A Compositional Approach Derived from Material and Ephemeral Elements

Ellen Fullman

ABSTRACT

The author discusses her experiences in conceiving, designing and working with the *Long String Instrument,* an ongoing hybrid of installation and instrument integrating acoustics, engineering and composition.

My primary artistic activity has been focused around my installation the *Long String Instrument,* in which rosin-coated fingers brush across dozens of metallic strings, producing a chorus of minimal, organ-like overtones, which has been compared to the experience of standing inside an enormous grand piano [1].

Background

In 1979, during my senior year studying sculpture at the Kansas City Art Institute, I became interested in working with sound in a concrete way using tape-recording techniques. This work functioned as soundtracks for my performance art. I also created a metal skirt sound sculpture, a costume that I wore in which guitar strings attached to the toes and heels of my platform shoes and to the edges of the "skirt" automatically produced rising and falling glissandi as they were stretched and released as I walked (Fig. 1). A contact microphone on the skirt amplified the sound through a Pignose portable amp I carried over my shoulder like a purse. I was fascinated by the aesthetics of the Judson Dance Theater [2] in their incorporation of everyday movements into performance, and this piece was an expression of that idea; the only thing required for me to do was walk. Upon graduation I moved to Minneapolis-St. Paul, where I continued working with extended tape-recording techniques through classes I took at Film in the Cities, a nonprofit media lab and gallery. I was naively unaware that there might be a context for my work that was between visual art and music. Suddenly I found myself right at home when the New Music America festival came to the Walker Art Center in 1980. Film in the Cities presented my metal skirt performance as a satellite event of the festival. I met many people there who continue to be important to me. Alvin Lucier's *Music on a Long Thin Wire* was installed for the festival. This inspired me to explore working with long wires.

My first long wire installation used the idea of a child's cup-and-string "telephone." In my warehouse loft, I strung piano wire attached to coffee cans and suspended these with springs to each wall. I bowed the wire and sang into the cans as a way to acoustically filter my voice. One day I accidentally bumped against the wire where my bowing had left a deposit of rosin and discovered a very pure and loud sound. I replaced the coffee cans with large metal mixing bowls filled with water and rubbed the wires with my hands, tipping the bowl to modulate the sound. I wanted to be able to tune the wire, but changing the tension did nothing. I knew I needed help from an engineer. At the time I was listening with great interest to Pauline Oliveros's album *Accordion and Voice.* I could imagine making music with this kind of timbre, playing

Fig. 1. ***Metal Skirt Sound Sculpture*, 1980. (© Ellen Fullman. Photo © Ann Marsden.)**

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Fig. 2. First working installation of the *Long String Instrument* at the Terminal New York show, 1983. (Photo © Sarah Drury)

chords with many strings. I was invited to perform at the Kitchen in 1981 and moved to New York City. It was here that I met Arnold Dreyblatt at a concert at Phill Niblock's loft. Arnold invited me to his studio, where he demonstrated his instruments, the Miniature Princess Pianoforte and the miniature Portative Pipe Organ, and showed me his numerically based tuning system and scores. The acoustic sound, the weird-sounding tuning, the quirky rhythmic structure—it was a shock to suddenly find something so appealing and evolved. This was the kind of world I wanted to be in; I only needed to find technical information to develop my idea. Then Arnold told me, "You know this long string thing has been done before. . . ." He played one of Terry Fox's albums. My first response was disappointment that it had been done before, and I wondered if I should quit. When I thought about it, however, I realized that what I had in mind was very different from Fox's work.

