat accents in all the parts dying away while an alarm clock, set off by the pianist in the last measure, rings for ten seconds. Hiller states: "Machine Music is . . . meant to be humorous and rather satirical. I have . . . discovered that this . . . often baffles and infuriates. One introduces humor into the concert hall at one's peril."<sup>10</sup>

The work involves the use of numerous compositional techniques for articulation of the structure of both the overall form and the individual movements. Numerous relationships are created and transformed in a variety of ways, from sonata allegro processing to serial manipulation of pitches, rhythm, articulation and dynamics.

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<sup>9</sup>Lejaren Hiller, Machine Music. (Bryn Mawr: Theodore Presser, 1964), p. 27.

<sup>10</sup>Gagne and Caras, p. 229.

This gives some insight into Hiller's interest in using computers as composing aids.

## CHAPTER 4

### PERFORMANCE PROBLEMS FOR THE PERCUSSIONIST IN LEJAREN HILLER'S MACHINE MUSIC FOR PIANO, PERCUSSION AND TWO-CHANNEL TAPE

Machine Music is a demanding work for both the pianist and percussionist. The piano's twelve-note chord on the downbeat of the first movement is an indication of the technical problems that will be encountered. Other challenges involve synchronization with the tape, drastic dynamic changes, tempo changes, percussion notation, and percussion instrument selection and location.

The electronicist (a term Hiller uses to specify the tape operator) plays a crucial role in the performance of the work. In movements in which the tape and performers begin simultaneously, the electronicist indicates to the performers when the tape will start. A bar of recorded clicks precedes these movements. These clicks, however, must not be heard by the audience. Hiller instructs the performers how this should be done: "It is suggested that an arrangement be provided whereby the speakers can be cut off during these clicks and turned at the downbeats of the movement. The operator of the tape console should listen to these clicks and provide beats to the other performers. He can do this by listening to

the tape with a headset."<sup>1</sup> This can be accommodated in at least three ways. If the amplifier has speaker assignments, they could be left off until the downbeat. The headphone output from the amplifier is usually unaffected by the speaker routing. Secondly, if the tape deck has VU meters, they could be used as beat indicators allowing the operator to switch the amplifier's channel routing switch to the proper position right before the downbeat. A third way to accommodate the problem is to use a mixing board. The original signal could be directly routed to the headphone monitor and to an output buss which is directed to the amplifier. A half beat before the downbeat the buss assign switch in the tape deck's channel could be turned on.

The tape part is thoroughly notated in the score with pitch, rhythm and timbre indications. It is one of the most detailed electronic scores of the sixties.<sup>2</sup> Pitches and rhythms are indicated in a grand staff with descriptive and technical terminology used for timbre. Phrases such as "twanging tones", "rumbling and screeching sounds" and "crack" are used to describe the concrete material incorporated into the work. Indications such as "ring modulated sine tone shaped by envelope generator", "beating tones (3134+3138)", "filtered sawtooth tones" and "HC: 2400----->3600cps" refer to the pure electronic sounds used. The specificity of the notated tape part

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<sup>1</sup>Lejaren Hiller, Machine Music (Bryn Mawr: Theodore Presser, 1964), performance notes.

<sup>2</sup>Schwartz, p. 110.



significantly aids in the preparation of the work for performance. It also elevates the tape part to a position equal to that of the live performers. The tape can be observed and studied in a way similar to the music written for acoustic instruments. Many tape compositions do not allow for such observations.

For the percussionist, Machine Music presents many problems, not the least of which is becoming accustomed to the notation. When the full complement of instruments is used, as in movements I, VIII and XI, parts are notated on a multiple staff system. The treble clef instruments, xylophone, tubular bells and glockenspiel, are placed on top. On the bottom is a bass clef staff for the timpani. Between the two pitched lines are single line clefs for the non-pitched instruments. To indicate which instruments are to be played symbols are utilized (see example 13). Thomas Siwe, for whom the

Reverse sticks

14

pp

Example 13. Movement 8, measure 14.

piece was written, provided the notational key to the composer. Although inconvenient to read, the notation system adequately conveys the information needed for performance.

