

AN EDITORIAL
FROM
CORLETT WOOD

AND

CONTRIBUTING PAPERS
FROM

Benjamin Brady
Department of History
University of Virginia
Charlottesville, Virginia, USA

Billy O'Steen & Lane Perry
College of Education
University of Canterbury
Christchurch, New Zealand

John T. Yates, Jr.
Department of Chemistry
University of Virginia
Charlottesville, Virginia, USA

Pauline Oliveros
Department of Music
Rensselaer Polytechnic Institute & Mills College
TROY, NY, USA & OAKLAND, CA, USA

JEFFERSON SCHOLARS FOUNDATION
112 CLARKE COURT
P.O. BOX 400891
CHARLOTTESVILLE, VA, 22904-4891

WWW.JEFFERSONJOURNAL.ORG

JEFFERSON JOURNAL OF SCIENCE AND CULTURE

2

*The scholarly publication from
Jefferson Scholars Foundation*

Issue 2 • July 2012

“To see differently in this way for once, to want to see differently, is no small discipline”

Reverberations: Eight Decades

Pauline Oliveros
Department of Music
Rensselaer Polytechnic Institute & Mills College
Troy, NY, USA & Oakland, CA, USA

“THE ORIGIN OF ALL TECHNICAL ACHIEVEMENTS IS THE DIVINE CURIOSITY AND THE PLAY INSTINCT OF THE working and thinking researcher as well as the constructive fantasy of the technical inventor.”

Albert Einstein

Abstract

KEYWORDS – technology, radio, recording, analog, digital, improvisation, composition, tape music, electronic music, consciousness, meditation, sound, music, digital, analog

This article traces the composer’s journey and relationship to technology from the influences of the early days of radio, recording, accordion playing, improvisation, tape music, to analog electronic music studios, live electronic music performance, to digital technology, computer music of the 20th century and hybrid forms of electro-acoustic music of the 21st century. The composer Pauline Oliveros was born in 1932 when CBS broadcast episodes of Buck Rogers in the 25th Century twenty-five years after the first commercial radio broadcast. She describes artifacts of the sounds of radio, radio programs, and of the effects of wind-up phonographs on her musical sensibility; wire recording, magnetic tape recording, cassette recording to digital recording. The sections of the article will be formed around the technologies of major compositions such as Time Perspectives, Bye Bye Butterfly, I of IV, Sound Patterns for Mixed Chorus, Sonic Meditations, Echoes from the Moon, Contenders, Njinga the Queen King, and more. Each piece represents new uses of technology in a long evolution with musical friends that continue to the present and projects into the future. She will expand upon changes in consciousness through the use of technology.

Early Influences

DOES ANYONE REMEMBER WILMA DEERING? SHE WAS CO-PILOT TO BUCK ROGERS ¹, AND WORKED WITH DR. Huer, the genius scientist, fighting the bad guys 500 years into the future. A woman aviator or rocketeer was an advanced concept in the 1930s. I am glad that Wilma Deering was there for me. The radio show, originally named The World in 2432 (CBS radio launch 1932), was part of my cultural background. Sound effects with their dramatic impact were certainly not lost on me. “A Schick electric razor held at just the right distance from the microphone produced the sound of Buck’s psychic destruction ray.”² The sound effects crew could also simulate anything from a regiment of marching robots to a scary rocket-ship crash.”³ Dr. Huer’s Electrohypnomentalphone – made direct contact to the brain: the sleeping Buck could speak aloud directly from his unconscious mind without using his voice. The palpability of this new science fiction surrounded my brother John and me provoking our imaginations. We made our way to the Tower Theater for Houston’s Saturday morning Popeye Club where Wilma and Buck with Dr. Huer and his machines loomed large on the movie screen and infused our minds with memories for our futures. Sound was prominent at the Popeye Club: The theater manager handed favors out to all the kids – Popeye’s singing pipe (Kazoo), or a small cardboard resonator with a vinyl strip that could be played with fingernails rendering a “hello sweetheart” in a voice modulated by the speed of the stroke.

One day I spotted an ad in one of the super hero comics that I was reading – probably Captain Marvel, Wonder Woman, Superman, or Bat Man. The ad was riveting – it was for a book called Wonders of Science now long out of print. Somehow I managed to order that book, and have it still somewhere! I was fascinated and transfixed by each page of Wonders of Science. There were diagrams of sound waves generated by using electromagnetism; how the microphone converts sound waves into electric currents: the vacuum tube for generating electric waves. Little did I know that Einstein gave his talk on Wonders of Science in 1930 in Berlin, at the opening of the Seventh German Radio and Audio Show. In his speech

Einstein presented the radio as a communication tool for reconciling differences between cultures because peoples could be exposed to one another in a new and faster way.⁴ Radio sounds fascinated me. I loved static in between the stations of my grandfather's crystal radio that was hard to tune. I loved the pops and whistles of my father's short wave radio also difficult to tune. I played with radio dials endlessly caring little for the programs excepting the adventure stories with sounds made by the Foley guys.

Then of course there was the music in the house - Piano Music! My mother, grandmother and grandfather sat together on one bench playing piano trio versions of classical music. Piano lessons started at 7 in the morning and continued in the afternoon after school. I listened and watched and don't remember the first time I sat at the keyboard. I do remember the Hohner 120 bass piano accordion that my mother brought home one day in the 1940s. The ornate grillwork, buttons and keys immediately fascinated me. I wanted to play this instrument. So I learned and continue to play sixty-nine years later.

The Houston Fat Stock Show and Livestock Exposition (known now as the Houston Live Stock Show and Rodeo) also dating from my birth year of 1932 had become a major annual event by the 1940s. The show always generated a lot of excitement in town and was another part of my cultural background. My first experience of performing in a massive group was with one hundred accordions at the Fat Stock Show. That shimmering sound of all those free reeds has never left me.

Could I be a Composer?

BY 1948 I WAS DREAMING OF BEING A COMPOSER PROMPTED BY MY INNER HEARING OF STRANGE SOUNDS and unfamiliar phrases of music. At the time I had no notation skills to translate my mental hearings to written music. I would sometimes wake in the middle of the night with the intention of writing what I was hearing only to become frustrated. It took great patience to gradually notate a pitch at a time pecking around on the piano keyboard for what I heard. This was a very slow process. I succeeded in writing my first pieces as a student in composition at the University of Houston in 1951. I wrote for horn and harp, wind quintet, violin and piano always attentive to the sounds of the instrumentation and still trying to transcribe from what I was hearing mentally to the written page. I resisted musical models. It was not until I began to work with electronic music in 1965 that I felt that I was dealing with my inner listening – those strange sounds that didn't fit on a conventional staff.