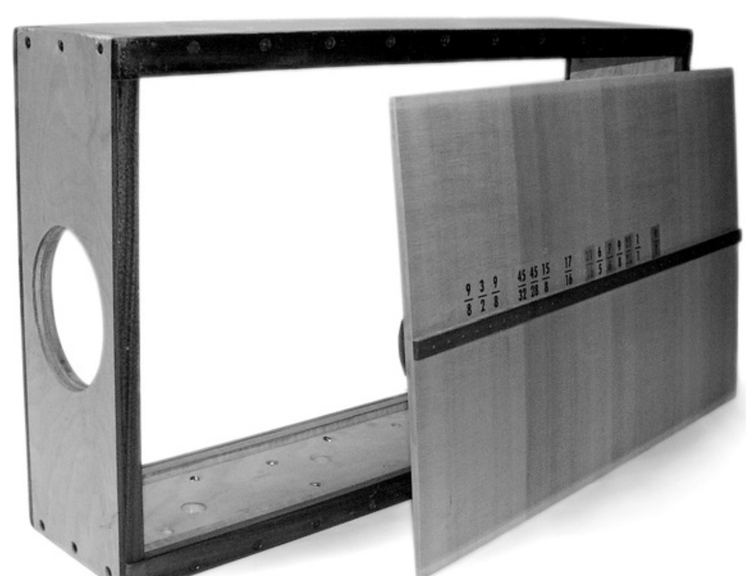
Arnold arranged a meeting with Bob Bielecki at Niblock's loft, where I had my installation set up while Phill was out of town for the summer. Bob brought *The Handbook of Physics,* some brass wire and a vise grip. He clipped the vise grip to one of my strings and it changed the tuning. We suspended a brass string and it put out a lower frequency. Bob showed me a chart in the handbook that showed the speeds of longitudinal waves through various metals. The longitudinal mode is set into motion through bowing a wire lengthwise, as opposed to the transverse mode of vibration that all other string instruments employ. In the longitudinal mode, a compression wave travels back and forth from end to end at a consistent speed. Length and composition of the metal, not gauge or tension, are the only factors in determining pitch in the longitudinal mode. The thinnest string will sound at the same frequency as a thick rod at the same length if both are made of the same alloy. Waves travel more slowly through dense materials, and the slower the wave, the lower the frequency produced at any given length. Bob told me that by using the speed of the wave divided by the frequency, we could calculate the length at which to stop the string. We decided that I needed to build a wooden resonator box to amplify the strings acoustically. A group of Williamsburg artists organized a 600-artist exhibit, Terminal New York, in the Brooklyn Army Terminal in Red Hook in 1983 (Fig. 2). I used this space to construct my first *Long String Instrument* with an acoustic resonator and worked there during the run of the exhibit.

Material Elements

Wooden box resonators are mounted at one end, with 22 strings terminating at each resonator soundboard. Strings extend to another fixed point across the room and are tensioned using harp pins in tuning blocks. The instrument is played by "bowing" with rosined fingertips while walking. Performers walk in pathways between two resonators with strings suspended at waist height. Enormous lengths are required when strings are excited in the longitudinal mode or played by bowing lengthwise. They are tuned using mathematical ratios, or just intonation, and their pitch range is determined by length: A4 (440 Hz) spans 8 meters in length. Every octave lower requires a doubling of length. Installations thus far have ranged from 50 to 300 feet. A uniquely designed capo on each wire changes the vibrating string length much like a capo on a guitar.

Even though, in the longitudinal mode, string length is the only factor de-

Fig. 3. Double-sided resonator frame with soundboard. (Photo © Ellen Fullman)