Preparation for any multiple percussion piece involves careful planning of instrument placement within the percussionist's setup. This is especially crucial in Machine Music because of the instruments involved and the tempi of some of the movements. It is also necessary to acquire or construct special stands and devices to make some of the required instrument and mallet changes possible.

Although a diagram of the percussionist's setup is given in the score, variations will be encountered with each performance as a result of the use of different instruments. The basic setup used by the author for movements I, VI, VIII, X and XI is shown in illustration 1. A fifth timpani has been added to the score-specified setup to alleviate some of the pitch change problems. Within this setup several special stands and devices are required. A triangle machine allows for the triangle to be struck with metal beaters instead of the felt covered rubber mallets being used to play the rest of the instruments in movements I and VIII. The machine suspends the triangle above two metal beaters which are fastened firmly below with strips of rubber tubing. The beaters can be struck with hands or mallets which, in turn, are propelled up to the bottom of

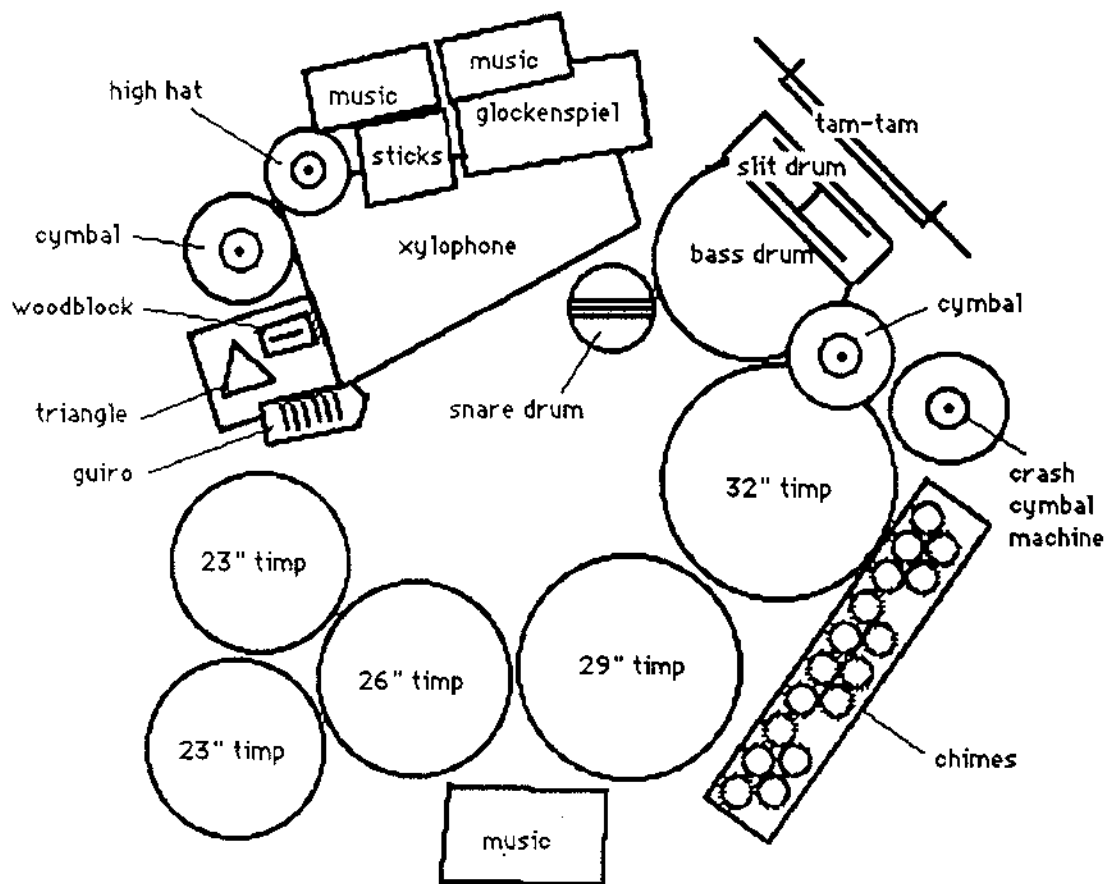


Illustration 1. Percussion setup for movements I, VI, VIII, X and XI.

