SCHAULUST:
A STUDY IN LIGHT AND SOUND

— by —
Mark Cetilia

Submitted in partial fulfillment of the requirements for the Degree of
Doctor of Philosophy in the Department of Music at Brown University

Providence, RI
May 2016

This dissertation by Mark Cetilia is accepted in its present form by the Department of Music as satisfying the dissertation requirement for the degree of Doctor of Philosophy.

Date _____ _____

Joseph Rovan, Advisor

Recommended to the Graduate Council

Date _____ _____

Todd Winkler, Reader

Date _____ _____

Ed Osborn, Reader

Date _____ _____

Shawn Greenlee, Reader

Approved by the Graduate Council

Date _____ _____

Peter Weber, Dean of the Graduate School

Education

Ph.D Brown University: Computer Music + Multimedia, 2016
MFA Rhode Island School of Design: Digital + Media (with Honors), 2008
MA Brown University: Computer Music + Multimedia, 2012
BA Roanoke College: Studio Art, 1997

Honors / Awards

2015 Brown University Creative Arts Council Student Grant Program
Awarded funding for development of audiovisual fixed media works.

Deans' Faculty Fellows Program
Awarded full fellowship support for completion of my Dissertation in Fall 2015. In Spring 2016, I will be appointed a Visiting Assistant Professorship in order to teach a course on Analog / Digital Hybrid Systems in the Music Department at Brown.

Teaching Certificate III
Awarded Teaching Certificate from Brown University's Sheridan Center for Teaching and Learning.

Brown University Creative Arts Council Student Grant Program
Awarded funding for realization of John Cage's *Imaginary Landscape No. 5*.

2014 Brown University Creative Arts Council Student Grant Program
Awarded funding for Schaulust dissertation performance.

2013 Teaching Certificate I
Awarded Teaching Certificate from Brown University's Sheridan Center for Teaching and Learning.

Brown University Creative Arts Council Student Grant Program
Awarded funding for Ctrl+Alt+Repeat Ten Year Anniversary concert.

2012 Brown University Graduate International Colloquium Fund
Funding awarded for planning / production of colloquium on experimental data sonification.

ICMA 2012 Scholarship
Funding for *Pulse Shape 22* performance at ICMC 2012 in Ljubljana, SI.

Brown University International Affairs Travel Fund
Travel funding for *Pulse Shape 22* performance at ICMC 2012 in Ljubljana, SI.

2011 Brown University International Affairs Travel Fund
Awarded travel funding to create a site-specific audiovisual installation at Sound-Fjord, the United Kingdom's only sound art devoted gallery and research unit.

Brown University Creative Arts Council Student Grant Program
Awarded funding for development of performance system used in the realization of a solo version of Cage's *Radio Music for 1 – 8 performers* to be premiered in 2012.

2010 Brown University Creative Arts Council Student Grant Program
Awarded funding for development of Fraktur v.4 hybrid analog / digital modular performance system.

2008 Atlantic Center for the Arts
Selected to work as part of a collaborative group with acclaimed media artist Camille Utterback.

Rhode Island State Council for the Arts Individual Project Grant Award
Mem1 awarded funding to produce an album of collaborative recordings with artists such as Steve Roden, Frank Bretschneider and Jan Jelinek.

2007 Stein Family Fund
Travel grant awarded for collaboration with Israeli video artist Liora Belford.

2006 Creative Capital Foundation
Redux awarded a Creative Capital grant to create *Callspace*, a sound installation utilizing cellular technology to network ambient sound from inaccessible spaces.

Residencies

2014 O' (Milan, IT)
2013 Free103point9's Wave Farm Study Center (Acra, NY)
2012 SoundFjord (London, UK)
2009 USF Verftet (Bergen, NO)
2008 Kunstenaarslogies (Amersfoort, NL)
STEIM (Amsterdam, NL)
Atlantic Center for the Arts (New Smyrna Beach, FL)
2007 Harvestworks (New York, NL)

Teaching / Employment

2016 Visiting Assistant Professor: Brown University (Providence, RI) — *Analog / Digital Hybrids*

2015– Media Lab Co-Director / Instructor: Community MusicWorks (Providence, RI)

2014 Instructor of Record: Brown University (Providence, RI) — *Narrative and Immersion*

2013 Ensemble Leader: Brown University (Providence, RI) — *Electroacoustic Improvisation Ensemble*

Teaching Assistant: Brown University (Providence, RI) — *Narrative and Immersion*

2012 Teaching Assistant: Brown University (Providence, RI) —
Real-Time Systems

Teaching Assistant: Brown University (Providence, RI) —
Narrative and Immersion

2008 Instructor of Record: Rhode Island School of Design (Providence, RI) —
Of Sound and Vision: An Integrated Introduction to Max/MSP/Jitter

2007 Teaching Assistant: Rhode Island School of Design (Providence, RI) —
Interactive and Reactive Media Environments

2006 Teaching Assistant: Rhode Island School of Design (Providence, RI) —
Creative Programming

Workshops / Presentations

2015 Workshop (three weeks): AS220 Media Arts (Providence, RI) —
Sound and Fury: Audio Programming with SuperCollider

2013 Workshop (six weeks): Brown University (Providence, RI) — *Max Bootcamp*

2012 Guest Critic: Rhode Island School of Design (Providence, RI) —
The Artist's Machine: Electricity and Electronics for Artists

Guest Lecturer: Rhode Island School of Design (Providence, RI) —
Experiments in Optics

Workshop (six weeks): Brown University (Providence, RI) —
Max Bootcamp

2011 Guest Lecturer: Rhode Island School of Design (Providence, RI) —
Installation / Sight & Sound

Presentation: Hexagram-Concordia Centre for Research-Creation in Media Arts and Technologies (Montreal, QB) — *Understanding Visual Music*

2009 Workshop (four weeks): TELIC Arts Exchange (Los Angeles, CA) —
Introduction to Max/MSP/Jitter

Artist talk: Bergen Senter for Elektronisk Kunst (Bergen, NO)

Workshop and presentation: Hamidrasha School of Art (Kfar Saba, IL)

2008 Workshop and presentation: Hogeschool voor de Kunsten (Utrecht, NL)

Workshop: Spullenmannen (Amersfoort, NL) — *Max/MSP Toko*

Workshop and presentation: Emory & Henry College (Emory, VA) —
A Certain Distance

Workshop for children ages 8 – 18: Community MusicWorks (Providence RI)

2007 Guest Lecturer: Rhode Island School of Design (Providence, RI) —
Digital Media Continuum Studio

2006 Workshop: Rhode Island School of Design (Providence, RI) —
Introduction to Max/MSP/Jitter

Reviews / Publications

2015 *A Simple Procedure* reviews: Textura, Loop

A Floating Wave of Air reviews: Textura, Loop, Bad Alchemy

2014 *Impact + Aftermath* reviews: The Sound Projector, Neural, Metamkine

2013 *The Grove Dictionary of American Music*, Oxford University Press: Mem1 article

Impact + Aftermath reviews: Textura, Loop

Anticipations + Suspensions review: Textura

2012 *Sound Objects: Speculative Perspectives*, Mandy-Suzanne Wong
Tetra review: Aquarius Records

2011 *Age of Insects* reviews: The Silent Ballet, Le Son du Grisli, Touching Extremes, Cyclic Defrost, Foxy Digitalis

Tetra reviews: Metamkine, Fluid Radio, Static Sound, Future Sequence, Dusted Magazine, Norman Records, Textura, Vital Weekly

Mem1's Top 10 Most Influential Live Performances, Textura: Mem1 feature

Featured, Rare Frequency: Mem1 interview

2010 *+1* reviews: Ampersand Etc., Neural

Pick of the Week, LA Weekly: Ctrl+Alt+Repeat feature

Sound Object Analysis, Mandy-Suzanne Wong: Proceedings of the International Conference Beyond the Centres: Musical Avant-Gardes Since 1950, Thessaloniki, Greece, 1 – 3 July 2010

2009 *Pick of the Week*, LA Weekly: Mem1 / Steve Roden / Domizil / ICST at LACE

+1 reviews: Junk Media, The Wire, The Sound Projector, Textura, Exclaim / Destination Out, Foxy Digitalis, Dark Entries, Cyclic Defrost, Le Son du Grisli, Earlabs, Nonpop.de, Sentire Ascoltare, Aquarius Records, Boomkat, Sound Proector, Smallfish Stationary Drift reviews: Touching Extremes, Textura
Borealis re-visited, STEIM Blog: Mem1 performance review

Live at OCMA review: Synesthetech

Mem1 at Sound of Mu, Oslo, Soundscaping: Mem1 performance review

2006 *Alexipharmaca* reviews: Forced Exposure, Boomkat, Cyclic Defrost Magazine, Touching Extremes, Neural, Aquarius Records, Textura, Smallfish, Metamkine, Vital Weekly

Improvisations + Edits CD Feature: Tokafi

2005 *Repeat that, please*, Tokafi: Ctrl+Alt+Repeat feature

Discography

2015 Various Artists: *A Simple Procedure* Compilation, Estuary Ltd. (2xCD, 42x 7", DL)
Steve Roden + Mem1: *A Floating Wave of Air*, Estuary Ltd. (CD, DL)

