Solar Organetti

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ABSTRACT
The solar organetti are modular, solar-powered acoustic pipes designed to be installed in various landscapes, suspended from trees. The challenge of obtaining meaningful amounts of mechanical energy from the sun, and compositional strategies, are addressed.

Keywords
Solar engine, musical iconography, Chloroplast engine, panpipe, organ pipe, sound installation, environmental art, BEAM.

1. INTRODUCTION
In this project, the desire was to create modular, organic sound objects powered by the sun. The objects would breathe with the brightness of the sun, and have a subtle and complex envelope: some sort of ground to some beautifully tuned wind chimes heard in a garden. They would from trees and light posts, like fruit or icicles. The interactive portion of the organetti is compositional: they set in motion by design choices, yet subject to chance (weather).

1. BACKGROUND
There were some interesting historical precedents for such a project. Along with the Utrecht Psalter, the Stuttgart Psalter from c. 820-830 illustrates various organs and other instruments. Likely made in a northern French scriptorium, the manuscript illustrates Psalm 136/137 ("By the rivers of Babylon...") with little organs hanging from trees; this image is found in early Greek Psalters as well. These *organetti*, possibly a fantasy, a miniature of reality, and/or an artistic convention, differ from the solar ones in that they have seven pipes each, six or seven little key-tabs below the pipes, a frame, and an oblique bar across the pipe rows. Later representations become less reliable until perhaps the later thirteenth century [4]. There may be some connection with the panpipes sometimes shown hanging in foliage in pagan Roman sculpture (see figure 1).

Figure 1. *Sacrifice to Hercules. Note pan pipes in arbor. [2]*

Another account of interest hails from the Lakota Sioux. The Lakotan Siouan Sundancers blow a bird bone whistle that serves as a conduit between the source of power and humanity, that is, *Wakan-Tanka* and the Sundancers. During the Sundance, power is said to flow from *Wakan-Tanka* through the sun and the sacred central tree in the dance ground, to the Sundancer, who blows a hollow bird bone whistle, which fills with that power [1].

In Greek legend, the nymph Syrinx was pursued by Pan and turned into a hollow reed, the hollow stem being a lilac from which he made his first pipe. This relates to many images of vegetation sprouting as visual sound (see figure 2).

Figure 2. *Pan. Note foliage from syrinx. [5]*

The term *organetto* in Italian refers to a bird, as well as a type of pasta; in this case, we refer to a small portative organ, with one hand playing the pitches, and the other pumping the bellows (figure 3).

Figure 3. *Musician with portative. [6]*

The solar organetto has some of the same characteristics as the traditional one: it's portable, uses pipes, and has its own source of wind power. It would be up to the artist to decide the number of solar organetti and their position. There are also *organetti morti*, which are non-functional pipes introduced into the façade of a pipe organ to achieve visual symmetry.

1. DESIGN

1.1 The Solar Engine

Simplicity, durability, and cost were the driving design constraints for the solar engine. The approach was to create robust analog circuits that perform a particular function, that is, turn a blower that has enough volume and pressure to set a column of air vibrating in a pipe.

The research being made in BEAM robotics was of immediate use [7]. The most popular BEAM engines are Type I solar engines, which are voltage controlled; the first engine built for this project was a Symet solar engine, along the lines of the Symet design found on the Solarbotics Web site [8]. It uses a 1381 voltage detector that triggers at about 2.5 volts, when the charge collected by the solar cell is allowed to flow from a storage capacitor into the circuit. Large electrolytic capacitors were used to store charge, but the 1381s maximum voltage is only ~4.4V. Despite being able to move small blowers like the Sunon Maglev (5VDC, 0.9W) for about 10 seconds, any blower capable of supplying enough air volume and pressure was going to need much more power.

For a more powerful circuit, a Maxim 8212 voltage monitor was tested. This IC has programmable hysteresis and trigger values (up to 16.5V). Three Panasonic BP-378234 solar cells in series achieved approximately 16V; their maximum current is ~30mA in full sun. To match the solar cells, three 1.0F, 5.5VDC Panasonic NF series double-layer capacitors were connected in series.

Various resistors configured the 8212 to the desired trigger voltage and hysteresis. There were however some problems with the circuit locking up; adding a 3904 NPN transistor before the motor seemed to alleviate the problem [10]. It became possible to drive more powerful motors with the 8212, but from a design standpoint, the use of the IC was undesirable.

The design finally selected was a modified Chloroplast engine, originally designed by Craig Maynard [9]. This simple engine was designed for higher torque applications. The flavor of Chloroplast used in the organetti is along the lines proposed by Wilf Rigter; it is a Miller-style Chloroplast engine, in that a capacitor is placed in between the ground pin and the voltage monitor pin of the undervoltage sensor, a Motorola MC34164-3 (see figure 4). This introduces a timing delay into the circuit, making the hysteresis of the undervoltage sensor larger. The size of the capacitor regulates the amount of hysteresis and the time the blower motor runs (in this case 10µF). The resistor and capacitor values were determined experimentally. As R2 increases, the trigger voltage increases; with R2=300kOhm, V_{max} was ~14V. The NPN transistor (MPS-A12) is a Darlington transistor; when its base is pulled high through the 100kOhm resistor (R1), it turns on, allowing the solar energy stored in the storage capacitors to discharge through the motor.