the triangle. With two beaters fastened under the triangle, tremolos as well as single strokes are possible.

The guiro, which is used in movement VIII, must be stabilized so that it remains in place and upright. The author uses a gourd guiro which has been stuffed with a towel and then placed on the end of an upright cymbal pole. The towel helps hold the guiro firmly without damaging the instrument.

In the last movement, crash cymbals are called for but there is little time for the percussionist to pick them up and play them in a traditional manner. A high hat stand can be used to simulate a cymbal crash. Placed on the far side of the bass drum, a high stand with a pair of crash cymbals attached can be hand-activated by depression of the spring-suspended, top cymbal pole.

In movement III, the percussionist moves to another set of instruments which is diagramed in illustration 2. Two unusual instruments are called for in this movement: a poly chord and an ocarina. A polychord is simple, multiple-stringed device commonly used to demonstrate the acoustical properties of a vibrating string. An ocarina is a clay, globular flute consisting of a mouth hole and several finger holes. It is held in both hands since all ten fingers are typically involved in the hole covering. However, the percussionist's hands are not available to hold the instrument so a stand must be constructed. Siwe taped the ocarina to a microphone boom stand to hold it in place.

Another problem encountered is the selection of mallets which will work effectively on different instruments. In several of the movements, one pair of mallets must be used to play on timpani, xylophone, glockenspiel, bass drum, gong, suspended cymbal, woodblock, high hat, slit drum and snare drum. The author uses a large-headed rubber mallet which is covered with felt. The large mass is needed to activate the fundamental of the bass drum and timpani and the hardness of the rubber allows for an articulate

sound on the snare drum and xylophone. Mallet changes are occasionally indicated in the score (e.g., m. 28 and 34 in the first movement), however, there is little time for a change. Double-headed mallets may be a possible solution but a two-tone mallet works effectively for the author.

Timpani intonation is a significant problem. Spring tension pedals are preferable since changes can be made faster and since glissandos are more readily accommodated. Five drums are used with the fifth placed to the outside of the 23 inch instrument. In the first movement, the starting pitches, from bottom to top, are A, B, C, E-flat and F. Several passages require fast changes. Two drums are retuned between measures 20 and 29 during which time there is transitional and thematic material being played on the cymbal, bass drum, triangle and xylophone. The low drum, which presents the initial statement of the glissando theme in m. 17-19, should be tuned to G-flat in m. 20 since the right foot will already be in position. The second drum should be tuned to A immediately thereafter in measure 21. At that point the drums are in tune for the the Ia material which appears in m. 29.

Fast pitch changes are also encountered in measures 37-39. The fourth drum, playing an E-flat eighth note in m. 37 must be changed to D for the last eighth note in m. 39. The A in m. 37 must also be changed to an A-flat for m. 39. Since body movement from the xylophone to the fifth drum will be clockwise, the A should be changed first in m. 38. The D is tuned during the first three eighth

notes of m. 39. An E and B are needed in m. 50 for the return of the glissando theme. The fourth drum D can be changed to E during the grand pause in m. 47. The third drum C can be dropped to B during the first three eighth notes of m. 50. Because the glissando in m. 52 leads directly to a xylophone double stop on the downbeat of measure 53, the left foot should be used for the third drum glissandi in measures 50-52.