2014 Various Artists: *Quark: How Does The Invisible Sound?* [Q06] Compilation, Farmacia 901 (DL)

2013 Mem1: *Suspensions*, Radical Matters (CD-R, DL)
Mem1: *Anticipations*, Radical Matters (DL)
Mark Cetilia: *Impact + Aftermath*, Estuary Ltd. (CD, DL)

2012 Various Artists: *Iron: Dragon's Eye Sixth Anniversary* Compilation, Dragon's Eye Recordings (DL)

2011 Mem1 + Stephen Vitiello: *Age of Insects*, Dragon's Eye Recordings (CD-R, DL)
Mem1: *Podcast Special Ed. 50: Mem1 Live*, Rare Frequency (DL)
Various Artists: *Wood: Dragon's Eye Fifth Anniversary Compilation*, Dragon's Eye Recordings (DL)

2010 Mem1: *Tetra*, Estuary Ltd. (LP, DL)
Mark Cetilia: *Antimony*, Iynges (CD-R, DL)
Various Artists: *Power / Field 2* Compilation, Anarchymoon (2x CD-R)

2009 Mark Cetilia: *Anemoi*, Quiet Design (Mini CD-R, DL)
Mem1: *+1*, Interval Recordings (CD)
Mem1: *Live at OCMA*, MPRNTBL (DL)

Various Artists: *Laptopia #5* Catalog, MoBY / Ben Ari Museum for Contemporary Art (Book + CD)
Mem1: *Stationary Drift*, Resting Bell (DL)

2007 Various Artists: *SFEMF 2007* Compilation, SFEMF (CD)
M. Cera: *Schismogenisis*, Subduction (DL)

2006 Mem1: *Alexipharmaca*, Interval Recordings (CD)
Kadet + Mem1: *Infinite Delay*, Tektonic Shift (DVD-R)
Various Artists: *SoundWalk 2006* Catalog, FLOOD (Book + CD)

2005 Various Artists: *SoundWalk 2005* Catalog, FLOOD (Book + CD)
Mem1: *Improvisations + Edits*, Self Released (CD-R)

2004 Various Artists: *Polyrhythmic Winter 2004* Compilation, Polyrhythmic (CD-R)

Performances

2015 Aurora (Providence, RI): Mem1
Deep Sound, AS220 (Providence, RI): Mem1
Machines with Magnets (Pawtucket, RI): Titans of Jazz
A Simple Procedure: Epic Release Party, Machines with Magnets (Pawtucket, RI): Mark Cetilia realizes John Cage — *Imaginary Landscape No. 5*
DOT AIR, Machines with Magnets (Pawtucket, RI): Apathy and Steel
Redroom (Providence, RI): Mark Cetilia
SASSAS, MorYork (Los Angeles, CA): Mem1
MATA (Los Angeles, CA): Mark Cetilia
Museum of California Art (Pasadena, CA): Mem1 + Steve Roden
Machines with Magnets (Pawtucket, RI): Mem1
Ctrl+Alt+Repeat, Machines with Magnets (Pawtucket, RI): Titans of Jazz
CMW Media Lab Experimental Music Concert, Providence Public Library (Providence, RI): Mark Cetilia
Washington Street Arts Center (Boston, MA): Idle Hands
Machines with Magnets (Pawtucket, RI): Idle Hands
186 Carpenter (Providence, RI): Mem1
Machines with Magnets (Pawtucket, RI): Mark Cetilia
Thee Eldritch (Providence, RI): Titans of Jazz
Ctrl+Alt+Repeat, Proxy (Providence, RI): Mem1

2014 Psychic Readings (Providence, RI): Mem1
Next Fiends, Palisades (New York, NY): Mark Cetilia
Machines with Magnets (Pawtucket, RI): Mem1 + Attila Faravelli
Washington Street Arts Center (Boston, MA): Mem1
75 Waterman (Providence, RI): Schaulust
Machines with Magnets (Pawtucket, RI): Titans of Jazz
Sonic Focus 3.5, Granoff Center for the Arts (Providence, RI): Schaulust
P.U.F.F.E.R.S.S. IV, 230 Oak St. (Providence, RI): Mark Cetilia

Thee Eldritch (Providence, RI): Mark Cetilia
Nightvisions (Providence, RI): Mem1
DOT AIR, Pawtucket River Bridge (Providence, RI): Dislocation Ensemble
AS220 (Providence, RI): Mem1
Soundwave Biennial, Intersection for the Arts (San Francisco, CA): Mem1
In the Garden of Sonic Delights, Lyndhurst Estate (Tarrytown, NY): Ed Osborn + Mark Cetilia + Laura Cetilia + Peter Bussigel — *Palm House Transect*
Machines with Magnets (Pawtucket, RI): Mem1
Machines with Magnets (Pawtucket, RI): Titans of Jazz
95 Empire (Providence, RI): Black Iron Prison
Machines with Magnets (Pawtucket, RI): Titans of Jazz
O' (Milan, IT): Mem1
Psychic Readings (Providence, RI): Mem1
Ctrl+Alt+Repeat, Machines with Magnets (Pawtucket, RI): Schaulust
Machines with Magnets (Pawtucket, RI): Titans of Jazz
Kristina's World (Providence, RI): Schaulust
95 Empire (Providence, RI): Schaulust
Bach to the Future II, Manning Chapel (Providence, RI): Titans of Jazz

2013 Grant Hall (Providence, RI): MEME Ensemble — *pp > p*
Machines with Magnets (Pawtucket, RI): Titans of Jazz
Ampersand, MIT Bartos Theatre (Cambridge, MA): Mem1
Ctrl+Alt+Repeat, Machines with Magnets (Pawtucket, RI): Intimacy & Intrigue (Laura Cetilia + Mark Cetilia + Sakiko Mori)
Machines with Magnets (Pawtucket, RI): Mark Cetilia
Machines with Magnets (Pawtucket, RI): Mem1
Wesleyan University (Middletown, CT): Mark Cetilia — Dissolution
186 Carpenter (Providence, RI): Mem1
Machines with Magnets (Pawtucket, RI): Mark Cetilia
LeHum, Galerie Sans Nom (Moncton, NB): Mem1
Grant Hall (Providence, RI): Mem1
Grant Hall (Providence, RI): Mark Cetilia
Non-Event, Café Fixe (Boston, MA): Mark Cetilia
A.I.R. Gallery (Brooklyn, NY): Mem1 — *Andrei Rublev — 60 minutes*
Grant Hall (Providence, RI): Idle Hands
Granoff Center for the Arts (Providence, RI): Mem1 + Stephen Vitiello — *Way Down East* (Audiovisual Performance)
Ctrl+Alt+Repeat, 500 Broad (Providence, RI): Mem1

2012 Piksel, Østre (Bergen, NO): Mark Cetilia — *Pulse Shape 22*
Interaction / Immersion, RK Projects (Pawtucket, RI): Mark Cetilia — *Pulse Shape 22* (Audiovisual Performance)
ICMC 2012, Menza Pri Koritu (Ljubljana, SI): Mark Cetilia — *Pulse Shape 22* (Audiovisual Performance)
Wave Energy Series, UCSD (San Diego, CA): Mem1
Re:Flux Festival (Moncton, NB): Mem1

Third Mind, Grant Hall (Providence, RI): Mark Cetilia —
Pulse Shape 22 (Audiovisual Performance)
Ctrl+Alt+Repeat, The Arsenal (Providence, RI): Mark Cetilia —
John Cage: *Radio Music*
Café OTO (London, UK): Mem1

2011 Second Sight, Grant Hall (Providence, RI): Mark Cetilia —
Pulse Shape 22 (Audiovisual Performance)
MATX Mixtapes, VCU (Richmond, VA): Mark Cetilia — *Backscatter 03*
Palimpsestic, RK Projects (Providence, RI): Mark Cetilia
One Thousand Pulses, Fairleigh Dickinson University (Teaneck, NJ):
Mem1 + Stephen Vitiello
Pixilerations, Grant Hall (Providence, RI): Mem1 —
Aphrosia (Audiovisual Performance)
Sonic Afterimage, RK Projects (Providence, RI): Mark Cetilia
Understanding Visual Music 2011, Hexagram-Concordia Centre for Research-Creation in Media Arts and Technologies (Montreal, QC): Mem1 —
Aphrosia (Audiovisual Performance)
((Audience)), 16 Beaver Group (New York, NY): Mark Cetilia
AS220 (Providence, RI): Mem1
Ctrl+Alt+Repeat, Firehouse 13 (Providence, RI): Mem1
Overheard / Underground, BCA / Mills Gallery (Boston, MA): Mem1
Non-Event, Goethe-Institut (Boston, MA): Mem1
186 Carpenter (Providence, RI): Mark Cetilia
Non-Event, Spectacle (Boston, MA): Mark Cetilia
Basilica of St. Patrick's Old Cathedral (New York, NY): Mark Cetilia
Hertz Celebration, Rádio Zero (Lisbon, PT): Antonio della Marina + Gintas K + Ben Owen + Rui Chaves + Gonçalo Alegria + Daniel Gomes + Pablo Sanz + Carlos Santos + Jorge Valente + Sarah Boothroys + Noisy Ghost, Andrius Rugys + Daniel Martin-Borret + Mark Cetilia + Paulo Raposo (coordination & mix)
186 Carpenter (Providence, RI): Mem1
Eastern Butcher Block Fest, RK Projects (Providence, RI): Mem1