In 1952 I left for San Francisco to seek a composition mentor and an independent life. After a hellacious first year of survival economics I managed to establish a string of students, find my way into playing gigs on my accordion to eke out a living. In 1954 I found my way into San Francisco State College, and the composer's workshop where I met lifelong musical friends, Terry Riley, Loren Rush and later Stuart Dempster. Robert Erickson, was very open to our work, and assisted us greatly with suggestions and examples that supported our differing interests and aesthetics. Erickson encouraged us to improvise as well as write. It was a benchmark decision for us to seize the opportunity to improvise as a trio when Terry needed a five-minute sound track for a film project.⁵ To my knowledge no other group from an art music background had attempted free improvisation. We were crossing a forbidden boundary. Improvisation was not included in conservatories and music departments and was discouraged in establishment music circles. Earl Brown was working on his open-form concept by 1952, John Cage was working with indeterminacy, Christian Wolff, Morton Feldman and others were working with performer choice options in their scores but always continued composer control. In fact John Cage disapproved of improvisation thinking that it was too egocentric. Our performances were free and controlled by listening to one another, recording, listening to the result and then discussing what we heard. We discovered that if we tried to impose controls before we played that the results usually fell flat. So a method of free improvisation was born at Radio KPFA in 1957. The method: Play, record, Listen to the recording, discuss the results, and then repeat the cycle.

A Home Tape Music Studio and the Sonics Series

TIME PERSPECTIVES (1961)⁶ WAS MY FIRST TAPE PIECE MADE AT HOME WITH MY TAPE RECORDER AND MY improvised methods of processing found sounds. My tools consisted of the tape machine, its two speeds 7½ and 3¾ IPS, variable speed by hand winding the tape in record mode; card board tubes of differing lengths served as filters; and my bathtub served for reverberating the sounds. I wound up with two stereo tapes and no way to mix them. So two stereo tape machines and four speakers were needed for the performance.

Time Perspective was part of the launch of a concert series at the San Francisco Conservatory called Sonics organized by Ramon Sender and myself. This concert featured Sound Study Number One

(1961) by Phil Winsor, Traversals (1961) by Ramon Sender, (M...Mix (1961) by Terry Riley. In subsequent concerts Morton (Mort) Subotnick joined us in improvisations, as did dancers from Anna Halprin's Dancer's Workshop. Sonics were wild mixes of tape music, acoustic instruments, theatrical actions, film fragments and props including a Maytag washing machine filled with rocks—what a sound! Notwithstanding our successes with audiences and critical reviews all of this activity finally got us thrown out of the Conservatory!

Ramon devised one technique that was to be continually important in my later work during the Sonics series. He strung tape from one tape machine to a second with a long distance between the machines. What was recorded on the first machine played back at a later time regulated by the distance between the machines fed through speakers into our improvisations. Alfred Frankenstein the noted critic for the San Francisco Chronicle described the tape delay as a "most remarkable idea".⁷ This "most remarkable idea" had been prompted by Terry Riley to Ramon. He had been experimenting with tape delay between two machines. In 1963 Terry's Music for The Gift became the basis of his famous tape delay system the Time Lag Accumlator. Brian Eno and Robert Fripp followed with their use of delays in the 70s and 80s.

1961: Sound Patterns for Mixed Chorus

AFTER TIME PERSPECTIVES(1960) I WROTE SOUND PATTERNS FOR MIXD CHORUS (1961).⁸ THIS PIECE HAD no text, and was made of mouth noises and vocables that I could perform. I figured out how to notate each sound and used my own method of notation.

Figure 1
A Sample score from Sound Patterns for Mixed Chorus (1961)

I SENT THE SCORE OFF TO THE GAUDEAMUS FOUNDATION CONTEST IN BILTHOVEN HOLLAND. MUCH TO my surprise I was invited to come to the Gaudemus Festival for a performance of Sound Patterns by the Hilversum Chorus, Fred Barth conductor. Gyorgi Ligeti awarded first prize for the best foreign work to me. He told me that I had broken new ground with my piece and that there was nothing else like it. I figure that this piece was a turning point in absorbing the sounds of tape and electronic music that I had heard and was my way of expressing my relationship with these new sounds. Later Alvin Lucier recorded Sound Patterns with his chorus at Brandeis University and David Behrman produced a vinyl album called Extended Voices(1966) on Odyssey Records. Most of the pieces on that recording used electronic processing, and Sound Patterns was often mistaken for a piece of electronic music although it was vocal only. My intention was to have the chorus sound electronic.

1964: Tudor Fest

IN 1963 I MET DAVID TUDOR, WHO CAME TO SAN FRANCISCO OFTEN IN THE 60S, AND WE WERE SOON PERFORMING together. I had been improvising a solo that I called Apple-Box⁹ in which I attached a piezo contact microphone to an apple box, and used it as a resonator for a variety of small found objects clamped or held on the box, and struck, bowed or strummed with the vibrations amplified and sent to speakers. David joined me to perform Apple Box Double (1964).¹⁰ In those days an apple box was made of wood with half inch solid end pieces and quarter inch sold side and bottom pieces. I still have a couple of antique apple boxes available for performances. Later in January of 1966 I formed a ten person. Apple Box Orchestra with performances at the Marine's Memorial Theater in San Francisco. There was still no portable mixer available for live electronic performances, so Apple Box Orchestra featured separate speaker channels for each player with all ten glowing tube amplifiers loaded onto a tabletop that was ported into the theater.

David Tudor curated the music, and I organized the Tudor Fest for the SFTMC in 1964. There were three concerts, each performed twice, with music by John Cage, Toshi Ichianagi, Alvin Lucier, and me. Performers included John Chowning, Stuart Dempster, Warner Jepson, Douglas Leedy, Robert Mackler, Pauline Oliveros, Dwight Peltzer, Ann Riley, Terry Riley, Loren Rush, Ramon Sender, Stanley Shaff, Linn Subotnick, Morton Subotnick, Ian Underwood, and Jack Van der Wyk.

Cage was still rather raw from the treatment he received from the players in the New York Philharmonic Orchestra. They had sabotaged the performance of his Atlas Eclipticalis.¹¹ Under the tutelage of David Tudor we performed Atlas Eclipticalis with the respect that it deserved. David was meticulous in his performance practice, and gave full attention to every detail of the score and means of performance. As prescribed by Cage in the score we used an individual contact mic for each instrument. There were no performance mic mixers available in bigger than 2 channels, certainly not the sixteen or more channels needed for this performance, so our technician Michael Callahan (barely out of high school) devised a box with a knob and pad for each mic.

David and I performed my *Duo for Accordion and Bandoneon with possible Mynha Bird Obligato*, see saw version¹² in the *Tudor Fest*. The see-saw staging for the piece was conceived and created by choreographer Elizabeth Harris. Though there were no electronics the effect of the seesaw motions served to throw our sounds around the space. We were seated on opposite ends of the seesaw that went up and down, around right or left and had swivel chairs. All of this turning caused sounds to be reflected off the walls, floor and ceiling in different ways from our different movements and speed of movement in space.

The intense creative activity of 1964 culminated in an SFTMC national tour featuring Ramon Sender's *Desert Ambulance*,¹³ *Mort's Mandolin*,¹⁴ my *Mnemonics III*,¹⁵ and a group improvisation with Mort on Clarinet, Ramon on piano and me on French horn. Our tour took us to Ann Arbor where we met composers Gordon Mumma, Robert Ashley, film maker George Manupelli, performance artist Mary Ashley of the Once Group for the first time, although we had been corresponding by mail and playing their tape music at SFTMC.

