Noisegate 67 for Metasaxophone
Composition and Performance Considerations of a New Computer Music Controller

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ABSTRACT
Noisegate 67 was the first fully interactive composition written for the Computer Metasaxophone, a new computer controller interface for electroacoustic music. The Metasaxophone is an acoustic tenor saxophone retrofitted with an onboard computer microprocessor and an array of sensors that convert performance data into MIDI control messages. While maintaining full acoustic functionality the Metasaxophone is a versatile MIDI controller. This paper discusses the compositionally driven technical and aesthetic concerns that went into building the Metasaxophone, and the resulting aesthetic implementations in *Noisegate 67*. By juxtaposing the compositional approach to the saxophone before and after the electronic enhancements an attempt is made to expose working paradigms of composition for metainstruments.

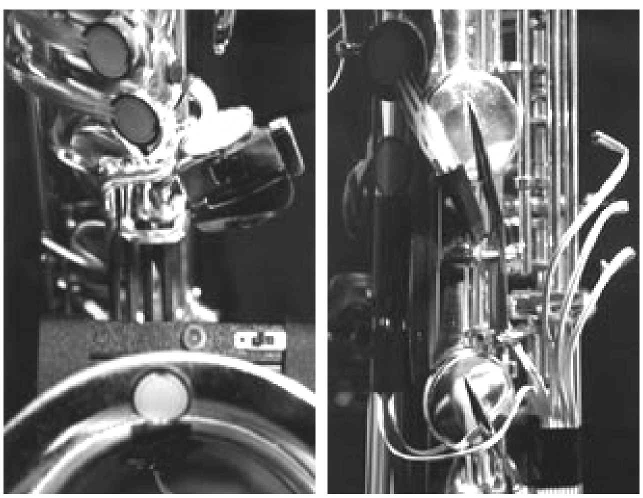

Figure 1 - The Metasaxophone: Front and Back Views

INTRODUCTION
New Control Parameters for an Old Interface
Since its first appearance in public in 1842 (Rascher 1970), the saxophone has proven a highly flexible performance interface with acoustic characteristics that have allowed it to flourish in a wide range of musical styles and aesthetics.

The young instrument builder Adolphe Sax intended his instrument to have the dexterous flexibility of the strings, the coloristic diversity of the woodwinds, and the dynamic power of the brass. An instrument designed to unite instrumental elements, the saxophone, has also proven stylistically flexible, continually being adapted to new performance needs. Styles as diverse as the orchestral, band, jazz, rock, improvised and electroacoustic music traditions have embraced it.

Electroacoustic music raises new possibilities for extending the timbral range of acoustic instruments. Very often, however, the instrumental interface is not suited for direct performer control of the new timbral opportunities. This paper discusses how a project involving music for electronics and acoustic saxophone drove the development of a human computer interface project extending the expressive performance possibilities of the saxophone.

The Metasaxophone is classified in the field of human-computer interaction as an augmented traditional instrument. It is part of a growing trend in instrument design that uses traditional instrumental performance interfaces as input devices for computer instruments (Cook and Morrill, 1993; Hunt, Wanderley and Kirk, 2000; Orio, Schnell and Wanderley, 2001; Paradiso, 1997).

Previous notable attempts at augmenting the saxophone have sacrificed the actual acoustic instrumental sound for MIDI controller capabilities. The first MIDI saxophone, the Synthophone, is a versatile MIDI controller marketed by Softwind Instruments (Softwind, 1986). The developers of the Synthophone were interested in preserving the tactile interface of the saxophone but not its acoustic sound. The Synthophone therefore produces no sound of its own, the saxophone body being only a housing for the electronics. Retaining the true sound of the saxophone has been of primary importance in developing the Metasaxophone.