2010 Tune In / Tune Out, Grant Hall (Providence, RI): Mark + Laura Cetilia — *Twilight Hour*, Kyle deCamp + Stephan Moore + Mark Cetilia — *Urban Renewal (excerpt)*
Pixilerations, Grant Hall (Providence, RI): Mem1 —
Hræsvelgr (Audiovisual Performance)
Le Cagibi (Montreal, QC): Mem1
Floating Points Festival, Issue Project Room (Brooklyn, NY): Mem1
Volume, Torrance Art Museum (Torrance, CA): Mem1 —
Hræsvelgr (Audiovisual Performance)
Ctrl+Alt+Repeat, Synchronicity Space (Los Angeles, CA): Mem1
Resbox, Steve Allen Theater (Los Angeles, CA): Mem1
Art LA Contemporary, Pacific Design Center (Los Angeles, CA): Mem1

2009 San Francisco Cinematheque, Yerba Buena Center for the Arts (San Francisco, CA): Kadet Kuhne + Mem1 — *Infinite Delay* (Audiovisual Performance)
REDCAT Lounge at Walt Disney Hall (Los Angeles, CA): Mem1
Luggage Store (San Francisco, CA): Mem1
Blim (Vancouver, BC): Mem1
Jewelbox Theater (Seattle, WA): Mem1
Dunes (Portland, OR): Mem1
SoundWalk (Long Beach, CA): Redux
LACE (Los Angeles, CA): Mem1
Pehrspace (Los Angeles, CA): Mem1
Slow Sound Festival, Open (Long Beach, CA): Mem1
John Natsoulas Gallery (Davis, CA): Mem1
Echo Curio (Echo Park, CA): Mem1
5 Traverse Gallery (Providence, RI): Mem1
Outpost 186 (Boston, MA): Mem1
King Street Manor (Northampton, MA): Mem1
L'Envers (Montréal, QC): Mem1
Monkeyhouse (Burlington, VT): Mem1
Listen / Space (Brooklyn, NY): Mem1
Brickbat Books (Philadelphia, PA): Mem1
Sonic Circuits, Pyramid Atlantic (Silver Spring, MD): Mem1
Ghost Print Gallery (Richmond, VA): Mem1
Borealis Festival, Logen Teater (Bergen, NO): Mem1
PrøveRommet, Landmark Kunsthall (Bergen, NO): Mem1
Transplant (Dale i Sunnfjord, NO): Mem1
Sound of Mu (Oslo, NO): Mem1
Uganda (Jerusalem, IL): Mem1
Laptopia #5, Levontin 7 (Tel-Aviv, IL): Mem1 + Ido Govrin

2008 De Observant (Amersfoort, NL): Mem1
Electronic Church (Berlin, DE): Mem1
Sonic Peripheries, Galerie Kunstlerstatte Stuhr-Heiligenrode (Heiligenrode, DE): Mem1
Proeflokaal, Theater Kikker (Utrecht, NL): Mem1
Stadsgalerij (Amersfoort, NL): Mem1
Vrij Glas (Zaandam, NL): Mark Cetilia
Local Stop, STEIM (Amsterdam, NL): Mem1
Inventorium, Atlantic Center for the Arts (New Smyrna Beach, FL): Mark Cetilia + Corey Allen + Blake Carrington — *Teleforce Weapon* (Audiovisual Performance)
White Electric (Providence, RI): Mem1 + Liora Belford — *Sonodendron* (Audiovisual Performance)
Roulette (New York, NY): Mem1 + Liora Belford — *Sonodendron* (Audiovisual Performance)
Ctrl+Alt+Repeat, Firehouse 13 (Providence, RI): Mem1

2007 Narwhal Arms (Providence, RI): Mark Cetilia
Alt-Space, Cormack Planetarium (Providence, RI): Mem1 + Area C
AS220 (Providence, RI): Mem1
Bushwick Starr (New York, NY): Mem1
Sonic Arts, GASP (Boston, MA): Mem1
Pixilerations, The Space at Alice (Providence, RI): Mem1 + Envyloop
San Francisco Electronic Music Festival, Project Artaud Gallery (San Francisco, CA): Kadet Kuhne + Mem1 — *Infinite Delay* (Audiovisual Performance)
Levontin 7 (Tel-Aviv, IL): Mem1 + Liora Belford
Rosa (Jeruslaem, IL): Mem1
Ctrl+Alt+Repeat, Dangerous Curve (Los Angeles, CA): Substrate
Alt-Space, Cormack Planetarium (Providence, RI): Mem1 + Area C
Ctrl+Alt+Repeat, Firehouse 13 (Providence, RI): Mem1

2006 Om Factory (New York, NY): Mem1, Mark Cetilia
Pixilerations, 191 Westminster (Providence, RI): Mem1
Ctrl+Alt+Repeat, Dangerous Curve (Los Angeles, CA): Mem1
Soundscapes, Orange County Museum of Art (Newport Beach, CA): Mem1
Ctrl+Alt+Repeat, Inmo Gallery (Los Angeles, CA): Mem1
2006 CEAIT Festival, REDCAT Theater at Walt Disney Hall (Los Angeles, CA): Kadet Kuhne + Mem1 — *Infinite Delay* (Audiovisual Performance)
Definiens Crescent Series, Culver Hotel (Culver City, CA): Mem1

2005 Ctrl+Alt+Repeat, Selah (Los Angeles, CA): Mem1
SoundWalk (Long Beach, CA): Mem1
Ctrl+Alt+Repeat, Il Corral (Los Angeles, CA): Mem1
L.A. Art Fest 2005 (Los Angeles, CA): Mem1
Tenbyten Performance Lab, Koo's Art Center (Long Beach, CA): Mem1
Tenbyten Performance Lab, Koo's Art Center (Long Beach, CA): Redux — *RGB Shift* (Audiovisual Performance)
2005 CEAIT Festival, REDCAT Theater at Walt Disney Hall (Los Angeles, CA): Redux — *Heredity Vector* (Audiovisual Performance)

2004 Ctrl+Alt+Repeat, The Red Room at Zen (Los Angeles, CA): Mem1
Killradio Benefit, The Silverlake Lounge (Los Angeles, CA): Cera

2003 Create:Fixate, 8601 Wilshire Blvd. (Los Angeles, CA): Cera
[Sub]URBAN [Sub]VERSION, Little Tokyo Lofts (Los Angeles, CA): Cera
Killradio Benefit, Zip Fusion (Los Angeles, CA): Cera
Twine, The Knitting Factory (Los Angeles, CA): Cera
Polyrhythmic, Killradio (Los Angeles, CA): Cera (Weekly internet radio show)

2002 Decompression, 833 S. Spring St. (Los Angeles, CA): Cera
Polyrhythmic, The 56 (Los Angeles, CA): Cera (Weekly DJ residency)

2001 Twine, The Knitting Factory (Los Angeles, CA): Cera

1999 Parallax, Storyville (San Francisco, CA): Cera (Weekly DJ residency)

1998 Core, Liquid (San Francisco, CA): Cera (Weekly DJ residency)

Radio Interviews / In-Studio Performances

2013 Saturday Afternoon Show, WGXC (Acra, NY): Redux — Performance + Interview
2011 Rare Frequency, WZBC (Boston, MA): Mem1 — Performance
2009 Drachim Tzdadiot, 106 FM (Tel-Aviv, IL): Mark Cetilia — Interview
Psychotechnics, KXLU (Los Angeles, CA): Mem1 — Performance

Installations / Screenings / Group Exhibitions

2015 The Abandoned Mines, Centrale Fies (Dro, IT): Curandi Katz + Mark Cetilia — *Parola per Parola* (Audiovisual Installation)

2014 Future Tense, The Spielberg Theatre at the Egyptian (Los Angeles, CA): Kadet Kuhne + Mem1 — *Infinite Delay* (Screening)
Balagan Films, Norman B. Leventhal Park (Boston, MA): Mark Cetilia — *Sleep of Ondine* (Screening)
O' (Milan, IT): Mark Cetilia — *Citarum*, *Sleep of Ondine* (Screening)
O' (Milan, IT): Mem1 — *Visiting Hours II* (Screening)

2013 Complexity, Granoff Center for the Arts (Providence, RI): Mark Cetilia — *Sleep of Ondine* (Audiovisual Installation)
Live Works, Centrale Fies (Dro, IT): Curandi Katz + Mark Cetilia — *Parola per Parola* (Audiovisual Installation)
Ende Tymes Festival, Silent Barn (Brooklyn, NY): Mark Cetilia — *Pulse Shape 22* (Screening)
The Futures Project, Alabama Contemporary Art Center (Mobile, AL): Kadet Kuhne + Mem1 — *Infinite Delay* (Audiovisual Installation)
Red Room, Baltimore, MD: Mark Cetilia — *Sleep of Ondine* (Screening)

2012 Interaction / Immersion, RK Projects (Providence, RI): Mark Cetilia — *Pulse Shape 22* (Audiovisual Installation: 4.1 sound + single channel video)
Sound // Space, V22 (London, UK): Mark Cetilia — *Pulse Shape 22* (Screening)
Sound // Space, V22 (London, UK): Mark Cetilia + Laura Cetilia — *Visiting Hours* (Screening)
Sound // Space, V22 (London, UK): Mem1 — *Hræsvelgr*, *Aphrosia* (Screening)
Imperium Naturæ, Armory Center for the Arts (Los Angeles, CA): Kadet Kuhne + Mem1 — *Infinite Delay* (Screening)
Make Music Festival (Los Angeles, CA): Kadet Kuhne + Mem1 — *Infinite Delay* (Screening)
Sublimation, Oboro (Montréal, QC): Mark Cetilia + Laura Cetilia — *Visiting Hours* (Audiovisual Installation)
SoundFjord (London, UK): Mem1 — *Visiting Hours II* (Audiovisual Installation)