Several other problems are encountered in the first movement. A soft cymbal roll with brushes is called for in the second measure following three three loud strokes with a hard mallet on the bass drum. Using a four-mallet grip, the brushes can be held as the inside mallets and the hard mallets can be held on the outside. The brushes can be put down in m. 3.

Also in m. 3, a new tempo is established. The relationship is approximately that of 16th notes in m. 2 equalling the speed of the compound eighth notes in m. 3. The piano and percussion are involved in a rhythmic dialogue from measures 3 to 8. Accurate placement of the percussionist's eighth note values at the end of each measure is crucial. The triangle roll in m. 8 can be executed with the mallets striking the two beaters held in the triangle machine. The same technique can be used in m. 48. To eliminate extraneous snare noise during the development and first portion of the recapitulation, the snare strainer can be disengaged in m. 25 following the soft triangle strokes. The snares can be turned back on during the grand pause in m. 43.

Cueing off the tape is critical to maintaining the ensemble throughout the work. Several ensemble lines in the first movement require careful attention. In measure 12 the woodblock plays on the downbeat, the piano on the second eighth note and the tape on the third. In the following measure, the tape's high D lies between two sixteenth-note E's in the piano. In measure 16, the first three sixteenth notes are passed between the cymbal, tape and piano. The second subject begins in the next measure with concurrent downbeats in all three parts. Tempo maintenance becomes critical thereafter to ensure that the piano and percussion end their phrases at the same time that the tape enters in m. 20. Eighth notes in the tape from m. 27-31 provide the tempo to hold the end of the development section together. The four chords in m. 35, though in an 8:5 polyrhythm, provide a strong cue for the downbeat of the recapitulation. The glissando theme in the tape in m. 53-55 provides the cue for the tutti closing chord on the fifth eighth note of m. 55. Tempo memorization is required to lock into the coda at m. 56.

The next movement to involve percussion is the third. A different percussion setup than the one the first movement is used. The third movement requires a polychord, triangle, tam tam, ocarina, glockenspiel (or crotales) and four automobile brake drums which are placed next to the piano near the middle of the stage (see illustration 2).

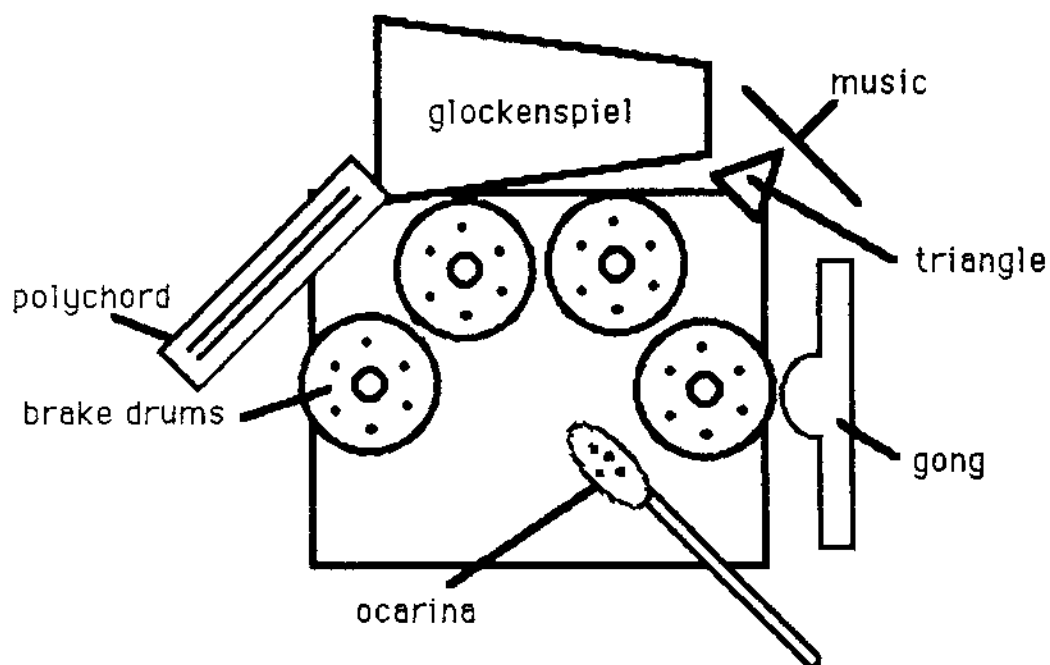


Illustration 2. Percussion setup for movement III.