From Accordion to Electronic Music

IN 1965 I WAS TAKING MY MID-NIGHT TURN IN THE SFTMC STUDIO. WHILE STARING AT THE THREE LARGE Hewlett Packard Oscillators and studying the interface with the large dial and the switch for different frequency bands I noticed that the oscillator could be set above the range of hearing. My experience with

playing difference tones on my accordion came to mind. My teacher, Willard (Bill) Palmer, had taught me to play high frequency intervals and pull the bellows hard so that I could hear the difference tones change as the intervals changed. I immediately wanted to try this with the oscillators. I set about switching the range of two oscillators above hearing, patched them to speaker and was disappointed to hear nothing. Then I thought maybe I needed an amplifier to hear the difference tones. Sure enough when I patched in a line amplifier there was a beautiful full-bodied difference tone. This was one of those unforgettable moments of revelation. The sound felt fantastic. I was only hearing the difference tone as the generating frequencies were above the range of hearing. I had always wondered what that might sound like without hearing the generating tones and now there in the wee hours of the morning in the studio I was hearing a lone difference tone filling the space around me and resonating my body.

Now, those huge dials on the oscillators had a new life for me. The slightest turn produced new frequencies and new sounds from heterodyning or frequency modulation. I combined these sounds with tape delay and very shortly began producing my first electronic music – that is music from electronically generated sounds. I did this in real-time with no cutting and splicing of tape as a studio performance.

I had the idea that I wanted to add a record into the tracks through the patch bay, so I picked up a record that was lying on a nearby table and put it on and patched in the turntable along with the oscillators. I didn't know what the record was and didn't care. I wanted to be surprised. By this time I was using a variety of routing configurations by feeding tape tracks crisscrossing back from a second tape machine with the tape shared between the two machines. Track 1 playing back to track 2 from tape machine 1 and Track 2 playing back to track 1 etc. I played the oscillators, dropped the needle on the record and heard the crisscrossing thumping sound then an orchestral attack that began to answer itself, then the Aria from Puccini's *Madam Butterfly*¹⁶ which I accompanied by improvising with my difference tones and voila *Bye Bye Butterfly*¹⁷ - an early re-mix.

Meanwhile downstairs in the concert hall Don Buchla was demonstrating his new 100 series Modular Electronic Music System based on advice from Mort and Ramon. This was an enormous achievement for electronic music eliminating the need for cutting and splicing tape, enabling sequencing of sounds and making live performance possible. The Buchla Box as we called it would occupy my attention in the next few years. Mort used the Buchla Box to compose *Silver Apples of the Moon* (1967), and to realize his idea of the vinyl record as venue for his composition with Nonesuch Records. "This was the first time an original large-scale composition had been created specifically for the disc medium -- a conscious acknowledgement that the home stereo system constituted a present-day form of chamber music."

1966: University of Toronto Electronic Music Studio

IN ORDER TO GAIN NEW KNOWLEDGE OF AN ELECTRONIC MUSIC STUDIO AND ITS OPERATION I TOOK A SUMMER course at the University of Toronto with composer Gustav Ciamaga and engineer Hugh LeCaine. This was very enlightening as all I knew was our funky SFTMC studio with a hap hazard array of pooled, borrowed, and donated WWII surplus equipment, none of which was originally intended for making music. At the University of Toronto Electronic Music Studios (UTEMS) I had the opportunity to work in a well-equipped and maintained "classical" electronic music studio. I am indebted to Hugh LeCaine for my experience of this magnificent studio. Hugh LeCaine was a very creative engineer whose invention of the electronic Sackbut predated and inspired Robert Moog to build his synthesizer. At UTEMS we encountered LeCaine's twenty-channel loop machine with all the loops running on a single capstan. Though he did not claim to be a composer LeCaine's tape piece *Dripsody* (1955), made from a single drop of water, is a classic in the field.

I lost no time setting the twelve Lafayette Signal Generators in the studio to above the range of hearing with the luxury of using one below the range of hearing to implement amplitude modulation. Early in my six-week stay I made *I of IV*¹⁸ – another unforgettable experience. There were four speakers in the UTEMS studios. Even though the destination tape was stereo the opportunity to hear my work in four channels was significant. My delay configurations meant that I could patch track 1 from the first machine to speaker 1, track 1 from the 2nd machine to speaker 3, track 2 from machine 1 to speaker 2 and track 2 from the second machine to speaker 4. Thus I could hear *I of IV* as a four-channel piece while improvising it in real time but the result could only be recorded in a stereo version with two of the four channels virtual within the stereo.

I made three pieces that day then the fourth one - *I of IV* exhibited some really unusual characteristics. There were some delicious sounds that looped continually with new material forming low

and moaning resonances. The amplitude modulation was working beautifully. Suddenly about mid-way a screamer came out of nowhere and dominated for some incredible moments in the piece. The enormous melody ranged from the low end to the high end and prevailed over everything in canon with itself until it finally dissolved into the background and the piece continued roiled by that amazing entrance.

Composer Reynold Weidenaar was in the studio at the time listening in. I was laughing hysterically at the wonder of the sounds that emerged. To this day I of IV is one of my own favorites. David Behrman produced it on another Odyssey Record in 1969 along with *Come Out* by Steve Reich and *Night Music* by Richard Maxfield.¹⁹

It is only now in 2012 that Important Records has released a Box Set of all of my unreleased electronic music of the 60s most of which has been sitting on the shelf since my residency that summer at UTEMS. The Box Set includes all the music that has not been released by other labels from my home studio, SFTMC, UTEMS, MTMC and UCSD.

The work at UTEMS was the last of my oscillator difference tone pieces. The Mills Tape Music Center consisted of the new Buchla 100 series Modular Electronic Music System and new professional Ampex and Scully tape machines. As the director I had to learn the new system and demonstrate it to students. This meant teaching myself as I had taught myself about the oscillators. There were no courses available to learn new music technology.

In my year as director of the MTMC I made a number of pieces including *Beautiful Soop*²⁰ and *Alien Bog*.²¹ I continued to use my tape delay system with the Buchla Box. I became very involved with the ability to develop patches between modules. I would invariably find ways to use feedback to enrich the sound. The difference between transistor and tube oscillators was huge for me. What was gained in ability to control signal flow was lost in terms of sound qualities.

8x4 Mixer for Live Electronic Performance

MY FIRST TAPE PIECE, TIME PERSPECTIVES, PLAYED IN FOUR CHANNELS USING TWO STEREO TAPE MACHINES. Multi channel diffusion continued to be of interest to me. I wanted to have more than one channel of sound for pieces that I could perform live, so I designed a mixer for this purpose that was built by Carl Countryman in 1967. It was an eight by four channel mixer with eight high/low impedance inputs, and four outputs that fit in a neat brief case for portability.

I planned to use it at the *First Festival of Live Electronic Music* (1967) that took place atop the Cyclotron at University of California Davis hosted by composer Larry Austin. I set up my equipment but I was not able to get the mixer to work for that performance. It turned out that the power supply had fallen out of its socket—the hazards of live electronic performance struck early for me.