2011 Livewire Festival, University of Maryland Baltimore County (Baltimore, MD): Mark Cetilia — *The Vermillion South* (Diffusion)
Radiofutura, Future Places / Radio Zero (Lisbon, Portugal): Mark Cetilia — *Backscatter 01 / 02* (Diffusion)
Happy Happy Sound Day, SoundFjord (London, UK): Mem1 + Liora Belford — *Sonodendron* (Screening)
Re/Flux: Sublimated Landscape / Sonic Topology, Institute of Contemporary Arts (London, UK): Mem1 — *Aphrosia* (Screening)

2010 Pixilerations [v.7], Machines with Magnets (Pawtucket, RI): Redux — *Callspace* (Sound Installation)
Works That Disturb the Moonlight, Alphonse Berber Gallery (Berkeley, CA): Kadet Kuhne + Mem1 — *Infinite Delay* (Audiovisual Installation)

2009 Degeneration / Regeneration, Marina Abramovic Institute (San Francisco, CA): Kadet Kuhne + Mem1 — *Infinite Delay* (Audiovisual Installation)
Image + Nation Festival (Montréal, QC): Kadet Kuhne + Mem1 — *Infinite Delay* (Screening)
SoundWalk (Long Beach, CA): Mark Cetilia + Jon Coulthard — *Philosophical Mercury* (Audiovisual Installation)
Resonant Forms Festival, Los Angeles Contemporary Exhibitions (Los Angeles, CA): Kadet Kuhne + Mem1 — *Infinite Delay* (Screening)
PrøveRommet, Hordaland Kunstsenter / HKS (Bergen, NO): Mem1 + Liora Belford — *Sonodendron* (Screening)
Laptopia 5, Ben Ari Museum for Contemporary Art (Bat Yam, IL): Mark Cetilia + Laura Cetilia — *Visiting Hours* (Audiovisual Installation)

2008 Inventorium, Atlantic Center for the Arts (New Smyrna Beach, FL): Mark Cetilia + Deborah Johnson — *Filoa* (Screening)
Inside Out, Atlantic Center for the Arts (New Smyrna Beach, FL): Mark Cetilia + Camille Utterback + Bang Geul Han + Sophia Lycouris + Hector Canonge + Helen Pritchard + Nadia Hironaka + Wendy Wischer + Ivan Toth Depena — *Gift* (Audiovisual Installation)
Inside Out, Atlantic Center for the Arts (New Smyrna Beach, FL): Mark Cetilia — *Calvin R. Graf Lounge* (Audiovisual Installation)
Sound Nights, Projections on Lake (Pasadena, CA): Kadet Kuhne + Mem1 — *Infinite Delay* (Screening)
A Certain Distance, 1912 Gallery (Emory, VA): Mark Cetilia — *Vectorial Analysis* (Sound Installation)
Rhode Island School of Design MFA Thesis Exhibition, Providence Convention Center (Providence, RI): Mark Cetilia — *Effective Dose* (Audiovisual Installation)
(In)visible Sounds, Sol Koffler Gallery (Providence, RI): Mark Cetilia — *Dreammachine v2.1* (Audiovisual Installation)
Micromediations, Sol Koffler Gallery (Providence, RI): Mark Cetilia — *Creeping Dose* (Audiovisual Installation)

2007 Audiovision [v2], Grant Hall (Providence, RI): Mark Cetilia — *Creeping Dose* (Screening)
Laptopia 4, Levontin 7 (Tel-Aviv, IL): Mark Cetilia — *Hand of Doom* (Screening)
MIX NYC, MIX Factory (New York, NY): Kadet Kuhne + Mem1 — *Infinite Delay* (Audiovisual Installation)
Harvestworks (New York, NY): Mem1 + Liora Belford — *Sonodendron* (Screening)
Antimatter Underground Film Festival, Deluge Contemporary Art (Victoria, BC): Kadet Kuhne + Mem1 — *Infinite Delay* (Screening)
Electronic Music Midwest, Kansas City Kansas Community College (Kansas City, MO): Kadet Kuhne + Mem1 — *Infinite Delay* (Screening)
Ozone Film Festival, Haik Park Outdoor Theater (Covington, Louisiana): Kadet Kuhne + Mem1 — *Infinite Delay* (Screening)
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LA Shorts Fest, AMC Burbank Town Center 6 (Los Angeles, CA): Kadet Kuhne + Mem1 — *Infinite Delay* (Screening)
[Post] Laptopia 3, Uganda (Jerusalem, IL): Mark Cetilia — *Obliscence Field* (Screening)
Laptopia 3, Levontin 7 (Tel-Aviv, IL): Mark Cetilia — *Obliscence Field* (Screening)
Bars and Tone, Stairwell Gallery (Providence, RI): Mark Cetilia — *Obliscence Field* (Screening)
Fringe Exhibitions (Los Angeles, CA): Kadet Kuhne + Mem1 — *Infinite Delay* (Audiovisual Installation)
Digital + Media Open Studios, Rhode Island School of Design (Providence, RI): Mark Cetilia — *Hand of Doom* (Audiovisual Installation)
Sundance Film Festival (Park City, UT): Kadet Kuhne + Mem1 — *Infinite Delay* (Screening)

2006 Digital + Media Open Studios, Rhode Island School of Design (Providence, RI): Mark Cetilia — *Made for Television* (Audiovisual Installation)
SoundWalk (Long Beach, CA): Substrate — *Fixed* (Sound Installation)

2005 SoundWalk (Long Beach, CA): Redux — *Forbidden Fruit* (Sound Installation)

Jury Positions

2014 International Computer Music Conference / Sound & Music Computing Conference Review Committee
2013 International Computer Music Conference 2013 Video Music Composition Panel
2010 Rhode Island State Council on the Arts New Genres Fellowship Panel

Curatorial Activities

2015 Ctrl+Alt+Repeat [Fall 2015], Machines with Magnets (Pawtucket, RI): Jürg Frey — *Memorie, Horizon* performed by Konus Quartett, Tomas Korber — *Musik für ein Feld* performed by Konus Quartett + Tomas Korber

A Simple Procedure: Epic Release Party, Machines with Magnets (Pawtucket, RI): Blevin Blectum & Ed Osborn, Jeff Carey, Morgan Evans-Weiler, Sarah Hennies, Shawn Greenlee, Jeremy Harris, Donna Parker & Vic Rawlings, Andrea Pensado, Soft Target, Timeghost, Matt Underwood, Work/Death, John Cage's *Imaginary Landscape No. 5* realized by Mark Cetilia using contributed works from all 42 artists featured on *A Simple Procedure*

Blevin Blectum + Ed Osborn, Gilles Aubry, Ken Ueno, Andrea Pensado, Amnon Wolman, Ido Govrin, Rrose, Robert Donne + Stephen Vitiello, Daniel Menche, Steve Roden, Jeff Carey, Christine Ödlund, Area C, Reuben Son, Geoff Mullen, Yann Novak + Robert Crouch, Maia Urstad, Kraig Grady, Intimacy & Intrigue, Jeremy Harris, Work/Death, Val Martino, Davey Harms, Ren Schofield, Sot Target, Matt Underwood, Jen Boyd + Joe Cantrell, Dalglish, Titans of Jazz, Ernst Karel, Sarah Hennies, Shawn Greenlee, Timeghost, Keith Fullerton Whitman, Christopher Forgues, Agnes Hvizdalek + Harald Fetveit, Power Monster, Morgan Evans-Weiler, Vic Rawlings, Donna Parker, Mem1, Attila Faravelli, John Cage's *Imaginary Landscape No. 5* realized by Mark Cetilia using contributed works by artists listed above — *A Simple Procedure* (Estuary Ltd. EST5007 Dual CD / 42 Lathe-Cut 7" Records)

Steve Roden + Mem1 — *A Floating Wave of Air* (Estuary Ltd. EST5006 CD)

Ctrl+Alt+Repeat [June 2015], Machines with Magnets (Pawtucket, RI): Will Guthrie, Titans of Jazz, André Cormier — *Hic et Nunc* performed by Emily Dix Thomas (cello) + Laura Cetilia (cello), Philip Glass — *Strung Out* performed by Chase Spruill

Ctrl+Alt+Repeat [March 2015], Proxy (Providence, RI): Deleuzer, Ren Schofield, Donna Parker, Mem1, Jürg Frey — *Relikt + Wen #46* performed by Luke Moldof

2014 Nightvisions no. 3, Grant's Block (Providence, RI): live performances by Laurie Amat, Donna Parker, Mem1 / video screenings by Matt Underwood — *Decoder*, Kadet Kuhne — *Fight or Flight*, Adam Morosky — *No Strings*

Ctrl+Alt+Repeat [Ten Year Anniversary], Machines with Magnets (Pawtucket, RI): Rrose, Blevin Blectum, Shawn Greenlee, Schaulust, Iannis Xenakis' *Psappha* performed by Piero Guimaraes