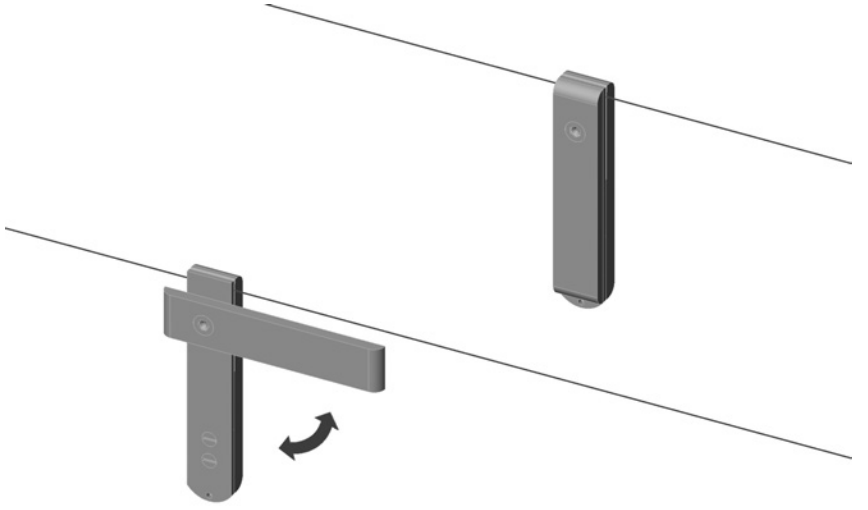


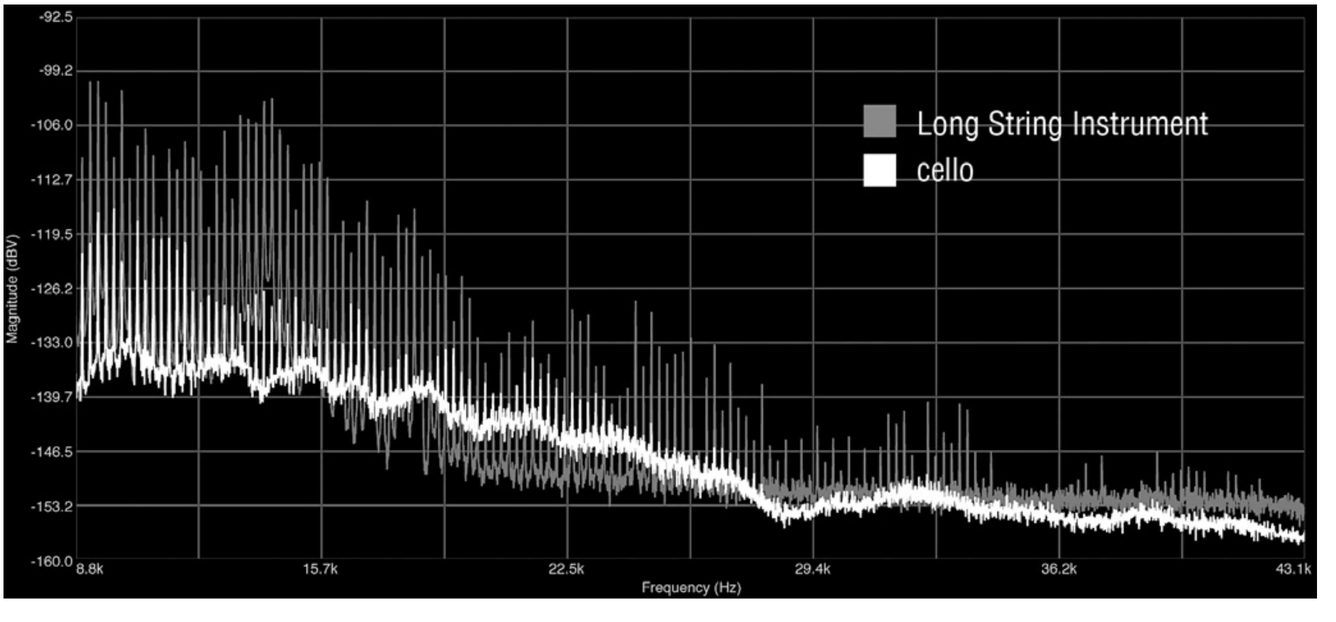
Fig. 4. Brass capo. (© Ellen Fullman. CAD drawing © Rob Dennis, REM Design.)

termining pitch, I tension the instrument just under the breaking point in order to maximize resonance. The use of various metals and alloys not only changes the tuning but changes the timbral quality as well. Finer gauges produce less surface noise and output more pure tone when bowed, because it takes less energy or pressure to get the string to speak. When I first started working with long wires I used steel piano wire. Recently, I have started using stainless steel and, because it is stronger than piano wire, I have been able to reduce the gauge from .0135 inch to .009 inch. Stainless steel has a muted quality that I find to be more "musical" than steel piano wire. I also work with phosphor bronze, which gives an interval of about a fourth lower than a stainless steel string of the same length. Bronze is a proven musical material, used on the sitar and tambura; the overtone spectrum is round and beautiful in the lower ranges. I sometimes use brass string when working within the limitations of a particular room length. The same length of brass is about a minor second lower than bronze. Brass wire is harder to excite and lacks a full upper partial spectrum but, when played with other related pitches, can give a bottom end to the sound.