Tony and I collaborated on *Circuitry for Light and Percussion*²² (1966) using my Countryman mixer and a Countryman SCR controller that Tony designed. There were five percussionists each with a separate mixer channel with output to the SCR matrix that controlled score lights that indicated what the percussionists would play in a giant feedback loop. Each player had an on/off light indicating when to play. Action from the players determined who would play when and what. A lighting design by Tony was also a part of this circuitry so that suddenly a bass drum would light up or lights would sequence around the solo trap drummer or shadows of other interesting objects would appear.

Joining Academia: The University of California San Diego

HAVING SPENT 1967 DIRECTING THE MILLS TAPE MUSIC CENTER I ACCEPTED A POSITION AT THE UNIVERSITY OF CALIFORNIA SAN DIEGO MUSIC DEPARTMENT AS LECTURER. I was hired on the basis of my five years experience with electronic music, gained in my home studio, with the SFTMC, and at Mills. UCSD wished to establish a program in electronic music for the graduate students. The Music Department purchased both Buchla and Moog electronic music systems, and established an excellent recording studio. I taught electronic music studio technique, composition, and eventually offered a course in the history of electronic music. My first graduate student was Allen Strange, who went on to write *Electronic Music: Systems and Techniques*,²³ which became a classic in the field.

Perception, Awareness, Consciousness

With the writing of *Some Sound Observations* (1968)²⁴ published in *Source: Music of the Avant Garde* (edited

by Larry Austin and Stanley Lunetta) my attention was turning to perception, awareness and consciousness. I was observing how my mind was changing with sound and how I was listening. I began to meditate on long tones that I played on my accordion and sang. Each tone became its own universe of sound as listening deepened.

In 1970 I formed a women's improvisation group for performing and continuing my interest in the study of mind/body practices. We met once a week at my house in Leucadia CA to share journals, dreams, bodywork and *Sonic Meditations*.²⁵ *Sonic Meditations* are instructions for directing attention to listening. Working with this group helped me to integrate the growing awareness of the experience of listening as distinct from or as a result of hearing.

As discussed in *Software for People: Collected Essays 1963-1980*,²⁶ I thought of my *Sonic Meditations* algorithms or recipes in prose that produced musical results without the necessity of conventional music notation or training. More importantly my concern was how to program groups of people to draw on their basic creativity to produce a sonic event. Each *Sonic Meditation* directed attention to ways of listening and ways of sounding. Therefore anyone could participate with this software for people.

My first *Sonic Meditation* – *Teach Yourself to Fly* – directed attention as a starting point to observing breathing. This meditation is best lying down in a dimly lit space. I asked for the participants to simply observe their own breathing without voluntarily changing breathing. This tactic was based on my understanding that breathing would change involuntarily without willing it to change simply because there was observation. The second point was to allow the breathing to become audible with air escaping from the lips still just observing. The third point was to avoid habitual singing patterns by asking that the vocal cords be allowed to vibrate with out willing any tones. This meant that the sounds came out of the escaping air and roughly followed the breath. With a group participating together the sound accumulation sounded rather like airplane motors with a very grainy and dense texture developing. If anyone disregarded the instructions and simply started to sing the difference would stand out strikingly. The fourth point was to increase the volume of the sound to maximum then gradually return to breath and finally back to observation of the breath.

From *Sonic Meditation* I began to compose more pieces that directed attention rather than prescribing notes and rhythms. I was recognizing the algorithmic nature of *Sonic Meditations*.

Center for Music Experiment and Related Research

THE CENTER FOR MUSIC EXPERIMENT AND RELATED RESEARCH (CME) WAS FOUNDED IN 1973 AT UCSD with Roger Reynolds as its first director. I was a charter member of the Music Department, and led the first faculty project, which involved twenty participants, working for four hours a day, five days a week for nine weeks exploring mind/body practices and doing *Sonic Meditation*.

Brain waves of participants were measured at the beginning and end of the project. Most participants had high amplitude alpha waves on one hemisphere of the brain. At the end of the project the alpha waves tended to be more balanced between the hemispheres. This suggested that the practices and *Sonic Meditations* might bring about such a balance. Clinical Psychologist, Ron Nelson, did imaginal measurements of all the participants before and after the project, and found similar results. There was no one around at UCSD at the time called a Neuroscientist or a Cognitive Scientist. Although Ron Nelson understood the project well we missed the opportunity to follow up on our data. I still hope that I can connect with scientists interested in exploring and measuring the effects of *Sonic Meditations* and *Deep Listening*.

Center for Computer Research in Music and Acoustics

IN 1975, WITH LOREN RUSH, JAMES (ANDY) MOORER, AND JOHN GREY - JOHN CHOWNING FOUNDED THE *Center for Computer Research in Music and Acoustics*. (CCRMA), which remains one of the leading centers for computer music and related research. CCRMA was housed in a wonderful old roundhouse building away from the center of the campus. The building was the home of Stanford Artificial Intelligence Laboratory (SAIL) founded by John McCarty, and computer music research was given late night when traffic was light. A natural exchange between artists and scientists developed easily with proximity to each other.

In 1979 I was invited to teach composition for a semester at Stanford University. By this time, CCRMA was the leading center in the world for developing the use of computers for musical synthesis and composition. This gave me the opportunity to renew conversations with my old friend Loren Rush,

who was becoming a leading expert on digital recording. We spent a lot of time listening to recordings and discussing the qualities that we heard comparing digital and analog versions of the same piece. Analog artifacts such as hiss and hum in the noise floor were gone in the digital recordings. I also did some basic computer music work at (CCRMA). Trying out some of my programming ideas I managed to crash the system at least once!

Computer programming was not for me at this stage. I was rooted in sound and had not the patience to punch in numbers and wait for them to crunch. The yield was not interesting enough to engage me. However, I enjoyed the ambience and camaraderie at CCRMA.

1980s: The Move to Digital Electronics

AFTER A SABBATICAL LEAVE SPENT PARTLY IN THE NORTHEAST I RESOLVED TO RESIGN MY FOURTEEN-YEAR position at UCSD. I was interested in developing my work in new ways and needed free time to do that. I moved in 1981 to Mt Tremper in upstate New York, and lived in an A Frame on the grounds of the Zen Mountain Center. During my two years there I had opportunity to participate in Zen practice, and to meet the highly accomplished Watazumi Do Dozo Roshi bamboo flute player. I became involved with the Creative Music Studio in West Hurley. I offered workshops in *Sonic Meditations* and met many wonderful musicians.

Though I was not to become a computer programmer I found myself thinking conceptually about how to work with computer programmers. Composing *Sonic Meditations* was a preparation for thinking conceptually about data structure. I had learned a lot while hanging out at CCRMA and listening to conversations—ever the autodidact.

I acquired my first Apple Computer in 1983. The very flaky electricity in my A Frame was just enough to run a computer. My first use of my new computer was word processing. After years of writing and rewriting hand written or typed papers the computer felt like a God send. I loved the ease of editing. I would throw a lot of text on screen then move it around again and again until it felt right.