The entire movement is to be played at mezzo forte. Instruments and mallets must be chosen which will allow for an equal balance between the various sonorities. The author has chosen a set of four polyball mallets. They work effectively on all the instruments except the tam tam. To match the sound of the tam tam with the rest of the instruments, a patch of felt has been fastened to the striking area. The ocarina is positioned over the setup with a microphone boom stand to allow for it to be played without the use of the performer's hands. One of the more demanding aspects of the movement is the mallet independence required to play the brake drum and glockenspiel lines which occur simultaneously throughout. Another problem is staying synchronized with the tape. Following



the cue from the tape operator the performer can listen for the high E's on the upbeat of the first and third beats for reference points.

In movement VI, the thematic material played by the percussionist is derived from the tape part of movement III. The palindrome rhythm line is played by the right hand on the timpani using the repeating pitches C, G and F. It begins at pianississimo and gradually increases in volume through the movement. The left hand plays the upper line on the tubular bells beginning very loudly and gradually diminishing to the end. A-flats occur in the same place in every measure on the upbeats of the first and third beats. In addition to the A-flats, the left hand plays two outwardly expanding chromatic lines, one ascending and the other descending. By the end of the movement the percussionist is playing melodic leaps of a sixth with one hand at a very low dynamic level while the other hand is playing the timpani at fortississimo; dynamic independence between the hands is the key to an accurate performance of the movement.

The most demanding movement for the percussionist is the eighth. Because there is no time for mallet changes, mallets must be chosen which work on all the instruments. The felt-covered rubber mallets used in the first movement work adequately on the xylophone, timpani, tam tam, bass drum and small instruments. Use of double-headed mallets is not a possibility since the sticks are required to be reversed in measures 11 and 14 (a quarter rest is given at the beginning and end of each of those measures to accommodate the switch). The prescribed tempo, dynamic changes,

and setup size also create problems for the percussionist. Measures 8, 9, 11, 14, 16, 17, 19 and 24 utilize large groups of instruments in a rapid, linear fashion. As a result, awkward doublings and wide stretches are necessary (see example 14 and 15). Several of the double and triple stops create problems. Whereas the high hat

The image shows a musical score for two measures, 8 and 9. The score is arranged in four staves. The top staff is a Treble Clef staff with a key signature of one sharp (F#) and a time signature of 3/4. It contains melodic lines with triplets and dynamic markings. The second staff is a Percussion staff with various symbols for instruments like snare, cymbal, and high hat. The third staff is a Bass Clef staff with a key signature of one flat (Bb) and a time signature of 3/4, containing melodic lines with triplets. The bottom staff is another Bass Clef staff with a key signature of one flat (Bb) and a time signature of 3/4, containing melodic lines with triplets. Dynamic markings 'fff' and 'p' are present at the bottom of the score.

Example 14. Movement 8, measure 8 and 9.

The image shows a musical score for measure 24. It is written for a grand staff with a treble clef on top and a bass clef on the bottom. The treble staff contains several rhythmic markings above the notes, including vertical bars, triangles, and a circle. The bass staff contains a melodic line with a forte (ff) dynamic marking below it.