Several events came together to spur my departure from New York in 1985. I could not afford studio space for my instrument and furthermore I was working full time as a technician at a recording studio in midtown that specialized in advertising jingles, which I found to be depressing. During this time my apartment was brutally broken into, twice; the door was smashed to pieces and all my equipment was stolen. Then Deborah Hay invited me to collaborate with her on a project in Austin, Texas. I went to Austin only for the project and never went back. Deborah's assistant found a free studio for me in an empty unfinished office tower that I was able to use for 4 years. I missed the excitement and international connections of New York, but it was also a relief to just focus in and listen to what this instrument wanted to do without any career pressure.

From 1986 through 1993, I worked with Stephen Wise in Austin on resonator design. Whenever I received funding I was able to commission another experiment. Stephen is an engineer turned instrument builder with a very creative and experimental approach. I had made my own resonators up to this point, first out of plywood and finally with a spruce top. I had the grain running in the wrong direction, however, and it split. Stephen based his soundboard design on a harp, with a mahogany bridge running down the middle of the plate and the spruce grain running perpendicular thereto. The top and bottom edges of the board are tapered. Tapered edges function like

Fig. 5. Spectrum analysis of the frequency A 220 played by bowed cello (white) and *Long String Instrument* bronze wire (grey). Shown is the range from 9k to 43k. In the lower range of the spectrum both sources look very similar. In the high-frequency range, bowed cello drops off into noise at about 27k; bronze wire still contains some even spikes up to 40k. Sample rate used was 88.2 using a B&K 4011 microphone. (© Ellen Fullman)