I was not too interested in musical uses of the computer at the time. My deep devotion to the immediacy of sound was not satisfied by the programs of the day. These programs were mostly about frequency and amplitude. My bent was to timbre, texture and density. Playback of melodies on the computer seemed too perfect and mechanical, the sounds too synthetic. I missed the expressive “imperfections” of a human performer, computer generated rhythms seemed lifeless.

Until my next acquisition, a pair of Lexicon PCM42 digital delay processors, my solo and ensemble performances were with my unprocessed accordion. The sound of the PCM42s was good (because it was partly analog) and Lexicon engineer Gary Hall had included some performance parameters for the processors that made them a great substitute for the tape machines that I had lugged around to performances. With two processors I could use one each for the right and left hand sides of my accordion. Delays of up to ten seconds could be looped, modulated by sine, square waves and envelope following, with speed and depth control. Later on I would develop this into what I began to call the *Expanded Instrument System* (EIS).

In 1984 I experienced my first really long reverberation time in an underground cistern in Cologne Germany. The reverberation time was 45". I recorded *The Well* and *The Gentle* for the album *Vor der Flut*.²⁷

Back in Mt. Tremper I returned to improvisation with found sounds and microphone to work with my Lexicon delay processors and learn all of their functions. Music for choreographer Elaine Summers' *Flowing Rock/Still Waters* 1986 at Lincoln Center Out-of-Doors was performed with this system.

Dear John: A Canon on the name of Cage

IN 1986 I TRAVELLED TO MILLS COLLEGE IN OAKLAND, CALIFORNIA TO BEGIN WHAT WOULD BE A CONTINUING series of collaborations with programmers who would help me to realize my algorithms. *Dear John: A Canon on the Name of Cage* was commissioned by WDR Köln in celebration of John Cage's 75th birthday. It was conceived so that each time the program was executed a different version would play. The program was to be activated by visitors to an installation to punch a start button and receive a unique five-minute piece honoring Cage.

I designed the data structure for the program that guaranteed unique rhythms, timbres, dynamics, voices and octaves for every execution with pitch material limited to the notes C A G E. The program-

ming was done in an early version of Hierarchical Musical Specification Language (HMSL) by Larry Polansky at Mills College. The program drove 12 voices of a Kurzweil 250 keyboard. We were unable to realize the installation for Cage's birthday in Cologne because it was prohibitive to transport the equipment from the Mills studio to Cologne. So six different recorded versions of *Dear John* were used instead.

In 2003 the HMSL program for *Dear John* was translated to Max/MSP by Masaki Kubo and uploaded to the web.²⁸ Now in 2011 I am once again visiting the program. There is a great difference in the sounds from the 2003 version of MAX compared to the robustness of the 1980's Kurzweil 250 synthesizer. I am wishing to substitute sounds of different quality to be closer to that analog quality. There is always a difference in the sound when different media is used, this is why it took me a long time to move into digital electronics.

Developing the Expanded Instrument System

WORKING WITH THE DELAY PROCESSORS I GAVE A LOT OF ATTENTION TO WAYS OF PLAYING THAT WOULD disguise the mechanical repetitions of the delays by layering and introducing new sounds that would throw off or mask the repetitions much as I had done with my oscillator pieces of the 1960s. To achieve this I needed a lot more than two delay processors. After a while I had acquired six PCM42s. I also then acquired the need for a partner to help with signal routing and control of all the faders, this led to using a 24X8 mixer for the first time. Mixers proliferated at last.

Richard Zvonar, a former student from UCSD, was my first mix partner. We recorded *The Beauty of Sorrow for Tara's Room*²⁹ 1987 at Harvest Works in New York using a small accordion tuned in just intonation with the help of tuner Alfred Shabda Owens. This was my first venture in using Just Intonation and my Expanded Instrument System.

My second partner with EIS was Panaiotis, a Ph.D. graduate in composition from UCSD. Panaiotis was also a singer, and a skilled sound engineer. He was able to handle the configuration of the mixing board and signal routing that I could not manage on my own in performance while playing the accordion with both hands and manipulating pedals with both feet.

We traveled in Europe with EIS and performed in Germany and Switzerland. We also made a recording of *The Roots of the Moment*³⁰ or Hat Art records in 1987. Recorded at Studio Lussi, Allschwil, Switzerland on November 10, 1987. This piece was a benchmark in my ability to control modulation with my foot pedals. By this time I was interested in changes in the quality of spaces (both real and digital) as integral parameters of composition. Panaiotis had a good sense of how to use reverberation with Lexicon PCM70s to change the acoustic space, as was my wish.

Echoes from the Moon

I HAD WATCHED THE MOON LANDING IN 1969 WITH GREAT INTEREST. I THOUGHT THAT IT WOULD BE WONDERFUL to touch the moon with sound and hear it come back to earth. I wanted to make an installation that would allow visitors to send their voices to the moon and hear the return. Scot Gresham-Lancaster helped me with the research, and located Dave O'Lean, a Ham Radio operator and antenna maker who was first to bounce Morse Code off of the moon in the 1970s to enable longer distance Ham Radio transmissions.

I went to Dave's studio in Lebanon Maine in 1986 taking a few instruments. Using Dave's equipment the first sound I sent to the moon was a pitch from my accordion. The sound came back four seconds later modified by a slight Doppler shift (up if the moon was setting, and down if the moon was rising). The reflected sound was also somewhat thinner than the original. Now I had a delay system with the moon!

Sometime later I collaborated with sound system designer Andres Bosshard for a performance in the Domplatz in Salzburg, Austria. Four speakers were mounted on buildings around the Domplatz in a quadrasonic system for my accordion signals. These signals were also sent to the moon. An array of small plastic speakers was suspended over the heads of the audience to receive the echoes from the moon. Prior to the performance Ione, a partner and long time collaborator of mine, carried a microphone around to audience members so that they could send their voices to the moon and hear the return.

A Deep Listening and Deep Listening Band – Born in a Cistern

LISTENING TO REVERBERANT SPACES IS A LONG TIME INTEREST OF MINE. DIFFERENT SPACES AFFECT THE qualities of sounds. A benchmark recording occurred in October 1988 – *Deep Listening*³¹ was born in a cistern with a 45” reverberation time (Ft. Worden, Port Townsend, Washington). Stuart Dempster introduced Panaiotis and me to this space. Access was via a single opening in the top of cistern down a ladder fourteen feet long to access an empty sixty foot diameter underground space had once held sixty million gallons of water for the Army. Recorded by Al Swanson and released by New Albion Records in 1989 *Deep Listening*³² the recording is the signature recording of the *Deep Listening Band*.

Once again in my life the nature of a special kind of sound expanded my consciousness. My experience in the Cologne cistern in 1984 for the recording of *The Gentle on Vor der Flur*³³ was expansive, but the cistern at Ft. Worden is truly unmatched by any other reverberant space in my experience. The sentience of so much mirroring of sound from one’s direct sound was almost unprecedented. We immediately dreamed of simulating this space for concerts elsewhere where audiences could experience this remarkable environment. This simulation was to be a very long time coming. More than twenty years later RPI’s Jonas Braasch has made our dream of making the cistern available for our performances in venues come true by programming a simulation that we will perform with at the Experimental Media and Performing Arts Center on May 10, 2012.