FORMATIVE WORK
The Metasaxophone grew out of an ongoing project exploring the saxophone as an electroacoustic instrument. The project simultaneously pursues extended performance practice and the expansion of the instrument through electronics. Compositions such as *Incantation S4* (1997), *Split Voices* (1998) and *Portals of Distortion* (1998) were fundamental in redefining the performance practice of the saxophone and suggesting the Metasaxophone controller. Performance technique took on new meaning in these pieces, becoming a means of opening the saxophone

acoustically, bringing out its hidden resonant characteristics, and allowing it to speak on its own. All three of these pieces were recorded and released by Innova Records on the 1999 CD, *Portals of Distortion: Music for Saxophones, Computers and Stones* (Burtner, 1999). These compositions for saxophone are characterized by the fundamental aesthetic assumptions described below.

1) The Instrument as Complex Acoustic Filter

The saxophone was conceptually redefined as a complex acoustic filter and preconceptions of traditional notions of tone, intonation, fingering, and embouchure were discarded and replaced with a more open conception of the sound possibilities of the instrument. This reconception of the instrument was based on an observation that notions of saxophone performance practice were highly biased towards the aesthetics of traditional musics such as jazz and classical traditions.

A more open approach to the instrument suited the world of electroacoustic music well. It is characteristic of the way composers approach digital audio synthesis systems, with open ears and a desire to explore. This is most notably the case in *Portals of Distortion* for nine tenor saxophones, in which the ensemble is treated as a network of signal processors, mixed together into a complex signal.

In place of the traditional performance practice a new approach evolved based on continuous and variable pressure in the air column of the horn, changing the complex properties of the tube by applying various key combinations, and embouchure changes designed to both sustain the resonance and control the spectral properties of the signal.

2) Signal Processing as a Metaphor for Extended Instrumental Performance Practice

In order to enhance the timbral relationship between the saxophone and electronics, techniques of digital audio synthesis used in the composition of the electronic parts were applied analogously to the saxophone. These included techniques such as granular synthesis, spectral mutation, convolution, digital distortion, ring modulation, and spectral resonance. Each signal processing technique was applied acoustically, through the use of extended techniques, to the performance of the acoustic instrument and refined into a controllable performance practice. In general an attempt was made to form a greater unity between the electronic and acoustic instruments, allowing them to occupy a similar, extended timbral space.

3) Continuous timbral evolution of the instrumental sound

The repertoire of techniques that evolved included sonorities that could be modified greatly over time through subtle embouchure changes. Circular breathing was necessary in this context to sustain the changes indefinitely. Symmetries of the horn began to function almost motivically as observations of certain harmonic coincidences became apparent. Figures 2 and 3, excerpts from *Incantation S* and *Split Voices,* show ways this music was notated for the performer.