Example 15. Movement 8, measure 24.

has been struck with a stick for most of the work (in order to accommodate the wide dynamic range called for), pedal operation is required in measure 19 so the guiro, low timpano and high hat can sound simultaneously on the fourth beat. The high hat clutch can be activated using a quick release mechanism which is attached to the center pole of the stand. Thereafter the foot can hold the cymbals together for the high hat strokes in measures 20, 21 and 24. Also, with the fourth timpani tuned to E, measures 6, 11 and 16 can be simplified. This reduces the distance between the required timpani pitch and the other instruments significantly.

The drastic dynamic changes between measures, as prescribed by the use of the dynamic series, also creates technical problems. In addition to the technical difficulties mentioned for measures 8 and 9, there is a sudden drop from fortississimo in measure 8 to piano in measure 9. The fast instrument changes requiring wide arm

stretches in measure 9 must be accompanied with short strokes in order for the sound to be soft. The difficulty lies in the combination of large motor movement of the arms with small motor movement of the wrists and fingers. Similarly, measures 14 and 19 involve quick movement between instruments and double stops at soft dynamic levels. Double stops also complicate the final measure, which is the most developed version of the first theme. The movement is a significant challenge for the percussionist. In fact, Hiller was told by several percussionists that it was "the most difficult piece they know of in the percussion literature."<sup>3</sup>

Movement X is also a percussion solo. In contrast to the rigorous activity of the eighth movement, the tenth consists of eleven identical events consisting of loud high hat and bass drum bursts. It is related to the second and fifth movements, the second being a piano solo using soft, sustained chords in the retrograde rhythm of the percussionist's version and the fifth being the tape solo which combines the two rhythmic plans playing them at mezzo forte and exactly one half second in length. Though no indication is given in the score, the bass drum should probably be dampened to continue the shortening effect of the material as it is presented in the work as a whole. The piano starts soft and sustained, the tape appears next mezzo forte and short, the percussion concludes the idea very loud and very short.

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<sup>3</sup>*Ibid.*, p. 228.

The finale recalls many of the ideas from the opening movement. Many of the same types of problems are also encountered. Five metrical shifts are made through the movement. The first occurs in measure 3 with a sudden move from the opening tempo of grave to the quarter note equalling 60 beats per minute. The tempo for both are given plainly in the tape part. A less obvious change occurs in measure 5. The tempo changes abruptly from 60 beats per minute to 105. The relationship is roughly that of triplet eighth notes in m. 4 equalling duple eighth notes in m. 5. The second quarter note of m. 5 is given in the new tempo, however, no other cues are given until m. 9 which is the beginning of yet another faster tempo. The relationship of the allegro moderato to the vivace e capriccioso is approximately a quarter note triplet to a quarter note. Since the pianist is playing throughout m. 8 it may be necessary for the percussionist, who is free for the last four eighth notes, to calculate the shift and conduct the tempo at measure 9. The tempo shift from m. 12 to 13 is much simpler with the quarter in m. 12 equalling the speed of the eighth note in m. 13 (the marked tempi of 168 and 108 are inaccurate).

The shift from measure 30 to 31 is crucial. The coda progresses with a barrage of sound from the tape and only two obvious cues for the performers. A crying sound can be heard in m. 34 (occurring later in the measure than the downbeat where it is indicated) and in m. 41, two beats before the final crash. Otherwise, the performers are without tape reference to the tempo. The

relationship of the tempi in measures 30 and 31 is approximately that of eighth note quintuplets equalling eighth notes. The difficulty in reorienting the tempo reference is that both players must play parts in m. 30 which center around the presto tempo. Again, the percussionist can make the adjustment by conducting the quintuplet in measure 30. The chime note on the last eighth of the measure can be placed immediately after the fifth quintuplet note (on the second note of a thirty-second note sextuplet superimposed into the quintuplet, to be exact). Solid establishment of the tempo is critical in order for the downbeat in the final measure to be together.