Crone Music with Spatial Progressions

I HAD A LONG-STANDING INTEREST IN THE POSSIBILITY OF PERFORMING WITH SPATIAL PROGRESSIONS, AND my work with tape delay showed me that manipulating the amplitude of the delays created the illusion of spatial change. By 1989 *Crone Music*³⁴ recorded at Harvest Works embodied spatial progressions and I felt that I could speak of The Expanded Instrument System (EIS). What it meant to me was the ability to perform in the past, present and future simultaneously with alterations of space as well. I did keep wishing for more delay processors in order to increase the effectiveness of my space/time machine – EIS.

1990: Working with Programmers

A RESIDENCY AT THE BANFF MEDIA CENTER IN ALBERTA CANADA GAVE ME THE OPPORTUNITY TO WORK with computer programmer Connie Colyer, who had worked for many years with composer Iannis Xenakis. With Colyer I was interested in direct data transmission from a program which she wrote in C++ to control my Lexicon PCM42s. My idea was to transcend what I had been doing with voltage control from my foot pedals in *The Roots of the Moment*³⁵ and *Crone Music*. I wanted what I called a *Super Foot*. I had developed my pedal technique over the years, but was frustrated that I couldn’t move either more extremely slowly or faster to control the delay processors and their built in functions. The computer program would surpass my physical abilities.

The Lightning Box: A one-hour sound meditation with computer controlled delay processors and lighting was performed February 22 1990 in the Media Arts Project Studio, Lougheed Building, Banff Centre with Pauline Oliveros – accordion; Michael Century – keyboard; Cornelia Colyer – programmer; Colin Griffith - set-up design and technical assistance; Panaiotis - voice and Mmx; Trevor Tureski – marimba. *The Lightning Box* called for each player, as they were listening to their sounds being repeated and modified, to respond to the modifications as well as to each other. The ensemble was conducted in entrances and exits by a computer controlled lighting design. Sound output from each player was processed by computer controlled digital delays I designed. The delay times were changed by the program effecting transposition and pitch bending in a variety of forms and speeds. David Ward of Pan Digital Inc. constructed the digital interface that allowed program control of the delay processors. This was the lightning box.

The result was thrilling. I will never forget the feeling of my sounds being modified by an energy dislocated from my own body - modulations that I had imagined, and Connie had programmed that couldn’t be accomplished with my foot pedal.

I was disappointed though that I had not built in randomly changing algorithms to the program. It was hard wired in one way as a composition. This was a limiting factor at the time as there was no way to modify the program. It was written and that was it as far as Colyer was concerned. For me I had

learned an important lesson about collaborating with a computer programmer!

1991: Electronic Mid-Wifery – Four Decades of Composing

FOR A CELEBRATION OF *FOUR DECADES OF COMPOSING 1951-1991* I INVITED FRIENDS TO PARTICIPATE IN A video-telephone transmission between six cities. This network was set up by Joe Catalano and Eric Murphy as a telephone bridge conference call of three hours. The audio was continuous, but the video updated every five seconds as a still image, these were hilarious since there was no way to know what would show next. There was a twenty minute curated broadcast from each city, all participants could see and hear one another.

After all of the cities had broadcast we engaged in a six-city improvisation. Since whoever grabbed the line first, i.e. loudest signal would be heard and not the others it was important to respect the situation and make space for other performers. The improvisation worked well.³⁶

1990: Contender – Digital recording & Mixing

THE SOUND TRACK FOR *CONTENDERS* IN COLLABORATION WITH CHOREOGRAPHER SUSAN MARSHALL involved a mix of sports stadium roars, chants, pistol shots, and a series of ten pop songs meant to sound familiar that I created especially for the work. The sound files were recorded on DAT by me, and mixed by Panaiotis on computer with accordion EIS tracks that I made. This was a first use of computer mixing for me. The realism of the crowd sounds was very integral with the choreography, and was so convincing for the audience that *Contenders* won the Dance Theater Workshop Bessie Award in 1991. Our all night sessions waiting for the computer to crunch all the numbers paid off.

Warrior: an Application of GSF Technology

SINCE MY RESIDENCY AT CCRMA IN 1979 LOREN RUSH AND I HAD CONTINUED OUR CONVERSATIONS about Virtual Acoustics; the enhancement of live performances; how to mix contemporary instruments with older instruments; how to hear the detail of the music regardless of the size of the hall: how to show new things that can be done with acoustic instruments; how to make electronic instruments sound acoustic; and how to achieve excellent recording and careful mixing. These conversations eventually led to the founding of *Good Sound Foundations* (GSF) a non-profit organization dedicated to enhancing acoustic spaces and recording studios through technology. From my 1953 recording experience with my first tape recorder my consciousness of sound was changed forever. Loren was invested in good sound. All of his pioneering work with colleagues at CCRMA on the transition from analog to digital recording that led to the CD not only changed his consciousness—the consciousness of audiences listening to live music was also changed. The need for good quality sound was not generally understood until people got used to the clarity of detail that they heard in music played on a CD on their home systems. Audiences became more conscious of bad sound in many concert halls and theaters, and the blurring of detail in music and theatrical performances. Concert hall acoustics became a hot topic. Loren wanted amplified sound to blend perfectly with acoustic sound, achieving this including working with Meyer Sound Laboratories speakers, which could be tuned to the performance space for the best frequency response by Source Independent Measurement.³⁷ In the 1980s Loren Developed the Virtual Acoustic Environment VAE - a way of creating moveable electronic walls.

I was eager to try the virtual acoustical environment (VAE) for *Njinga the Queen King* (written and directed by Ione with my music and sound design). I wanted the actors on stage to be understood with the clarity of detail that could be possible through an enhancement system, and for the actors to hear everything clearly on stage, knowing that it would enhance their performance. I also wanted my sound design of four different spaces (savannah, ancestral world, CIA Angola 1970s and New York City) to be felt by the audience as real spaces with no consciousness of sounds emanating from sound system speakers. Finally, I wanted my music also on sound track to mix and blend seamlessly with on-stage traditional African music (drumming and singing).

GSF used a thirty-five-speaker array with the system designed by audio engineer Jim Meschter with Loren's VAE programming in the Majestic Theater at Brooklyn Academy of Music (BAM).

There were two hundred forty-seven sound cues delivered from three Professional Panasonic DAT machines with remote controls. Sound cues were sent to the mix operator for distribution to the speaker array. Each DAT machine had to be started and stopped by the operator. A second mixing board operator managed the onstage body mics for the actors. Over the eight years of creating and performing

Njinga the Queen King the technology changed from DATs to CDs to CD ROM with computer control so that the mix operator could punch cues independently, and do the live performance mixing. With sound tracks I always consider live performance mixing to be essential.