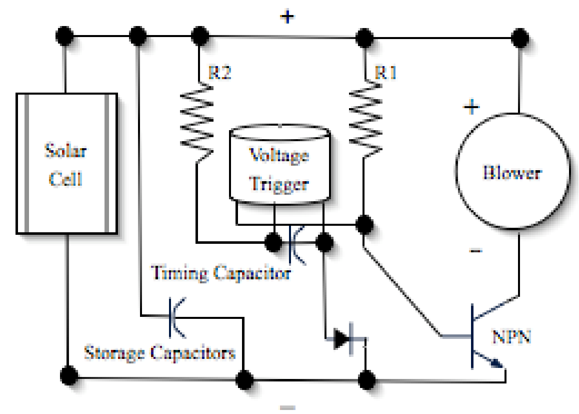

Figure 4. *The Solar Engine.*

For the collection of solar energy, three Panasonic BP-378234 cells (5.5V in full sun) in series were again used. They charged five Cooper-Bussman PB-series aerogel capacitors (5V, 1F) connected in series. The desire was to keep the maximum voltage of the solar engine to half the capacitor voltage, since this is favorable for rapid charging and discharging.

1.2 The Blower and Sound Element

The regulation of air in the case of an organ is an important issue; in this case, instead of constant pressure, a pressure gradient is produced. At the maximum air pressure of the fan, which corresponds to the maximum voltage of the solar engine, the pipe should speak. As the solar engine discharges, the pressure is reduced, revealing the non-driven partials of the pipe in the process. One may compare this with the air regulation issues in McBlare [11].

Figure 5. *Left: two small open pipes. Right: two stopped pipes.*

The sound element—a century-old stopped, wooden organ pipe—was probably regulated to speak at anywhere from one inch to three inches of pressure (figure 5). Pressure measurements with a pitot tube should be made in the future (see description in [12]). The dynamics of air in such a pipe are three-dimensional and not analogous to a one-dimensional string [13].

In choosing a blower, minimum power for maximum pressure was desired. Looking at various fans, a Sunon GB1205PHVX-8AY, a small 12VDC fan (50mmx50mmx15mm), had just enough pressure and volume (1'', 4.7CFM). The amount of air volume/time available to a pipe influences volume and pitch. This motor can make a much larger pipe speak at its fundamental, but softly. The art of pipe regulation and voicing can completely change the way a pipe speaks and the harmonics it produces; a good explanation is found in [13].

1. IMPLEMENTATION

There are many general questions to address—To what extent do instruments/musical objects determine a composition? To what extent is the composition the musical object, and how much of a composition is the instrument on which it is executed? Of what does a performance consist, and what is the role of the performer versus the composer versus the instrument builder? For instance, the way John Cage's $Organ^2$/ASLSP has been interpreted [15], or to use Cage again, the use of star maps and aleatoric techniques in his difficult Etudes [16].

In the case of the organetti, there are many degrees of freedom for the composer. For example, there is a degree of indeterminacy via the weather, a degree of determinacy via the patterns the sun traces across the Earth (the current organetto uses passive solar panels), and another degree of determinacy built into the solar engine. In full sun, it begins playing in the morning, with increasingly short periods of charging, and only slightly longer periods of operation, until the sun reaches its zenith. The entire pipe vibrates at its fundamental after the attack (that consists of partials of the pipe). The attack is when the most charge flows from the capacitors into the motor; as the capacitors discharge, other partials of the pipe are elicited.

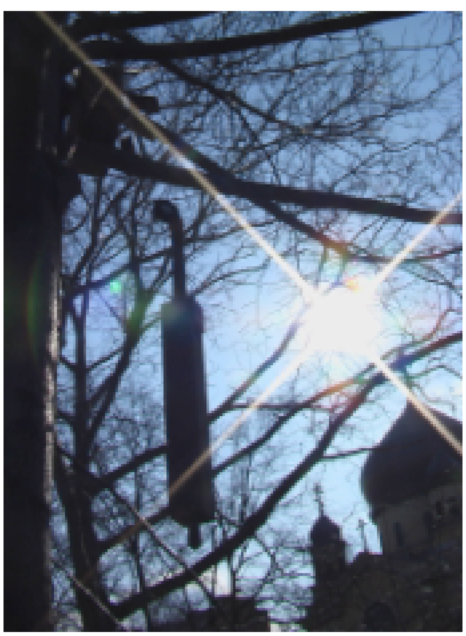

Figure 6. *Morning Sun, Brooklyn*

The path of the sun in the sky is determined by where on Earth the organetto is. Lower latitudes get more sun, and therefore more current, however higher latitudes have longer days some parts of the year. There are excellent models for computing the sun's position and solar intensity at various stations around the world [14]. Neglecting weather, global dimming, and other chance factors, these data could be used to get more precise performances from the system; the performance would change daily, albeit subtly, producing complex variation over timescales that are longer than a typical composition (months rather than minutes). There are weather patterns that occur over long enough periods that one could surmise that, for example, it will run less often in Seattle than in Florida. Depending on the panels' location, the sprouting of leaves on trees, shadows from new buildings, and other exogenous occurrences would change the system's behavior.