Blevin Blectum — *Irradiance* (Estuary Ltd. EST5005 CD)

Laura Cetilia — *Used, Broken & Unwanted* (Estuary Ltd. EST5004 CD)

2013 Ctrl+Alt+Repeat [December 2013], Machines with Magnets (Pawtucket, RI): Frank Bretschneider — *Kippschwingungen* (U.S. Premiere), Work / Death, Area C, Intimacy & Intrigue, Peter Ablinger — *Two Strings and Noise* performed by David Lee + Laura Cetilia, *Violine und Rauschen ("Veronica")* performed by David Lee, *Kleine Trommel und Ukw-Rauschen ("Conceptio")* performed by Caroline Park, and *Orgel und Weltempfänger*, 1999 performed by Luke Moldof (organ)

Ed Osborn — *Stone North* (Estuary Ltd. EST5003 CD)

Ctrl+Alt+Repeat [Fall 2013], The Arsenal (Providence, RI): Charles Curtis performs Éliane Radigue — *Occam V*, Christian Wolff — *One Cellist*, Alvin Lucier — *Slices for Cello and Pre-recorded Orchestra*, Alison Knowles — *Rice and Beans for Charles Curtis*, Tashi Wada — *Landslide*

Mark Cetilia — *Impact + Aftermath* (Estuary Ltd. EST5002 CD)

Ctrl+Alt+Repeat [Winter 2013], 500 Broad St (Providence, RI): Reuben Son, Ed Osborn, Mike Bullock + Vic Rawlings, Luke Moldof, Mem1, Geoff Mullen + Keith Fullerton Whitman, Jürg Frey — *60 Pieces of Sound* performed by CMW Players, Alvin Lucier — *Gentle Fire* performed by Caroline Park

2012 Ctrl+Alt+Repeat [Spring 2012], The Arsenal (Providence, RI): John Cage — *Vocalise For a Man with a Twelve-Tone Name* performed by Katherine Bergeron, *Three2* for three percussionists + *Four* for string quartet performed by CMW Players, *Radio Music* performed by Mark Cetilia, selections from *Song Books* and *Indeterminacy: New Aspects of Form in Instrumental and Electronic Music* performed simultaneously by CMW students + Forrest Larson, Nomi Epstein — *For Cage 99*

2011 Ctrl+Alt+Repeat [Spring 2011], Firehouse 13 (Providence, RI): Ernst Karel, Lyn Goeringer, Mem1, Morton Feldman — *Structures* + Christina Kubisch — *Vibrations* performed by CMW Players

2010 Mem1 — *Tetra* (Estuary Ltd. EST12001 LP)

Ctrl+Alt+Repeat [Spring 2010], Synchronicity Space (Los Angeles, CA): Svarte Greiner, Crystal Hell Pool, Cat Lamb — *In Passing/Parallel* performed by Robin + Cassia Streb, Mem1

2008 Ctrl+Alt+Repeat [Winter 2008], Firehouse 13 (Providence, RI): Mem1, HinjNoiz, Ken Ueno — *Age of Aircraft* + Kevin Patton — *That Every Mouth May be Stopped* (World Premiere) performed by Laura Cetilia

2007 Ctrl+Alt+Repeat [Summer 2007], Dangerous Curve (Los Angeles, CA): Steve Roden, Jeremy Drake, Substrate, David Monacchi, Marc Thomas, James Tenney — *Koan* performed by Robin Streb

Ctrl+Alt+Repeat [Winter 2007], Firehouse 13 (Providence, RI): Area C, Mem1, John Cage — *String Quartet in Four Parts* performed by CMW Players, Forrest Larson — *As Far As The Crow Can Fly* performed by Rob Bethel

2006 Ctrl+Alt+Repeat [Summer 2006], Dangerous Curve (Los Angeles, CA): Damion Romero, Clay Chaplin, Hans Fjellestad, Mem1, Mitchell Brown + the Seed Pod Pals (Michael Intriere + Heather Lockie + David Rothbaum + David Kendall + Jean Paul Garnier), André Cormier — *Scrubbing* (U.S. Premiere) for large ensemble

Ctrl+Alt+Repeat [Winter 2006], INMO Gallery (Los Angeles, CA): Mark Trayle, Kraig Grady, David Rothbaum, Mem1

2005 Ctrl+Alt+Repeat [Fall 2005], Selah (Los Angeles, CA): Francis-Marie Uitti, David Wessel, Mem1, Jen Boyd

Ctrl+Alt+Repeat [Summer 2005], Il Corral (Los Angeles, CA): Kadet Kuhne, Glenn Bach, RS-232, Mem1, Terry Riley — *In C* for chamber ensemble + robotics c/o Redux

2004 Ctrl+Alt+Repeat [Spring 2004], The Red Room at Zen (Los Angeles, CA): Polyrhythmic, Mem1, Steve Reich — *Different Trains* + John Oswald — *Mach* for string quartet and Metallica samples + selections from Philip Glass — *Fifth Quartet* performed by the Penderecki String Quartet

Acknowledgements
Dedicated to Laura Raquel Cetilia and Mara Izel Cetilia.

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And thanks to the community of Providence, may you continue to live up to your name.

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INTRODUCTION

Project Overview

Schaulust is a study in light and sound: an investigation of structure and rupture, of rhythm and noise. Schaulust performances are sensorial exercises focused on developing an awareness of the conditions of observation. These events pair custom hardware and software designed specifically for use in real-time improvisation with stroboscopic light and robotically-controlled mirrors and large, optical-quality cast-glass prismatic lenses, resulting in a full-body experience that embraces the base pleasures afforded by the generation and manipulation of light and sound as physical objects, evolving over time from the hypnotic to the chaotic.

History and Motivations

Schaulust performances bring together a number of my long-standing interests: noise, techno, improvisation, and the physicality of sound and light. I discovered noise music as a teenager in the early 90s growing up in a town of 800 people in Southwest Virginia near the Tennessee state line and not a whole lot else. The World Wide Web had yet to break, but upon being introduced to the work of the Hafler Trio by my friend Mike Clark, unearthing increasingly more extreme sounds from ever-more-distant corners of the earth became a personal quest, leading from small labels and mail-order distribution companies (RRRecords, Staalplaat, Subterranean, Extreme…) to Japanese noise music and, eventually, to the home taper scene. I began making my own works on tape using a broken boom box with a worn-out record head, my parents' old reel-to-reel, a cheap mic and any household items I could get my hands on that made an interesting noise.

When I went off to college, I decided to major in Studio Art, but continued my foray into lo-fi tape music, eventually managing to get a grant which allowed me to afford a four-track recorder and a multi-effects unit with a rudimentary sampler, and I began to incorporate the resulting sound works into sculptural installations and performances utilizing multiple slide projectors. I found it essential that I integrate sonic and visual information into the creation of a unified experience, and became increasingly more frustrated with the separation between artist and viewer, seeking out ways to create work which implicated the audience as active participants in the creation of the work.

It was around this time that I was introduced to the rave scene and not only were the sounds new and exciting, but this subculture seemed to present answers to all my questions regarding active participation in every aspect of its existence: The crowd was comprised of dancers, whose participation and engagement were of pivotal importance to DJs, who relied upon the crowd for motivation and direction; DJs were equally important

to the producers of the records that they played, because without DJs to play their records, the producers' work would go unappreciated—and without the producers, DJs would have nothing to play, and would be unable to make the crowd move, and the whole thing would come crashing down. It all fit together perfectly.

I reached out to participants in the local rave scene through Hyperreal's Southeast Raves list and made good friends with a handful of people who tried to teach me how to spin records (I was not very good at the time) and we would carpool to parties a few hours away pretty much every weekend. I was also taking design classes at the time, learning Photoshop and Illustrator and I would donate my services to flyers for parties—and while I was working on these designs in the computer lab at school, I would strike up a browser and listen to streaming radio stations like Betalounge out of San Francisco. I became enamored enough of the sounds I heard on Betalounge that I decided to head out there upon graduation.

My arrival wasn't easy, but I made friends with a local DJ named Jef who taught me how to match beats, and we started a weekly on Thursdays at a club in the Mission District called Liquid, and slowly worked my way into a position as the in-house graphic designer for a tech startup company. I began to pull away from DJing and spent my nights and weekends producing my own tracks in the small home studio I managed to piece together using the Cubase digital audio workstation, a Nord Lead 2 synthesizer and a portable DAT which I would use to gather recordings throughout the city.

I made friends with some other producers who ran a small label called Polyrhythmic, and who also performed together live under that name. When the dot com boom went bust, they moved to Los Angeles and I followed suit shortly after visiting and deciding that, contrary to my strongly-held beliefs (read "unfounded opinions") as a proud San Franciscan, L.A. was in fact a vital, thriving metropolis, rather than a cultural

wasteland. I also really wanted to be able to play live, and I realized that there was absolutely no way I could do that with my current set of tools, so I thought I should move down there to work with them and figure it all out.

Figure 1. Polyrhythmic promotional flyer by the author, 1999.