As in the first movement, timpani tuning is also involved. Three changes are required in measure 5-8. Four drums are needed. With the beginning pitches of F#, B, D and E-flat, all the changes can be made on one drum--the second. At the end of measure 5 the B can be changed to B-flat. At the end of measure 6 the B-flat can be changed to A-flat. At the end of measure 7 the A-flat can be changed to C. No dynamics are indicated during this passage but it can be assumed that the timpani should match the crescendo which takes place in both the piano and tape parts.

Following the timpani passage, crash cymbals are called for. Due to the lack of time available to pickup a pair of cymbals a second high hat stand is used as a "crash cymbal machine." Placed to the left of the timpani music stand, the cymbals can be activated by simply pressing down on the center pole of the mechanism, causing the top cymbal to crash onto the bottom one. The reduced complication also

allows the percussionist to conduct the new tempo. Following the tam tam stroke in m. 11, the percussionist must pick up the police whistle to have it ready for m. 13.

The most theatrical element in the work occurs in measure 20 when the percussionist is asked to "run excitedly in a circle rolling roller toy on the floor."<sup>4</sup> The instrument used by the author consists of a barrel which turns when pushed across the floor. As it turns, music-box-like sounds are produced. The instrument should be on the floor, propped up against the left end of the xylophone so that it is positioned to be activated as soon as the player leaves the setup. The author has found that there is enough time to circle the piano and return to the setup in time to play the ratchet in m. 26.

The coda requires the use of one hammer for the tubular bells and one felt-covered rubber mallet for the bass drum, tam-tam and suspended cymbal. Rewriting the rhythmic notation in measures 32 and 34 helps to line up the implied pulse of the piano part with the percussion part (see examples 16-18). In addition, an eighth note

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<sup>4</sup>Lejaren Hiller, Machine Music (Bryn Mawr: Theodore Presser, 1964), errata sheet.

32

11/8

11/8

11/8

11/8

11/8

11/8

11/8

Example 16. Movement 11, measures 32.



34

Reverberated arpeggio deriv  
electronic sources

cry

Example 17. Movement 11, measure 34.

32

34

Example 18. Movement 11, measures 32 and 34 with  
percussion part rebeamed

is missing from the tubular bell line in m. 32. Remaining consistent with the surrounding measures, the author has added an eighth rest to the end of the measure. The final event in the piece is the setting off of an alarm clock in measure 43. A windup travel clock is used by the author. It can be setup to ring for the instructed 10 seconds by winding up the alarm mechanism a determined number of times. Although the alarm clock part is written in the percussionist's part, the pianist or tape operator, as suggested by Hiller in the performance variation notes in the front of the score, can turn it on more conveniently.

## CHAPTER 5

### CONCLUSION

In many ways, Lejaren Hiller's Machine Music can be seen as a culmination of the developments which had been taking place in the history of electronic music and percussion literature. Several trends being followed in the 1960s are exhibited. The percussion part is exceptionally demanding both in terms of technical demand and ingenuity. A variety of conventional and unusual instruments are utilized. The tape part was constructed using both musique concrete and classical electronic studio techniques. Furthermore, the work as a whole is a complicated structure relying on both traditional formal processes and twentieth-century theories. In spite of the dense amount of activity involved with the piece, both in terms of compositional content and performance energy, the overall effect is cohesive and exciting.

Much of the work's complexity is due to the serial organization which is used. Rearrangement of motivic ideas within themes and wildly contrasting dynamics as a result of the utilization of dynamic rows create some formidable problems for the performers. The preparation time needed to accurately perform Machine Music is enormous because of the unusual physical feats required. Hiller's compositional approach is disruptive to the normal performance

approach, however, performers must be willing to accommodate the composer's ideas. Many of the elements which exist in a work such as Machine Music are not readily perceived; disregard for a dynamic level or substituting an instrument may jeopardize the integrity of the structure without the performer being aware of it. This illustrates the need for performers to discover ways to realize a work of this nature even though it may not be written in an idiomatic way. The composer must be allowed to manipulate material in whatever manner is desired, even if it is inconvenient for the musicians.

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