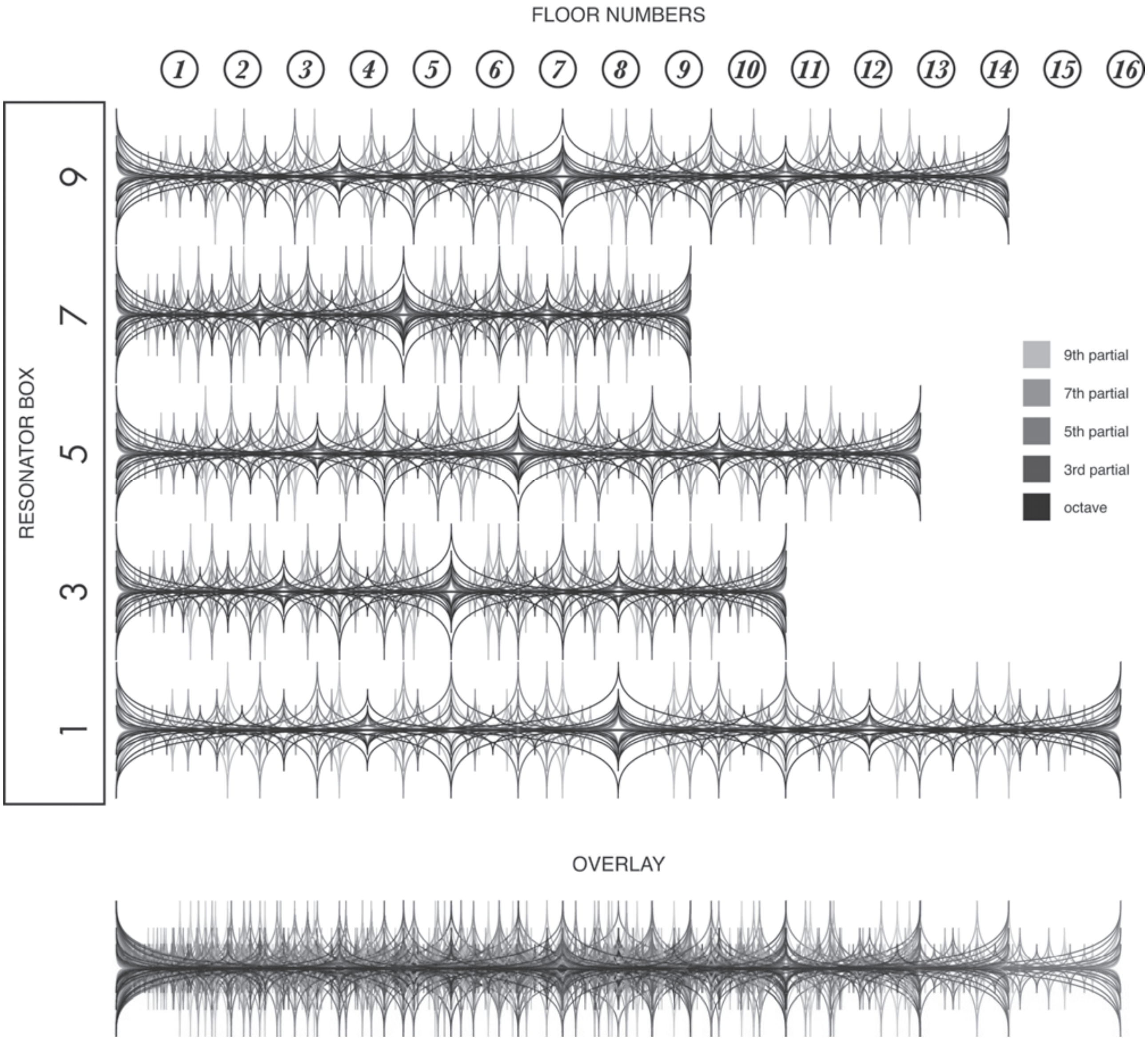


Fig. 6. Graphic representation of the nodal points of strings tuned to an overtone series chord of 1, 3, 5, 7 and 9, based on a fundamental of A 220, using phosphor bronze wire. The vibrating string length of each wire is shown in reference to the circled numbers that represent meters in length. The first octave nodes are drawn the tallest, mid-high spikes are the octave above and the smallest spikes are an octave above that. For clarity's sake, only the first few partials and first three octaves are shown; reality extends out much higher. (© Ellen Fullman)

a hinge for the heavier, loaded bridge, increasing resonance. Soundboards sound best when tensioned just under the breaking point. Our problem was knowing what that breaking point was. I installed a set of two new resonator boards that seemed fine, but several days later I found that they had exploded on the floor. Since there was no precedent for this work, Stephen had to push the limit, using educated guesses to obtain the best sound possible. Working with Stephen's resonators gave me a more refined timbre, a more musical tone. We experimented with proportions, based on the limits of my arm reach and considerations for traveling. One brilliant contribution that Stephen made was to keep the soundboard itself loose from the resonator so that it could expand and contract freely in extreme weather conditions. The resonator box itself is just a plywood box with a hardwood lip that the soundboard pushes against under string tension. I came up with the idea of double-sided resonators to more efficiently use a given room length for upper register strings. Fortunately, this sounded fine. In this case the resonator box is just a frame into which two soundboards fit (Fig. 3). I am sure there is more to discover in resonator design. However, I have been well satisfied with the sound from these resonators and have since focused my attention and resources on other aspects.

With funding from the Center for Cultural Innovation in 2009, I worked with REM Design and Keith Carey to redesign the capos used to tune my instrument. For many years, I used off-the-shelf c-clamps. I wanted something more compact and less likely to become entangled in adjacent strings while the instrument is being played. I had hoped to reduce the weight of the capo for the sake of traveling but found the tone to be "fuzzy" at any less than 2.5 ounces, the weight of the 1-inch standard c-clamp. My guess is that without a certain amount of weight, the energy of the wave pushes through

Fig. 7. Box bows. (Photo © Ellen Fullman)

the capo. We tested six prototype designs, including a spring-loaded one based on the clothespin and a design based on an X-Acto knife handle, where a slot is closed down by a horizontally rotating knurled collar. None of these creations gripped the wire hard enough to give as clear a sound as the c-clamp. We determined that a rotating handle needed to be as long as the one on a c-clamp in order to achieve the necessary amount of torque. After a year of prototyping, a final design was arrived at and put into production. This design uses a vertically rotating handle on a threaded post that, when fully tensioned, can be positioned to align with the closing plates into one streamlined unit (Fig. 4). We found that a capo made of brass gave more body or weight to the coloration of the tone, creating a sound that I preferred. Experiencing this has made me hyper-aware of musical resonance as a system of components, where the design and consideration of every element in the instrument construction has an effect on the music.