The answer was simple, if cost-prohibitive: lots of MIDI-synchronized hardware sequencers and drum machines. I didn't have the budget to do this, but I was able to pull together a modest live rig consisting of a Kurzweil K2600RS rack-mounted sampler / synthesizer, an Akai MPC2000XL for sequencing, and knob / fader box to control various synthesis parameters on the Kurzweil. This was fairly exciting at first, as I was now able to present my own work in a performance setting, and manipulate various synthesis parameters. However, I quickly started to notice the limitations inherent in this practice, the overarching duties of which consisted of playing back sequences that I had recorded in

my home studio; I simply triggered them in different order or combined with other pre-recorded sequences "live." In the year 2000, I saw a performance by Shawn Hatfield (AKA Twerk), who was using only a fader box and a laptop computer to great effect, running an application called Drool String Ukelele[1] that he had written in the graphical programming environment Max/MSP[2]. I decided it was time to set aside the hardware I had been working with and devoted myself to learning Max/MSP to define a new performance practice for myself. What resulted from this endeavor was a custom application I called Fraktur, which I have continued to develop up until today (though it has since moved into the SuperCollider platform).

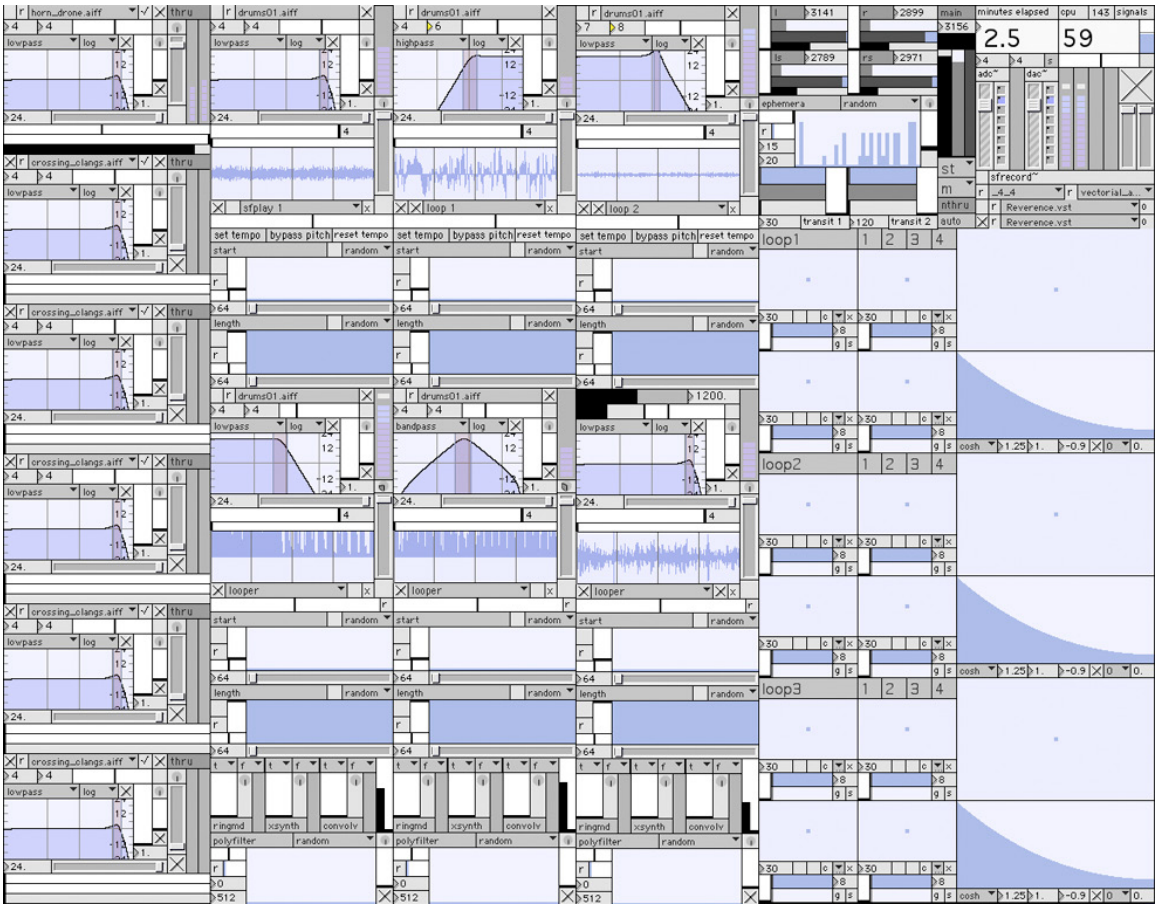

Figure 2. An early iteration of the Fraktur application.

[1] http://www.audibleoddities.com/twerk/?p=6

[2] https://cycling74.com

While its features and scope have grown and evolved over the past 10 – 15 years (and is a topic I shall return to in greater detail later), the fundamental building blocks of this application have remained the same since its inception. At its core, Fraktur is comprised of a number of loopers—looping audio sample players with selectable speeds, start- and stop-points, bit reduction, and high, low, and bandpass filters—whose signals are mixed together and sent to a common set of physical outputs. In its initial conception, Fraktur was simply meant to replace and augment my strategies towards the live performance of dance music, so its primary function was simply to play back pre-recorded audio loops, making sure that they were synchronized[3].

While this was a major improvement in terms of flexibility over any prior possibilities that were available to me, I began to find myself frustrated with (and unfulfilled by) the use of pre-recorded material in my performances. The material utilized had evolved from MIDI sequences that were basically fixed to audio recordings that could be manipulated beyond recognition, but I was still trapped, relying on fixed media in what should have been unique live experiences. In an effort to deviate further from the source material in live settings, I added the ability to record into the loopers, and designed a more flexible signal routing scheme, which allowed for the creation of complex feedback loops between multiple sample players / recorders. This was exciting new territory, but the question of what I should use as source material with which I might seed the feedback loop was still a point of contention—until I met a cellist by the name of Laura (now Cetilia), and we started a group called Mem1.

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[3] This was accomplished through the use of a single phasor~ object as a master clock for the patch; playback speeds for each looper were generated using a rate~ object in "sync lock" mode—this functionality was very much inspired by Drool String Ukelele and arrived at based on rumors I had heard of its inner workings.

The *Grove Dictionary of American Music* describes Mem1 performances as follows:

A Mem1 piece is typically an improvised, collaborative birthing and nurturing of a singular yet texturally complex sound. Spontaneously but carefully and gradually, the sound may begin as the breathing of the cello, played by Laura… Using a pick-up and laptop computer, Laura samples her own sound in real time, and loops them using looping/delay pedals that she operates with her feet while improvising on the cello. Her playing is far from traditional: she uses no vibrato, no figuration; she strives for thin tones of extensive duration, and employs extended techniques. Her idiosyncratic sounds also serve as source material for Mark, who samples and manipulates them in real time, with a laptop running software designed by the artist himself. He also adds to the burgeoning sonic texture using an analog modular synthesis system. Often the collaborative result sounds neither like a cello nor like electronics… Mem1 is a unified cybernetic force, or complex cybernetic entity, comprised of two human artists plus their instruments and systems. In fact, Mem1's evolving, custom-built systems are as important an aspect of the duo's achievements as their ever-innovative sound. Confounding the complexities inherent in human-machine and human-instrument relationship, Mem1 understands its music as a feedback loop between the past and present.[4]

Figure 3. Mem1, ca. 2005. Photo by Julie Fowells.[5]

[4] "Mem1", Mandy-Suzanne Wong in *The Grove Dictionary of American Music*, 441 – 2.

[5] http://www.mem1.com/press_photo/

In early Mem1 performances (i.e. for about the first five years), I devoted myself solely to processing the sound of her instrument. Laura would attach a pickup to her bridge; its output would then be sent to a preamplifier, followed by a looping / delay pedal which she controlled, and the effected and non-effected signals would then be passed to me. Over the course of countless hours rehearsing and performing, we arrived at a common language and a fluid performance practice.

The sounds of her instrument would weave in and out of alternate realities, beating against their processed twins and fluttering in response through the development of extended techniques of her own device, but eventually Laura began to confront the limitations of the technologies available to her when it came to manipulating the sound of her instrument without my involvement, so in late 2009 – early 2010, we took part in a series of artist residencies at STEIM in Amsterdam, Kunstenaarslogies in Amersfoort (a short train ride from Amsterdam), and USF Verftet in Bergen, Norway.