Figure 7. *Collecting energy through window, afternoon.*

In this organetto, at this time of year (30 January 2007), and at this latitude (New York City is 40˚43' N), from sunrise the system charged until there was a first cycle, which was 8 seconds on and then a span of minutes off. Sunrise was at 7:07AM (112˚ E-SE), noon was 12:09 PM (sun at 32˚ above horizon), and sunset was at 5:12PM (248˚ W-SW). The off period shortened as the sun rose in the sky. When the sun neared its zenith, the off interval was only 15 seconds. The off periods grew longer at sunset's approach, until there was no more sun and the system waited for the next sunrise.

The solar engine itself may be adjusted; one may choose a solar array and capacitor bundle that, on a sunny day, produces much longer on periods, but also much longer charging periods. In such an organetto, a cloudy day might produce one *ff* sigh, or nothing at all.

1. CONCLUSIONS

There are many other types of wind-blown sound elements that could be used, for example, ocarinas, made of clay, conch shells, and glass (embedded with a solar-collecting layer). One could also use the engine to create percussive instruments and plucked-string instruments. With more sound sources, there are more possibilities.

The video [18] shows an organetto in an incredibly noisy urban environment; there are no fewer than a dozen luxury condominium developments being built within five blocks of each other. It is interesting to note the similarity between the sound of the plane overhead and the sound of the organetto.

Development of the system with larger capacitor arrays would give flexibility in the selection of blowers, loudness, time values, and sound elements. The design allows for customized responses to varying solar conditions around the globe; this could really be described as a virtuoso element, since the panels' alignment could get very detailed. In matching pipes to wind sources there is much to be discovered. For instance, in stopped pipes, which have short attacks and accommodating pressure/fundamental pitch regimes, there is no first harmonic when the pipe is overblown; or, if one were skilled, one could voice the pipes specifically (the stopped pipe used in the video shows "nicking" at the languid that induces turbulence to the airflow) [18].

It is hoped that the organetti's open-ended quality will extend into unforeseen areas, as imaginative as the people who illuminated those beautiful scrolls so many centuries ago.

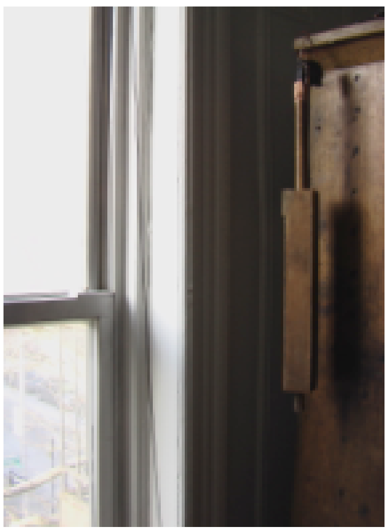

Figure 8. *Testing near window, afternoon.*

2. ACKNOWLEDGMENTS

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3. REFERENCES

[1] Carr, C. (Ed.), and Case, D. T. *Gathering Hopewell: Society, Ritual, and Ritual Interaction.* Springer. 678.

[2] Fiala, John L. *Lilacs: The Genus Syringa.* Timber Press. 5.

[3] Vanderhagen, *G. Sacrifice to Hercule.s* c.1766 (marble). Courtesy of Yale Center for British Art, New Haven, YBA 223179.

[4] Williams, Peter F. *The King of Instruments*. SPCK, London, 1993. 108-111.

[5] French School (15th century), *Pan.* Vellum. Courtesy of Bibliotheque Nationale, Paris. BNP 158673.

[6] French School (13th century), *Musician Playing a Portative Organ.* Vellum. Courtesy of Bibliotheque Nationale, Paris. BNP 154913.

[7] http://www.solarbotics.com/

[8] BEAM (Biology, Electronics, Aesthetics, and Mechanics) robotics Web site: http://www.solarbotics.net/

[9] http://www.solarbotics.net/library/circuits/se_t1_chloro.html

[10] http://ffaat.pointclark.net/blog/pages/BeamMax.html

[11] Dannenburg, R., Brown B., Zeglin, G., Lupish, R.: McBlare: A Robotic Bagpipe Player, in *Proceedings of the New Interfaces for Musical Expression Conference*, Vancouver, 2005.

[12] Da Silva, A., Wanderly, M., Scavone, G.: On the Use of Flute Air Jet as a Musical Control Variable, in *Proceedings of the New Interfaces for Musical Expression Conference*, Vancouver, 2005.

[13] http://www.pykett.org.uk/how_the_flue_pipe_speaks.htm

[14] http://rredc.nrel.gov/solar/

[15] http://www.john-cage.halberstadt.de/

[16] Nicholls, David. The Cambridge Companion to John Cage. The Cambridge University Press, 2002, 139-140.

[17] Munson, B., Young, D., Okiishi, T. Fundamentals of Fluid Mechanics, Wiley, 1994. 455-547.

[18] Video may be seen here: http://www.jaredlamenzo.com/organetti