The sound system for *Njinga* was revolutionary yet under noticed. This is partly because the system was designed to be 'inaudible', so the sound could be realistic, and for audiences to not notice that sound was coming out of speakers. The sound for *Njinga the Queen King* at the Majestic Theater was extraordinarily beautiful. Because it was successful and very transparent there was no consciousness of how it was happening! Due to the high cost of a large speaker array and processing we were unable to continue this standard for sound in subsequent performances elsewhere continuing up to 1998.

EIS from Analog to Digital

EIS WAS STILL A PAIN TO MANAGE WITH ALL THE PROCESSOR KNOBS TO TURN WITH BOTH HANDS AND FEET occupied during performances. Control of EIS was separated from the performers through a centralized mix station operated by Panaiotis. Through Loren Rush I heard about the *Reson8* a multiprocessor digital signal processing system for music and audio applications designed by Adrian Freed and Marie Baudet of CNMAT in Berkeley California. This was the first reasonable and portable solution for gaining program control over multiple delays and modulations that was available. My EIS system was ported to the *Reson8* in 1991, and first used with the Deep Listening Band. This was the continuation of computer control of delays begun at Banff Centre with David Ward's interface. The *Reson8* was not as flexible as we needed it to be, and meant that centralized control continued. So we were soon onto the next solution.

EIS was ported to *Max* in 1993 By David Gamper. David designed a multi-function foot control in *Max* for EIS. This enabled selection of controllable parameters on the fly. This was the best solution so far in the evolution of EIS to decentralize control so that each performer could choose and handle performance parameters at their own personal station.

In order to develop some new ideas about EIS I began to work with *Max/MSP* programmer Stephan Moore, then a graduate student at RPI. I wanted to develop some algorithms for modulations and spatial progressions for a new piece. These developments were applied in *Sound Geometries for chamber orchestra* (2001), which was performed in Brussels by Ensemble Musique Nourville. Stephan programmed ten geometric figures for sound to travel in the space around an eight channel Meyer Sound system installation. These geometries interacted with *SPAT*, the spatialization program from IRCAM that was incorporated in EIS at that time. The geometries could be sized and modulated during performances.

With the spatial geometries there was the illusion that different performers in the fifteen-piece ensemble would lift off into solo movement traveling and sounding in space around the audience. The whole ensemble at times seemed to lift off from their static position on stage. These geometries became an integral part of EIS as it continues to evolve.

2001: Rensselaer Polytechnic Institute (RPI)

RPI IS THE OLDEST TECHNICAL INSTITUTE IN AMERICA FOUNDED 1924. WHEN THE CALL CAME FROM CHAIR and composer Neil Rolnick to inquire if I was interested in leaving Mills College where I taught from 1995 to teach at RPI I was hesitant to leave the nurturing environment and composer's paradise at Mills. I enjoyed my students, connections with my old California friends, and my annual trips to the Bay Area from my home in Kingston NY. Neil lured me to RPI with word about the new Experimental Media and Performing Arts Center (EMPAC), and President Shirley Ann Jackson's plans to make RPI a top tier research university with a focus on technology. Rather than let go of my teaching at Mills I managed to keep teaching for two hours a week in the fall semesters using conference phone and Yahoo Video Messenger gradually changing to *iChatAV* then to *SKYPE*.

Experimental Telepresence

EXPERIMENTAL TELEPRESENCE DEVELOPED AS MY RESEARCH PROJECT AT RPI BECAUSE OF MY INTEREST IN distance performance and teaching. I was convinced too that internet work would be valuable for artists and education as the technology developed and improved, and I also wanted to perform with my California friends. RPI had an internet2 connection so I set about working with it. Since Mills did not have an inter-

net2 connection I connected at first with Scot Gresham-Lancaster of The Center for Immersive Technologies (CIT) at California State University at Hayward (CSUH). Mills students were able to travel to CSUH to participate in the first performance. Peerings³⁸ involved collaboration with Brian Lonsway of project *Synthetic Space Environment* (SPE), RPI Architecture Department, and performers from Mills College and RPI. Brian used blue screen for his design students to create performable moving sets accommodating vocalists, dancers and musicians from RPI and CSUH to perform in the same virtual space together. Our first performance also spawned an Internet synthesizer that could be played on line by four players in different locations. The programmer was Mills graduate student Tadashi Usami, with input from RPI graduate student Doug Van Nort.

In 2006 I began working with *JackTrip*, a low latency software for multichannel CD quality audio transmission over internet2. *JackTrip* developed by Chris Chafe, director of CCRMA. We began a weekly connection between RPI's iEAR Studios and CCRMA involving many different ensemble situations, and eventually performances. The weekly connection gave Chris opportunities to tweak the software, and offered a learning opportunity for my students. Performing at a distance with others using uncompressed audio is not plug and play yet, but it will eventually be possible to play with anyone who is connected as easily as sitting down with someone in the same room.

In 2008 the Deep Listening Institute³⁹ funded by the New York State Council on the Arts commissioned four composers to write pieces specifically for telepresence transmissions. The program – *Telemergence* conducted by Sarah Weaver- included: *Here Right Now* by Monique Buzzarté, using the network as a virtual concert hall; *Long Distance Sitting Piece #2: Untitled Sit for Multiple Virtual Bodies and You* by Michele Nagai, creating a meditative atmosphere throughout the network for Zen like entries; *NOW! ... and then?* by Kristin Norderval, proposes listening and processing strategies across the network; *and the curved gap* by Will Swofford, disseminating a soft drone throughout the network with players influencing each other. These pieces received premiere performances between iEAR Studios RPI, VistaMuse University of California San Diego and CCRMA Stanford on April 27 2008. Recorded at CCRMA these pieces sound phenomenally clear as if in the same space.⁴⁰

Telepresence was also employed in the 2008 project *Sedimental Journey: Through the Net*, a celebration of 50 years of musical friendship with Stuart Dempster. We used iChatav to accommodate an audience at Mills College. Stuart performed from DXArts at University of Washington in Seattle, I performed from iEAR Studio at RPI in Troy, our images appeared together on screen at Mills College where our major audience was gathered in the Concert Hall. Two dancers organized by collaborator/choreographer June Watanabe improvised on stage at Mills. Their images were intermittently projected on screen with our images. Audience members reported that the intimacy of this concert was extraordinary, perhaps because I processed both Stuart's and my sounds with EIS, and our images were larger than life and slightly overlapped on screen.

2008: An Artificially Intelligent System

In 2008 RPI COLLEAGUE JONAS BRAASCH AND I RECEIVED AN NSF *CREATIVEIT* GRANT, WHICH ALLOWED US TO WORK WITH DR. DOUG VAN NORT ON *A Robust Distributed Intelligent System for Telematic Applications*. This pilot project was based on my EIS and Doug's GREIS (a grain based system, which included feedback delay and resonant filters).⁴¹ We wanted to design a system that could listen to live musicians performing, recognize gestures and textures, and join in the performance creatively, as well as conduct or coordinate players across the network. In 2010 Selmer Bringsjord of RPI's Cognitive Science department joined the project to introduce a Reasoning Module. This incarnation of the project, *Creative Artificially Intelligent Reasoning Agent* (CAIRA), was also funded by the NSF.