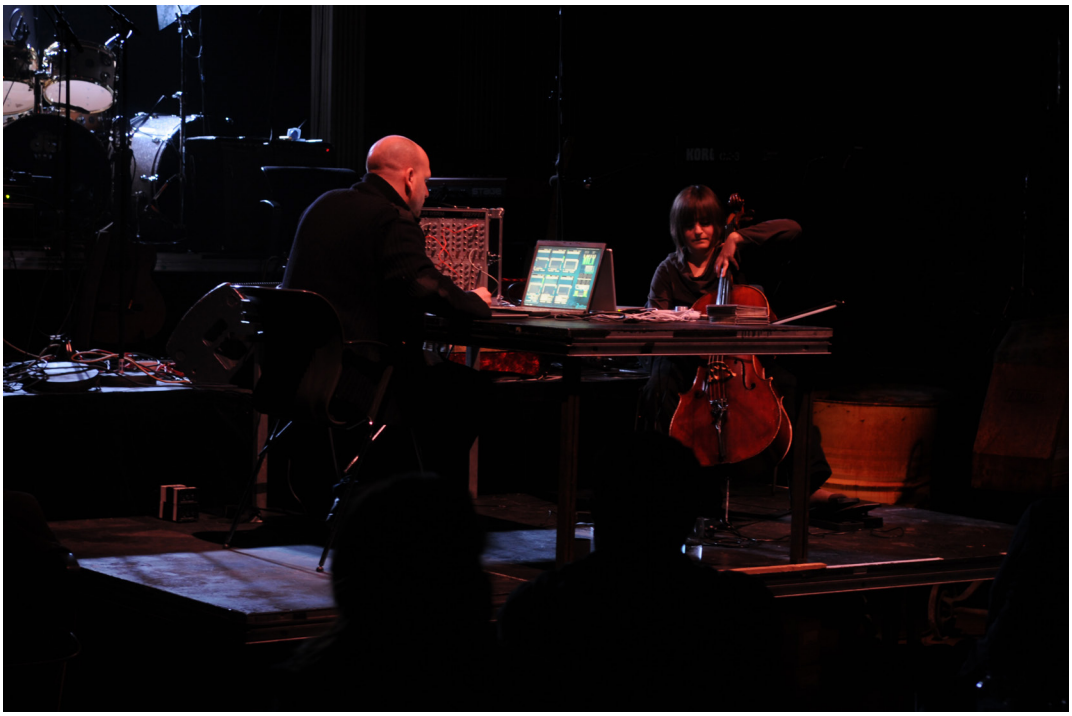

Figure 4. Mem1 live at Borealis 2009, Bergen Norway. Photo courtesy of Borealis Festival.[6]

[6] http://www.borealisfestival.no/2009/

Through these residencies, we were both able to arrive at new performance systems: Fraktur had a huge makeover in its transition between versions 4 and 5 of Max—I added a granulator[7] at the final mix stage, a new gesture recording engine for spatialization parameters, and completely overhauled the architecture of the patches to parallel the patching strategies set forth by the Jamoma platform[8]. At the same time, we designed a new system for Laura which replaced her looping pedal and utilized Max as an interface between an Akai MPD-16 drum pad controller (which she used with her feet) and STEIM's live sampling software LiSa[9].

By the time we finished this system, its functionality rivaled that of Fraktur, and I decided that my days of limiting my source material to the sound of Laura's instrument had reached their end, and I began to incorporate live-patching of my modular synthesizer into our performances. I had been working with modular synthesizers since my work with the Serge systems at the City College of San Francisco, and this synthesizer, a Doepfer A-100 suitcase system since 2005 (itself the product of a trade for my old Kurzweil, Nord and an Oberheim Echoplex that had been laying dormant since my move to Max/MSP), but until our residency at USF, the Doepfer, despite its portability, had never left the studio.

This move to incorporating modular synthesis into Mem1 performances helped bolster a sense of independence. I found that the modular synthesizer could act as

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[7] By "granulator," I mean a sample recorder and playback engine featuring a "granular" approach to playback—that is, it plays back short "grains" of the recorded material in a way that allows separation of pitch and time by smoothly repeating or skipping over such short segments of the recording, each of which may each be pitched up or down. In addition to allowing separation of pitch and time, many granulators also allow for randomization of pitch, grain length, time offset, panning, the number of grains, and so on.

[8] The Jamoma platform is "a modular framework for patching in Max" featuring a set of recommended practices and methodologies for organization and communication between patches. For more information, visit: http://jamoma.org

[9] For more information, visit: http://steim.org/2012/01/lisa-x-v1-25/

something of a counter-performer in Laura's absence, and began performing solo again for the first time in many years. Even using simple systems created on the fly, it is possible to set up complex interactions that lead to surprising results and help shape the direction of a given performance. I have found the process of live patching to be incredibly inspiring in live performances—it challenges me to think on my feet, and react quickly to unpredictable behaviors of systems I set in motion.

Throughout this time, my public involvement with techno and other experimental forms of dance music lay mostly dormant. This was not an accident, but a conscious decision I had made in reaction to the culture of the dance music world, which over time revealed itself to be less of the utopian counter-culture that I had once believed it to be, and more of a circus of ego-maniacs whose primary performance practice involved pressing "play." I couldn't abide by this any longer, so I chose to focus on Mem1. In the early days of Mem1, there were very few spaces in Los Angeles that were programming music along the lines of what we were doing, so Laura and I began organizing a series of concerts called Ctrl+Alt+Repeat.

Figure 5. Mark Trayle live at Ctrl+Alt+Repeat (Winter 2006). Photo by the author.[10]

[10] http://ctrl-alt-repeat.com/archive/winter-2006/

Ctrl+Alt+Repeat concerts aim to bring together diverse approaches to experimental electronic music, improvisation, contemporary classical music, and sound art, at galleries and alternative art spaces in Los Angeles like Dangerous Curve, Inmo Gallery and Selah downtown, and (Bob Bellerue and Shane "Stane" Hubert's) Il Corral in East Hollywood, all of which are by now sadly defunct.

Since arriving in Providence, we have continued to program these (and other) concerts, and have become more actively involved in the local experimental music community (or "noise scene" if you prefer), which I have found to be a thriving subculture, full of diverse talents and aesthetics. Through my involvement with this community, which seems to me a much healthier environment in which to explore rhythmic material than the club or rave scenes (perhaps due to its lack of interest in commercial success), I began to question what approaches I might take towards the generation of rhythmic material after so many years, were I to renew my public investigations into experimental forms of dance music.

At the same time, I have often looked for ways to incorporate video into my live performances, but ultimately found working with fixed media restricting—especially as my practice has become more improvisational. Over the years, I began to develop reactive video systems that could "improvise" with me. These systems allowed me a degree of fluidity in live situations, but the flatness of the screen seemed at odds with my sound practice, which is much more immersive in nature. I became interested in finding ways to incorporate the tangible properties and physical realities of projection into my performances, and through an investigation of artists who had asked similar questions, became aware of the fields of study known as Structural / Materialist film and Paracimenatic performance, dating as far back as the 1960s. It is only natural to begin with an examination of these pivotal influences upon the development of my thesis work.

CHAPTER 1: VISUAL INFLUENCES

Structural / Materialist Film

"Structural film" is a term that was coined by film historian / critic P. Adams Sitney in 1969 in his *Film Culture Reader* article entitled, simply, "Structural Film." In this article, Sitney lays out the four basic characteristics of structural film as follows: "a fixed camera position (fixed *frame* from the viewer's perspective), the flicker effect, loop printing (the immediate repetition of shots, exactly and without variation), and rephotography off a screen."[11] Sitney is careful to temper his doctrinaire logic by following up this statement with the caveat that "Very seldom will one find all four characteristics in a single film," noting that "there are structural films that avoid these usual elements."[12] However, Sitney's basic claim is that so-called structural films are part of a new "cinema of structure wherein the *shape* of the whole film is pre-determined and simplified, and it is that shape that is the primal impression of the film."[13]

The term "structural film" has been contested by filmmakers such as Malcolm Le Grice, who is concerned that the use of the term "structural" might easily be conflated with structuralism, "as it has come to be applied in anthropology, linguistics, or economics."[14] Le Grice prefers to refer to the work in question as "formal" or "material" film, and indeed many critics and scholars have taken to calling this body of work "materialist film" (including filmmaker Peter Gidal, who worked alongside Le Grice in the British film-making workshop known as the London Film-makers' Co-op in the 1960s and 1970s) in an attempt to steer the focus towards the ways in which the work allows for critical thought surrounding the materiality of film.

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[11] P. Adams Sitney, "Structural Film" in *Film Culture Reader*, 327.

[12] *Ibid*.

[13] *Ibid*.

[14] Malcolm Le Grice, *Abstract Film and Beyond*, 86.

The desire to generate cinematic works that speak to their means of production rather then relying upon tropes from other media, such as theater, literature, or music, is key to understanding the structural / materialist film movement. In his 1977 manifesto, *Abstract Film and Beyond*, Malcolm Le Grice claims that the problem with film is that it was never allowed the chance to become its own medium, but instead found itself subsumed by the desires of theater, literature, and music. He traces this back as far as 1908, with the *Assassination of the Duke of Guise*, which "tried to elevate the Kinematograph, a bastard of the circus and slide-show, to the level of high art" by "the application of acting standards and techniques drawn from the bourgeois theater of that time—and, incidentally, in that production, also by music specifically composed by Saint-Saëns."[15]

Le Grice claims that "most attempts to develop film as art have followed the pattern which applies principles from the theater or the novel," calling this "deeply established norm" a "historical 'error'" which could just have easily seen painting as the dominant model for filmic representation.[16] Le Grice cites Impressionist works such as Monet's *Rouen Cathedral* series which seek to portray the change of lighting conditions over the course of a day, and Cubist works such as Duchamp's *Nude Descending a Staircase*, which seeks to express the experience of motion within a single frame, as more important predecessors to film than any theatrical productions or novels.

Despite where and when film "went wrong," the issue of film's subservience to the traditional narrative tradition has long been noted—beginning with the Italian Futurists in the early twentieth century. In their 1916 manifesto entitled *The Futurist Cinema*, Marinetti, Cora, Binna, Balla and Chiti proclaim that:

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[15] *Ibid*, 7.

[16] *Ibid*.