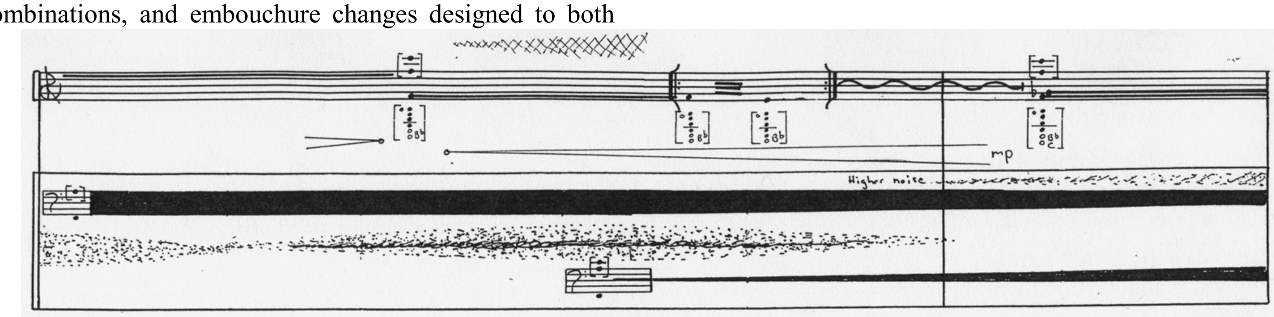

Figure 2: Excerpt from the Score of *Incantation S4*

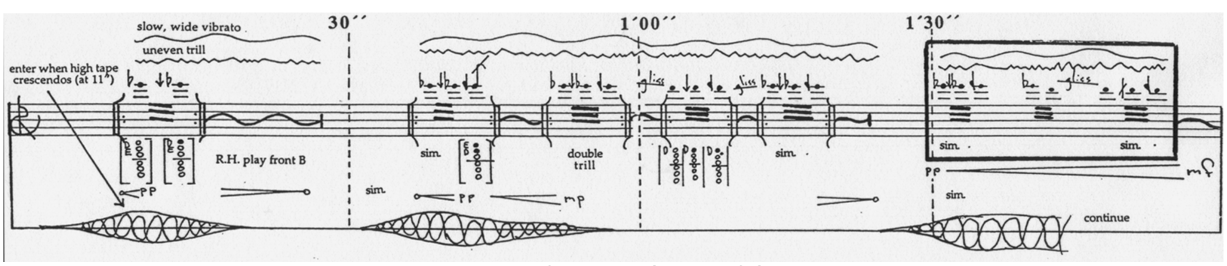

Figure 3: Excerpt from the Score of *Split Voices*

Figure 4: Metasaxophone Bell

REDEFINING THE FUNCTION OF A KEY

While performing compositions such as *Incantation S4*, *Portals of Distortion* and *Split Voices* it became clear that, in the context of these slowly evolving musical textures, much of the performer's tactile sensitivity was being unused. In each of those pieces, entire minutes may pass with the performer holding down one basic fingering. In the second part of *Split Voices,* for example, the front five keys are held down for over 5 minutes while the performer trills other keys and changes the embouchure and air pressure.

A perceived limitation of the manual interface gradually appeared: while the saxophone allows for continuous control over embouchure changes and changing air pressures, the fingers of the performer have very little direct continuous control over the instrumental sound.

For all practical purposes, a saxophone key is either open or closed. Half keying is an extended technique of some promise, and using very rapid, changing trills can give the impression of a continuously changing sound, but these both involve substantial changes in the air column that could disrupt other key work in progress. What was needed was a new level of key control that would not disrupt normal playing but could be used to substantially modify the sound.

It occurred that by giving the keys pressure sensitivity or "aftertouch", a feature common on MIDI keyboard controllers, direct tactile control over the electronic signal processing could be given to the performer. This computer interface could be placed easily in the expressive zone left unused by the instrument, namely finger pressure on the keys. In essence, the saxophone keys which normally execute only on and off changes of the air column, could be converted to continuous control levers.

TECHNICAL SPECIFICATIONS

Hardware

An approach was developed for retrofitting the acoustic Selmer tenor saxophone with sensors and a microprocessor that could convert the performance data into a continuous control data stream. A great deal of thought went into how and where the sensors would be attached to the instrument, and important performance considerations were contributed by Christopher Jones, Brian Ferneyhough, and Gary Scavone who also advised technically on the project. It was finally decided that the microprocessor would gather performance data from eight continuous voltage force sensing resistors (FSR), five triggers, and an accelerometer.

The FSRs (by Interlink Electronics) are located on the front B, A, G, F, E and D keys, and beside each of the thumb rests. Three triggers (also by Interlink) are located on the bell of the instrument, and two are positioned on the back, below each of the thumb rests. An Analog Devices ADXL202 accelerometer IC chip on the bell measures the position of the saxophone on a two dimensional axis - left/right and up/down.

The data from these sensors are collected via a 26 pin serial connector by a Parallax Inc. Basic Stamp BIISX microprocessor fixed to the bell of the instrument. Analog pressure data from the performer is converted to a digital representation by passing each analog signal through a resistor/capacitor (RC) circuit into the input pins on the BIISX (Figures 5 and 6). Trim potentiometers calibrate the input sensitivity of each sensor.