From the beginning of our project we formed *Triple Point* a trio using our own instrumentation: Braasch—soprano saxophone, Oliveros—accordion, and Van Nort—laptop. Our ensemble is a laboratory for testing the system, for telematic connections with other ensembles, and for public performances, demonstrations and recordings of our work-in-progress.

As our project moves forward and the software acquires more intelligence I am remembering the thrill of performing at Banff with my delay processors under program control for the first time. There is something special about performing with *Freeling Improvising, Listening, and Transforming Evolutionary Rominant* (FILTER) (Doug's name for the agent that he is creating). There is always surprise and coherence as the material that we play is recognized and we have an artificially intelligent agent making the Triple Point Trio into a quartet.

2012

EASING INTO THE EIGHTH DECADE OF MY LIFE JOURNEY I AM EXCITED! IN WRITING THIS ARTICLE I HAVE DISCOVERED my Popeye Club, Buck Rogers, Wilma Deering cultural beginnings and made the connection from Dr. Huer and the *Wonders of Science* to Nikola Tesla the genius scientist who harnessed Niagara Falls to give us alternating current and how I have been inspired all my life with the scientific discoveries intended for the good of humanity as both Dr. Huer, Nikola Tesla and Albert Einstein wanted. Now will the good guys win out?

References

1. Falkenberg, Buck Rogers Radio Script, 1932.
http://www.buck-rogers.com/radio_serial/ accessed February, 2012.
2. Randy Alfred, 'Radio Enters the 25th Century, Wired, 11/07/2008.
http://www.wired.com/science/discoveries/news/2008/11/dayintech_1107
3. Randy Alfred, 'Radio Enters the 25th Century, Wired, 11/07/2008.
http://www.wired.com/science/discoveries/news/2008/11/dayintech_1107
4. Albert Einstein, Wonders of Science, speech, 1930.
http://www.einstein-website.de/z_biography/speechfunkausstellung.html accessed March 2012.
5. Claire Falkenstein, Polyester Moon, 1958.
6. Pauline Oliveros, Time Perspectives, tape in four channels, 1961.
Recording: Pauline Oliveros, Four Electronic Pieces 1959-1966, (Sub Rosa, 2008).
7. 'Stimulating Sounds Too New To Be Named', San Francisco Chronicle, 03/26/62.
8. Oliveros, Sound Patterns, for mixed chorus, 1961.
Recordings: Various Artists, Extended Voices (Odyssey, 1967).
9. Pauline Oliveros, Applebox, 1963.
Documentation available in: David Bernstein ed., The San Francisco Tape Music Center: 1960s Counter.
10. Pauline Oliveros, Applebox Double, 1964.
Recording: Various Artists, Music from the Once Festival, (New World Records, 2003)
11. John Cage, Atlas Eclipticalis, (New York, Henmar Press, 1962).
Discussion of the New York Philharmonic performance in Benjamin Piekut, Experimentalism Otherwise: The New York Avant Garde, (Berkeley and Los Angeles: University of California Press, 2011).
12. Pauline Oliveros, Duo for Accordion and Bandoneon with possible Mynah bird Obligato, 1964.
Recording: Pauline Oliveros, Duo for Accordion and Bandoneon with possible Mynah bird Obligato (See-saw), (Musicworks, 1998).
13. Ramon Sender and Tony Martin, Desert Ambulance, for accordion, tape, slides and film, 1964.
14. Morton Subotnick, Mandolin, for viola, tape and slides, 1962.
15. Pauline Oliveros, Mnemonics III, 1965.
Recording: Tape and Electronic Music 1961-1970, (Important Music Records 2012).
16. Giacomo Puccini, Madame Butterfly, 1904.
17. Pauline Oliveros, Bye Bye Butterfly, 1965. Composed in the studio of the San Francisco Tape Music Center. Recording: Pauline Oliveros, Electronic Works, (Paradigm, 1997).
18. Pauline Oliveros, I of IV, 1966.
19. Recording: Steve Reich, Richard Maxfield, Pauline Oliveros, New Sounds in Electronic Music, (Odyssey, 1967).
20. Oliveros, Beautiful Soop, 1966. Recording: Pauline Oliveros, Alien Bog, Beautiful Soop, (Polydor, 1998).
21. Pauline Oliveros, Alien Bog, 1967. Recording: Pauline Oliveros, Alien Bog, Beautiful Soop, (Polydor, 1998).
22. Pauline Oliveros and Tony Martin, Circuitry for Percussion and Light, 1967, CCM Archive, Mills College.
23. Allen Strange: Electronic Music: Systems, Techniques and Controls, (Dubuque, Iowa : W.C. Brown Co., c1983).
24. Most recently published in Christoph Cox, Daniel Warner, eds. Audio Culture: Readings in Modern Music, (New York: Continuum, 2004), 102-106.
25. Pauline Oliveros, Sonic Meditations, (Baltimore, Smith Publications, 1974).

26. Pauline Oliveros, *Software for People: Collected Essays 1963-1980*, (Baltimore, Smith Publications/ Printed Editions 1984).
27. Pauline Oliveros, *The Well and The Gentle*, (Deep Listening Publications, 1984).
28. Oliveros, *Dear John: A Canon on the Name of Cage*, 1986.
29. Oliveros, *The Beauty of Sorrow*, 1987. Recording: Pauline Oliveros Tara's Room, (Deep Listening Label, 1987).
30. Pauline Oliveros, *The Roots of the Moment*, (Hat Art Records. 1987).
31. Deep Listening®—a practice named and created by Pauline Oliveros in 1991. Further discussion of this practice available in Pauline Oliveros, *Deep Listening: A Composer's Sound Practice* (iUniverse, 2005).
32. Most recent CD release: Pauline Oliveros, Stuart Dempster, Panaiotis, *Deep Listening*, (New Albion, 2009).
33. Various Artists, *Vor Der Flut: Hommage An Einen Wasserspeicher*, (Eigelstein Musikproduktion, 1985).
34. Most recent CD release: Pauline Oliveros, Crone Music, (Lovely Music, 1993).
35. Most recent CD release: Pauline Oliveros, *The Roots of the Moment*, (hatOLOGY, 2006).
36. This collaboration is detailed by Joe Catalano in "Electronic Mid-Wifery", *Leonardo Music Journal* Vol. 3, 1993
<http://www.jstor.org/pss/1513266>
37. Meyer Sound Laboratories Inc.
<http://www.meyersound.com/products/sim/sim2/> accessed March 2012.
38. Oliveros, 2002 <http://www.o-art.org/peerings/>
39. The Deep Listening Institute is a non-profit arts organization founded in 1985 as the Pauline Oliveros Foundation with name change to Deep Listening Institute, Ltd.
40. The scores are published in *Contemporary Music Review*, v. 28, no. 4-5, 2009.
41. Further information on Doug Van Nort's GREIS is available at <http://www.music.mcgill.ca/~doug/graneis/graneis.html> accessed