Ephemeral Elements

I have discovered an optimal bowing speed in which strings speak most clearly in the longitudinal mode, based presumably on a relationship to the speed of the wave moving through the material, which in turn regulates the pace of the walking performer. As a performer, I find that it takes me time warming up to synchronize with this speed—anywhere from 10 minutes to an hour. I really cannot pinpoint the exact speed; however, I know it when I hear it. Subjectively speaking, the difference in timbre that I hear is like the difference between a sensation of jagged shards of glass sticking into my ears and a feeling that the sound has plasticity and can be molded with my fingertips into undulating shapes, like a string of beads.

I first experienced this roundness in timbre in the late 1990s while living in Seattle, where I was surrounded by musicians—improvising musicians, musicians who practiced. As a composer, I did a lot of thinking and planning. I wondered what would happen if I practiced more. My solution to the high cost of renting a large studio space in Seattle was to work full time as a graphic designer. This job left me with little mental energy for composing, so I decided to commit myself to playing every evening: even to play only one chord continuously. I should preface this with the fact that I came to Seattle after studying North Indian vocal music for 4 years with Anita Slawek in Austin. Anita could bring so much beauty into singing just one note that it brought tears to my eyes. Working with her taught me to slow down and focus in, with more patience. She told me, "When you are really in tune, the music plays itself." Now if I

Fig. 8. Travis Weller (left) and Nick Hennies playing box bow at Seaholm Power Plant, Austin, Texas, 2010. (Photo © Craig Washburn)