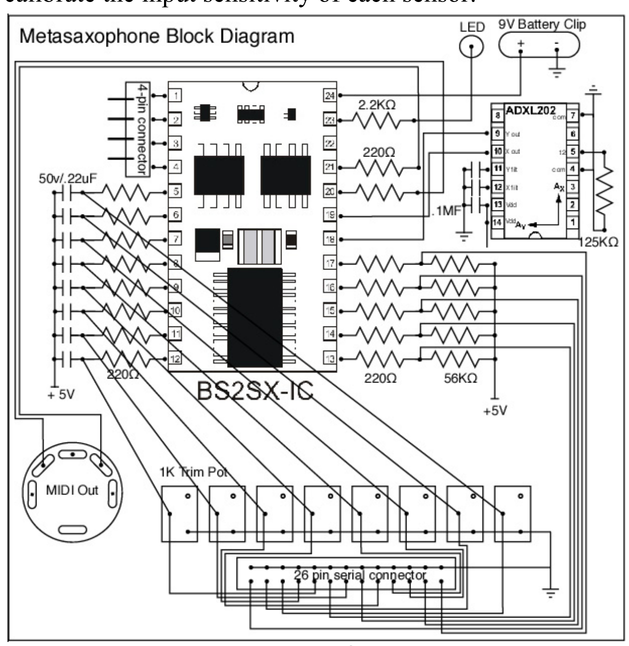

Figure 5: Block Diagram of the Metasaxophone

Software

The BIISX is programmed in Parallax Basic (PBASIC) and the software converts the sensor data into MIDI messages. Analog to digital conversion is accomplished using the PBASIC *RCTIME* (Parallax inc, 1999) function that measures the charge/discharge of the RC circuit over time. The Metasax program loops through the input pins reading the RCTIME counter of each pin.

Multiple programs can be loaded into the BIISX's EEPROM for a variety of applications. The standard Metasaxophone software sends MIDI control change messages 20-27 on channel 1 for the FSRs, MIDI note-on 1-5 on channel 1 for the triggers, and the accelerometer sends MIDI note-on messages 6-10 as the performer crosses certain thresholds of left/right, up/down tilt, and control change messages 28 and 29 for continuous control.

Figure 6: Metasaxophone Circuit Board

The continuous controller MIDI messages sent from the Metasaxophone are used to control digital signal processing and synthesis algorithms. Originally an interactive interface programmed in Max/MSP (Ziccarelli, 1989) was used. Current developments continue to use Max/MSP but also are exploring interface implementations in SuperCollider, RTCMIX, Scanned Synthesis and Pd.

The technical development of the Metasaxophone drew on a growing body of important alternate controller work. The technology used is a variation on a theme by Gary Scavone at Stanford University (Scavone, 1999), and Perry Cook at Princeton University (Cook, 1992).

MUSICAL APPLICATIONS AND NOTATION

The earliest applications of the Metasaxophone involved using the after-touch capabilities to control real time signal processing of the saxophone sound. An interface and set of signal processing networks in Max/MSP allowed the possibility of modifying the timbre of the saxophone in many ways simultaneously. For example, reverb can be controlled by finger pressure on one key, distortion can be assigned to a second, frequency modulation to a third, etc. In and of itself, this made the Metasaxophone a useful tool for the computer music performer. Figure 7 shows the Max/MSP interface for *Noisegate 67.*

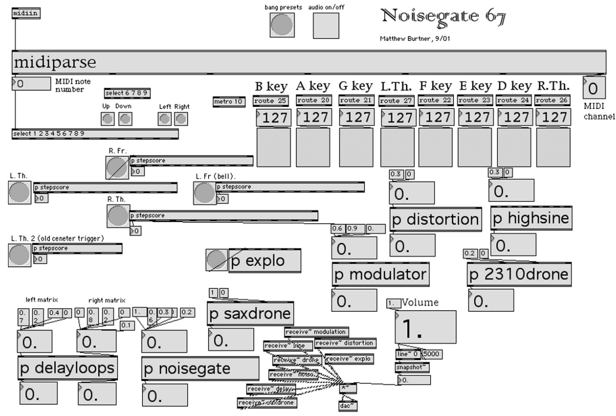

Figure 7: Max/MSP Performance Interface for *Noisegate 67*

Notation

Notational issues quickly arose due to the lack of a standardization for notating multidimensional continuous control changes over time. The glissando is a useful notational paradigm for continuous frequency change, and dynamic markings can express continuous changes in amplitude satisfactorily; but communicating to the performer how multiple key pressures would evolve in the context of saxophone music presented a compositional problem. The notation needed to be specific enough to show pressure changes for each finger, but it could not be too specific for the performance capabilities of the instrument. For example, while it is idiomatic to specify polyphonic pressure curves over specified time periods, it is not reasonable to notate very precise polyphonic controller values.

A system was devised in which each finger was given its own pressure staff, the total pressure of each finger occupying a space from pressure 0 (minimum) to pressure 1 (maximum) on the X axis. Contours for each finger could be drawn into the space and the performer could then follow the contours, approximating the types of changes over time. Above the pressure staff the traditional saxophone music is written.. Below the pressure staff, a third staff containing other controller information such as saxophone position and triggers was combined with a composite graphic representation of the sounding electronic part. Figure 8 illustrates a page of the new notation from *Noisegate 67.*

Noisegate 67

The ability to control real-time interactive electronics from the saxophone opened entirely new compositional and performance possibilities. The Metasaxophone allows the possibility for performer-controlled modular form, in which the electronics can track exactly the modulation between sections of the piece, allowing the performer great flexibility in time.

Noisegate 67 takes advantage of the interactive nature of the instrument by exploring controlled open form. The beginning and end of the piece are notated completely in time. The middle section, however, is a network of possible paths through which the performer can freely move, dramatically shaping the time/energy structure of the composition.

The score of *Noisegate 67* is in the form of a Triptych. The left and right panels of the score present the beginning and end of the piece and are notated in clock time. The performer plays the left panel first. After completing the left panel of the score, the performer folds open the two panels and enters the inner section of the music.

The inner four panels present 21 systems and a network of 25 paths for moving between them. The duration of each system differs depending on the performance. In this way, large-scale expressive control over the inner section of the piece is given to the performer. The duration and expressive potential of this section can vary greatly. Certain paths lead to a music of drama and intensity while other paths reveal a calm and reserved music.

In terms of computer applications, *Noisegate 67* explores the saxophone as a real-time, expressive noise controller. Each of the eight keys are connected to noise generators and filters. By applying pressure to the key, the amplitude of each noise generator is increased, creating an amplitude gate for the noise. By carefully controlling the finger pressure, the performer plays shifting bands of noise that are performed in counterpoint to the saxophone sound. The amplitude of the saxophone sound itself controls a ninth layer of noise. As the amplitude of the saxophone sound increases, the amplitude of the noise generator increases and key pressures control filter parameters.

In this manner the dynamic of the noise system is divided into two layers: 1) a noise part independent of the saxophone audio, formed of 8 key pressures, each with fixed filter coefficients, and 2) a noise part shadowing the saxophone's audio amplitude with continuously changing filter characteristics.

Additionally, certain keys continuously control modulation of the saxophone audio signal. The E key has a fixed modulation rate of 40Hz, and by adding pressure, the depth of the modulator is increased. The modulation rate of the D key on the other hand is determined by the saxophone's audio signal amplitude, and ranges from 1 to 100Hz. Additional keys are used to control delay lines, and to trigger samples from the computer.