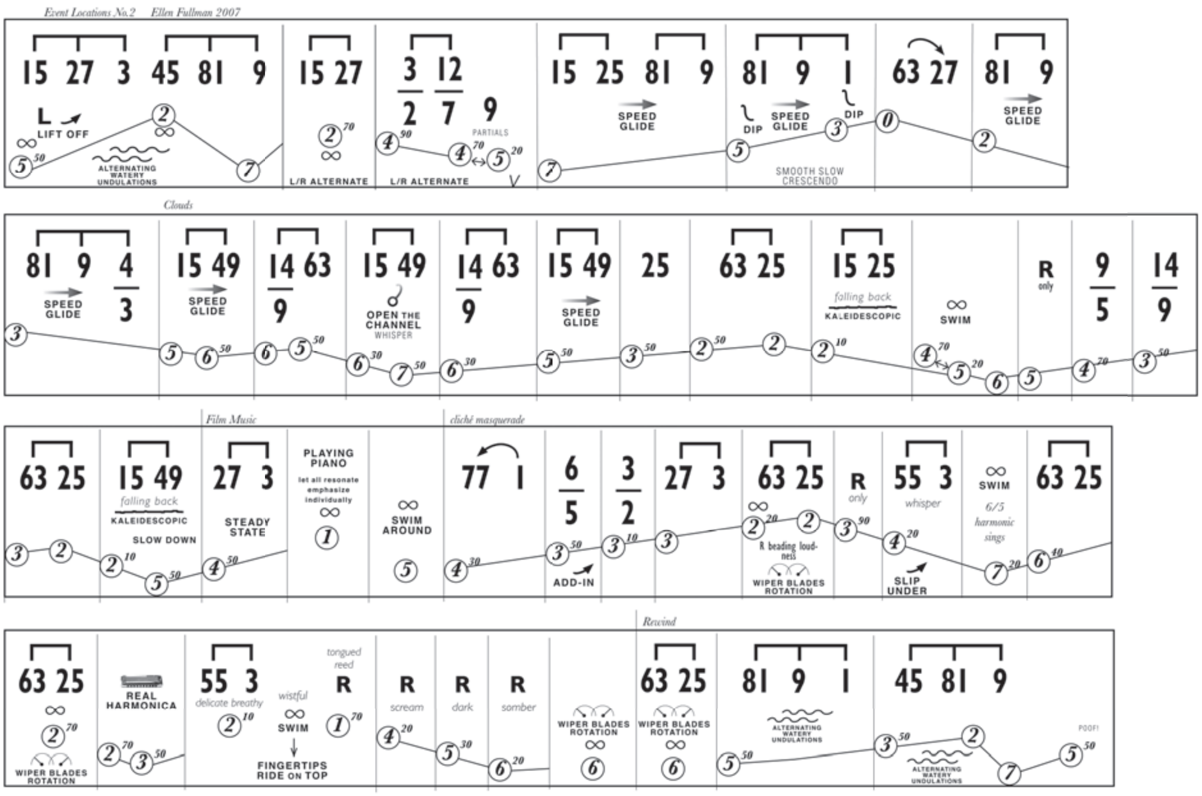


Fig. 9. ***Event Locations No. 2,*** **notation, 2009. Note values are expressed numerically—either as single numbers generated off the overtone series of F or as ratios based on A. Bracketed groups are to be played by one hand, from either the left or right bank of strings. Vertical lines separate chord changes. Diagonal lines direct the performer's movement either closer to or further from the resonator. Circled numbers reference those placed on the floor under the strings at every meter. Graphic icons indicate articulation. (© Ellen Fullman)**

feel something is not working I stop and tune, and I find it always helps. Over the years of working with Anita, I witnessed the resonance in my voice grow through a commitment to practice, practicing even when I was not pleased with how my voice sounded. Practicing on my instrument and with no tradition to follow, I discovered a new sound.

When measuring the waveform produced by the *Long String Instrument* using a spectrum analyzer, it can be seen that every upper partial of the fundamental tone is represented strongly up through about 35,000 Hz (Fig. 5). Just intonation, a natural tuning system generated off the overtone series, lends itself to a contemplation of precise alignments of resultant relationships among the upper partial tones. In 2003 my precision in tuning took a giant leap forward when Jörg Hiller introduced me to Peterson strobe tuners, with precision to the tenth of a cent. (In equal temperament, a cent is 1/100 of a half-step.) I admit I am unable to discern 1/1000 of a half-step, but I *am* able to sense alignments of partials when playing a chord—and walking. When the tuning is really clean, it is as if I am running a giant mechanically geared clock, each string like an individual gear of larger or smaller diameter, rotating at its own rate in relationship to the other gears in an overarching system that is aligned to eventually repeat.

Compositional Approach

In the late 1980s, I conceived of a graphic notation format in which timing and coordination of parts are determined by distance walked. This system still functions as the basis for scoring my work today. Numbers placed on the floor under the suspended strings at metric intervals are used as reference points indicated in the score. Transitions can be coordinated based on the time it takes to arrive at predetermined locations, thereby "choreographing" repeatable events to occur at specific locations. My notation functions like a roadmap for the performer, aligning musical events in time and space to coincide with specific upper partial content. Strings vibrate in mathematical subdivisions of the total string length, simultaneously vibrating in multiple modes at once. The performer's rosin-coated fingertips pass through these subdivisions or nodal points unfolding in a cascading spectrum, dampening the string and sounding partials associated with each passing location (Fig. 6).

My process of composing has been influenced by experiencing this instrument as an acoustic feedback system. I have observed that the upper partial spectrum of strings being played can be highly influenced through sympathetic resonances. With an introduction of a new tone into an existing chord, either from another instrument or on the *Long String Instrument,* previously unheard partials can be triggered to sound, and continue to sound, even when the triggering tone is no longer playing. Like puffs of wind blowing at a candle flame, the instrument responds fluidly to manipulation and then rights itself into a new alignment of overtone projection. After seeing the spectrum analysis of the *Long String Instrument,* this does seem possible; since every partial is represented, there must be frequencies closely aligned to any pitch (see Fig. 5).

I have the sense that my instrument is an open system, responsive to frequencies being played by other musicians and by the resonance of the room itself. When another musician's sound reinforces my tuning, I can even feel a buzzing energy driving my strings to resonate using very little pressure from my fingertips. A dead room is very unflattering to the sound of my instrument. The *Long String Instrument* is complemented by a resonant room, unlike a cello, for example, which has a self-contained resonance and beauty of tone within its own body that a resonant room merely enhances. The artifacts that my instrument produces are at the core of my work. I find myself feeling lost in a dead room; I do not know how to move. It is as if my instrument itself has disappeared like a phantom, because I think I am actually playing the resonance of the room. What may seem so difficult for me to pin down as an artist is actually measurable and can be defined. I am sure that a system can be designed to give me more reliability in my performing environment through sound reinforcement or even through defining audience proximity to the resonators.