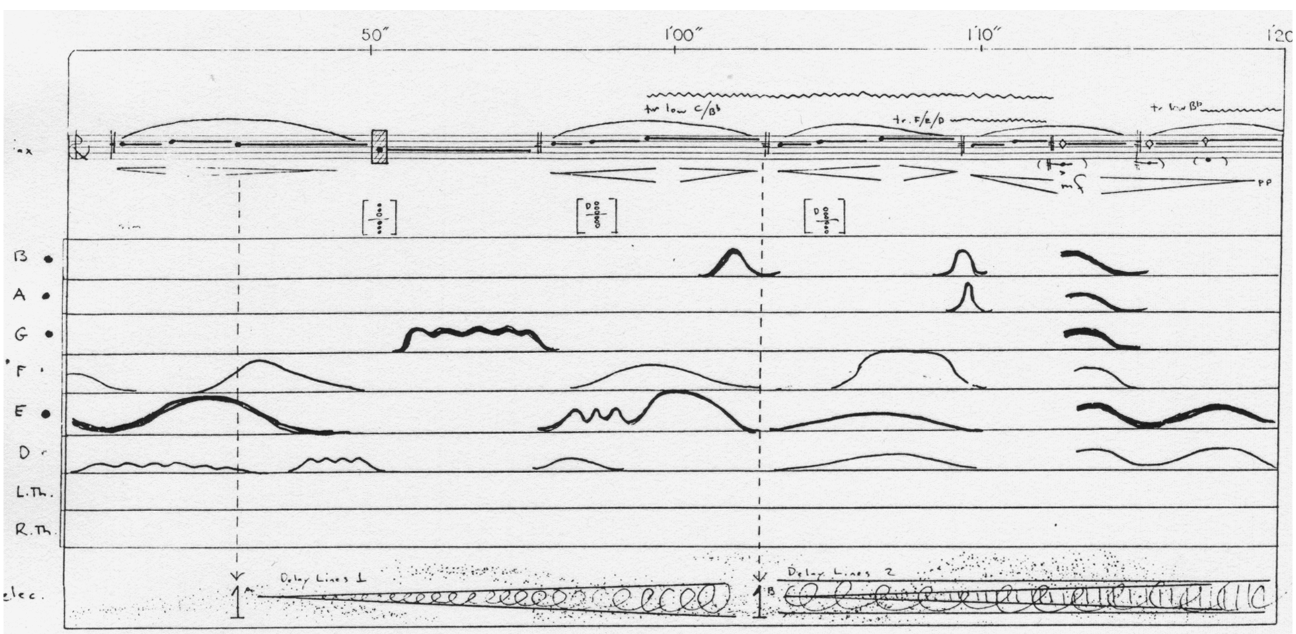

Figure 8: Metasaxophone Notation Excerpt from *Noisegate 67*

FUTURE DIRECTIONS

Current work with the Metasaxophone involves exploration of extended techniques for physical models. In an ongoing project with Stefania Serafin (Burtner/Serafin 2000 and 2001), the Metasaxophone has been used as a controller for bowed string physical models. By controlling the string from within the gestural space of a wind instrument, new expressive potentialities of the model are opened. The disembodied nature of physical models becomes a means of recombining it with other interfaces, creating extended techniques for physical models that would not be possible for the real instrument.

Another project with Max Mathews involves developing real-time interactive applications for Scanned Synthesis algorithms (Mathews/Verplank/Shaw, 2000). As in the work with physical models, the Metasaxophone controls a variety of parameters of a computer-modeled string. The keys act as complex hammers and change the damping, length and stiffness of the string.