From the beginning, I have wanted to create a variety of techniques for the *Long String Instrument* to be played by ensemble. I have explored rhythmic techniques for many years but have never felt them to be successful until I designed the box bow tool on my Deutscher Akademischer Austauschdienst residency in Berlin in 2001. The box bow, homage to the harmonica, is a hand-held, hollow wooden box made of Sitka spruce with a curved lower surface. I made a rough prototype and then worked with Berlin instrument builder Stefan Beck to build them (Fig. 7). Just as a violin bow can affect the timbre of the violin, I feel that the material, design and resonance of the box bow affect the timbre of my instrument. Techniques based on hand drumming inform the articulations of this tool used to strike groupings of strings tuned to chords. My Memphis roots hold a strong influence on my musical taste, and I have always wanted to embrace sounds from folk music in my composition. With the box bow, I have satisfied this desire while exploring more abstract concepts at the same time. I found that I am even able to achieve the wind-blown, vowel-like vocalization of the harmonica when the three string chordal groupings are tuned to fundamental, fifth and octave. Thus far I have defined nine distinct articulations with the tool, represented by graphic icons in my notation. In my piece *Through Glass Panes* (2010), various combinations of these articulations are used in repeated phrases and juxtaposed to form hocketed patterns. Two box bow performers play standing face-to-face at a double-sided resonator (Fig. 8).

This instrument has functioned as my personal music school. As I have absorbed musical concepts, my music has changed. In my earliest pieces I worked with an ensemble playing walking drone parts on my instrument. At the time the only way I knew how to get the strings to speak well was to play full-on as loud as possible, keeping the tonal content simple and including a lot of doubling up in the parts. In retrospect I can see that I used these approaches to achieve more resonance. As time went on, I became

Fig. 10. Ellen Fullman performing with Okkyung Lee at Muziekgebouw, Sonic Acts Festival, Amsterdam, 2012. (Photo © Bernd Wendt)

dissatisfied with the lack of articulation in my ensemble sound and I decided to take time to work alone. In *Event Locations,* my most detailed piece to date, composed in 2007, I focused on making minute decisions in articulation, inch by inch, and writing them down (Fig. 9). I now feel I am ready to take what I have learned and apply it to multiple-part works. I recently put out a call to interested graduate students at Mills College, Oakland, CA, and have found a fascinating crew to help me bring ensemble performance on my instrument to a new level.

What began as a raw exploration of sound many years ago has evolved into an articulated and unique musical language, occupying a space that one enters. Listeners and performers alike feel surrounded by this sound. My music functions on multiple levels, existing as temporal compositions, as sound in space and indeed as sculpture (Fig. 10). With my research, I hope to illuminate the physical nature of sound and the geometry of harmonic space.

Acknowledgments

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References and Notes

1. See <en.wikipedia.org/wiki/Judson_Dance_Theater>.

2. Chris Bohn, editor of *The Wire,* wrote of the *Long String Instrument,* "Listening to it, you feel like you are inside some cyclopean subterranean grotto . . . its bejewelled walls glistening with an alien luster (and) sounding like something that shimmers, iridescent shapes bend conventional pulse-based time and impose their own paradoxical temporality, where constant movement teems within a vast stasis." *The Wire,* Issue 291 (2008) p. 55.

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Ellen Fullman has been developing her installation, the Long String Instrument*, for nearly 30 years; exploring the acoustics of large resonant spaces with her compositions and collaborative improvisations. She has recorded extensively with this unusual instrument and has been the recipient of numerous awards, commissions and residencies. Releases include:* Through Glass Panes *(Important),* Fluctuations*, with trombonist Monique Buzzarté (Deep Listening) and* Ort*, recorded with Berlin collaborator Jörg Hiller (Choose Records).*