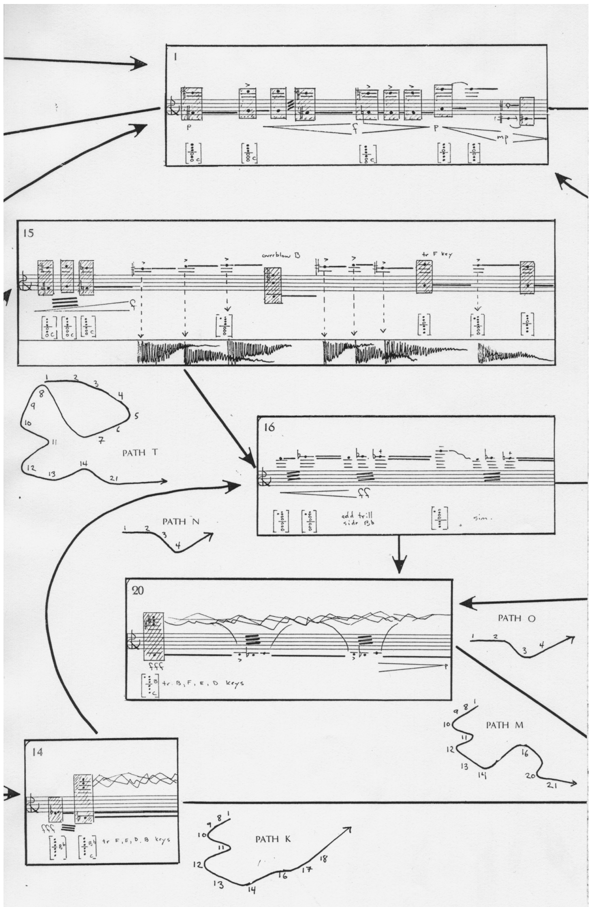

Figure 8: Excerpt from the Score of *Noisegate 67*

CONCLUSION

The computer Metasaxophone represents a further step towards formulating an integrated and meaningful electroacoustic performance practice. Through the development of imbedded systems and sensor technology, and through the use of general communication protocols such as MIDI, direct control of digital signal processing and electronic processes can be given to the performer. The Metasaxophone has proven a useful tool for opening new possibilities of real time integration of instrumental and computer-generated music.

In contrast to the earlier work for acoustic saxophone and electronics, *Noisegate 67* reveals insights into how the use of metainstruments can shape a compositional approach to computer music. Notation, performer control of timbre, and musical form were all radically reshaped in *Noisegate 67* as a direct result of the enhanced saxophone interface.

The possibilities of new applications for metainstruments are virtually infinite, and this enhancement of the saxophone has pushed the practice of saxophone performance and composition into new expressive areas.

REFERENCES

• Burtner, M., and Serafin, S.. *Extended Techniques for Physical Models Using Instrument Controller Substitution.* Proc. ICMA, Perugia, Italy, 2000.

• Burtner, M., and Serafin, S. *Real time Extended Physical Models for the Performer and Composer*. Proc. ICMC, Havana, Cuba, 2001.

• Burtner, M. *Portals of Distortion*, Innova Records, AMC, St. Paul, Minnessotta, USA, 1999.

• Cook, P. *A Meta-Wind-Instrument Physical Model, and a Meta-Controller for Real Time Performance Control.* Proc. ICMC, San Jose, USA 1992.

• Cook, P. *Principles for Designing Computer Music Controllers.* Proc. of NIME-01, Seattle, USA, 2001.

• Cook, P.R., Morrill, E., and Smith, J.O., *A MIDI Control and Performance System for Brass Instruments*. Proc. ICMC, Tokyo, Japan, 1993.

• Felts, R. *The Synthophone MIDI Saxophone*. Saxophone Journal, vol.17 #2, 1992.

• Hunt, A., Wanderley, M.M. and Kirk, R. *Towards a Model for Instrumental Mappings for Expert Musical Performance*. Proc. ICMC, Berlin, Germany, 2000.

• Mathews, M., Verplank, B., and Shaw, R. *Scanned Synthesis, A New Synthesis Technique.* Proc. ICMC, Berlin, Germany, 2000.

• Orio, N., Schnell, N., Wanderley, M. Input Devices for Musical Expression: Borrowing Tools from HCI. Proc of the NIME-01, Seattle, USA, 2001.

• Paradiso, J. *New ways to play: Electronic Music interfaces.* IEEE Spectrum 34, 1997.

• Parallax Inc. *BASIC Stamp Programming Manual*. Version 1.0. www.paralaxinc.com. 1999.

• Rascher, S. M. *The Story of the Saxophone*. http://www.classicsax.com . 1972.

• Scavone, G. *The Holey Controller*. http://www-ccrma.stanford.edu/~gary. 1999.

• Softwind Instruments, "The Synthophone Manual" http://home.att.net/~synthophone/manual/index.htm, Switzerland, 1986.

• Ziccarelli, D. *An Extensible Real-Time Signal Processing Environment for Max*, Proc. ICMC, Ann Arbor, USA, 1998.