> The cinema is an autonomous art. The cinema must therefore never copy the stage. The cinema, being essentially visual, must above all fulfill the evolution of painting, detach itself from reality, from photography, from the graceful and solemn. It must become antigraceful, deforming, impressionistic, synthetic, dynamic, free-wording… ONE MUST FREE THE CINEMA AS AN EXPRESSIVE MEDIUM in order to make it the ideal instrument *of a new art*, immensely vaster and lighter than all the existing arts. We are convinced that only in this way can one reach that *polyexpressiveness* towards which all the most modern artistic researches are moving.[17]

Similar sentiments were echoed again in 1926 by the eminent Russian filmmaker Dziga Vertov, calling "film-drama" (rather than religion) the opiate of the masses.[18] Unlike the Futurists however, Vertov's reasons for opposing narrative filmmaking were not raised out of the concern of generating a "new art," but out of frustration with film as a means of providing entertainment rather than portraying everyday life. The problem with film, Vertov claimed, was that it "was invented at a time when there was no single country in which capital was not power. The bourgeoisie's hellish idea consisted of using the new toy to entertain the masses, or rather to divert the workers' attention from their basic aim: the struggle against their masters."[19]

Though the Structural / Materialist filmmakers of the 1960s and 70s were perhaps more academic than Vertov, their pursuit of an filmmaking practice which avoided the tropes of narrative film was no less fervent. In his "Theory and Definition of Structural / Materialist Film," Peter Gidal explains that materialist film "attempts to be non-illusionist," stating that the "process of the film's making deals with devices that result in demystification or attempted demystification of the film process."[20]

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[17] F.T. Marinetti et al., "The Futurist Cinema 1916" in *Futurist Manifestos*, 207.

[18] Dziga Vertov, "Kino-Eye" in *Kino-Eye: The Writings of Dziga Vertov*, 71.

[19] *Ibid*, 67.

[20] Peter Gidal, *Structural Film Anthology*, 1.

The discourse on materialist film naturally focuses on work which draws "deliberate attention to the film material itself as the basis of image"[21] (cf. Alan Landow's *Film in which there appear Sprocket Holes, Edge Lettering, Dirt Particles etc.* (1966), which "incorporates all the elements blandly listed in the title"[22]) or replaces / augments traditional film stock with physical materials (cf. Brakhage's *Moth Light* (1963), which was "made by the direct collage of flower petals, moth wings, and thin stalks onto the 16mm film strip"[23]), but also includes discussion of duration (Warhol's *Empire* (1964), a fixed frame film consisting of "eight continuous hours of the Empire State Building through the night into dawn"[24] is an excellent example of how duration may be made material) and the use of stroboscopic light as an essential element throughout cinematic practice.

Stroboscopic light is often discussed as an important development in the history of cinema, as it relates to the"persistence of vision" and its supposed ability to create the illusion of motion within cinematic work. This sentiment has been echoed throughout film theory literature, time and again: retinal afterimages left over by presenting each frame of a film allow the illusion of motion to emerge as one image fades into the next. André Bazin, in his classic text *What Is Cinema?* from 1971, wonders how "the invention took so long to emerge, since all the prerequisites had been assembled and the persistence of the image on the retina had been known for some time."[25]

However, the myth of persistence of vision as the basis for perceived motion within film had been debunked as early as 1912, by Gestalt psychologist Max Wertheimer, who through a series of experiments "seized upon the phenomenon of apparent

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[21] Le Grice, *Abstract Film and Beyond*, 117.

[22] *Ibid*, 118.

[23] *Ibid*, 90.

[24] Sitney, *Visionary Film: The American Avant-Garde, 1943 – 2000*, 350.

[25] André Bazin, *What Is Cinema?*, 19.

movement to argue that the perception of movement was 'as direct an experience as… brightness or hue, an experience mediated by its own physiological mechanism rather than by experiences of change in position.'"[26]

The reader may recall examples of the persistence of vision from childhood, optical illusions caused by staring at images such as an inverted American flag for a minute without blinking, then quickly averting one's eyes from the image to a white wall or blank page, where a ghost of flag's image appears in positive color. As Bill Nichols and Susan J. Lederman point out:

> This series involves alternating positive and negative after-images, an experience never to our knowledge reported during a film presentation. Furthermore, the first after-image, which is positive, does not occur until some 50 milliseconds after the cessation of the initial stimulus. During an equivalent period of time in the projection of a motion picture, however, not one but three successive image-frames would be presented.[27]

If this were in fact the operational procedure at work behind the perception of motion in a filmic image, "figures on the screen would pile up, one on top of the other, resulting in a kind of chronophotographic display."[28] Nonetheless, the use of stroboscopic light is found in all cinematic works, and a number of structural / materialist filmmakers chose to focus upon its use as a means of production in what have been called "flicker films" by many, but which Le Grice called "perceptual film" so as to avoid being "too specific to define… by a single characteristic rather than its region of function," as such works "[attempt] to examine, or create experience through devices which work on the autonomic nervous system."[29]

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[26] Bill Nichols and Susan J. Lederman, "Flicker and Motion in Film" in *The Cinematic Apparatus*, 100.

[27] *Ibid*, 99.

[28] Joseph and Barbara Anderson, "Motion Perception in Motion Pictures" in *The Cinematic Apparatus*, 89.

[29] Le Grice, *Experimental Cinema in the Digital Age*, 50.

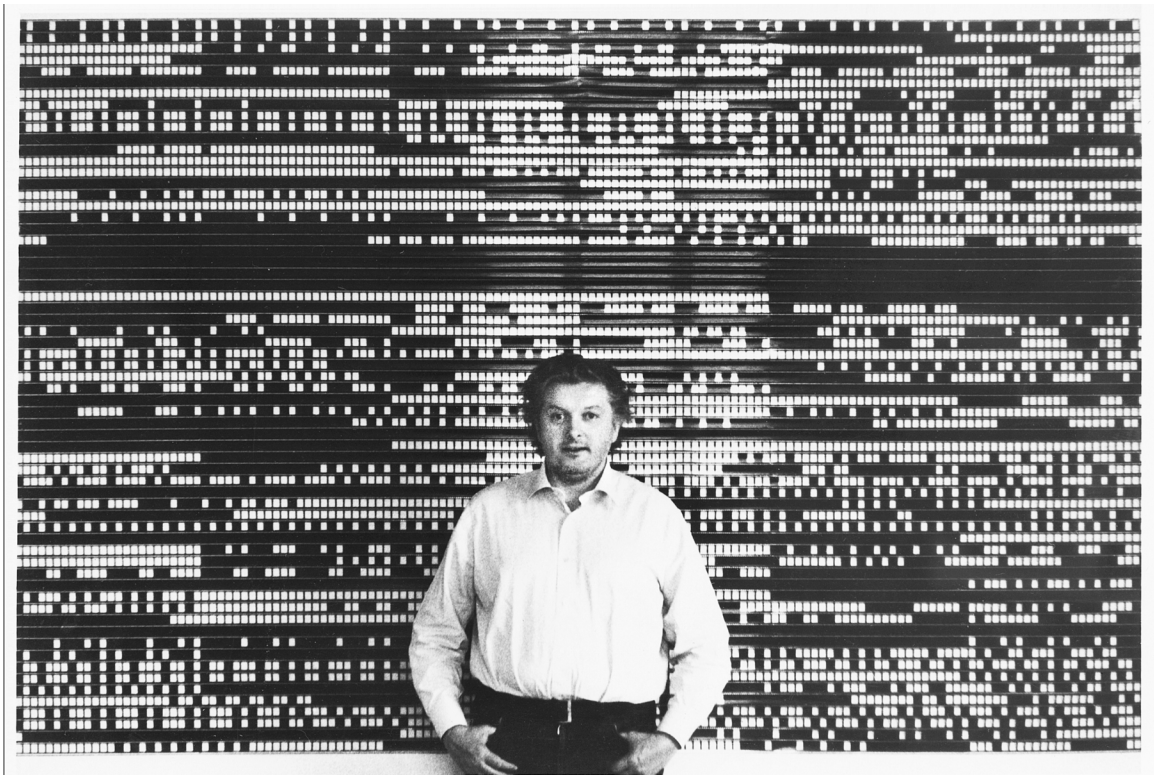

Figure 6. Peter Kubelka with wall installation of *Arnulf Rainer*. Photo by Roger Reed.[30]

Peter Kubelka's 1960 film *Arnulf Rainer* is widely considered the first "flicker film," although this piece was created not out of a concern with direct action upon the nervous system, but rather an interest in the formal qualities of film, and a narrowing down of focus to binary opposites through which form and structure could be studied. *Arnulf Rainer* is an intensely complicated composition consisting solely of black and white leader accompanied by alternating bursts of white noise and silence. Sitney explains the film as:

> an intricate pattern of synchronous clusters of flashes and explosions of sounds mixed with asynchronous patterns which evolve, recall, or anticipate other patterns on one of the two levels of sound and picture. At times the flickering of the black-and-white frames proceeds in silence, to be followed by the same or a similar rhythm on the soundtrack while the screen stays white or black. At a different moment the sound rhythm will forecast the visual pattern which appears in silence or with a different, and therefore not synchronized sound.[31]

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[30] https://www.filmmuseum.at/en/press/press_photos/film_museum_at_fifty/21_projects

[31] Sitney, *Visionary Film: The American Avant-Garde, 1943 – 2000*, 287.

The film is broken into 24 sections consisting of "transfers of meter from sound to picture, or the opposite, in phrases that may be (according to Kubelka's notes) 288, 192, 144, 96, 72, 48, 36, 24, 18, 16, 12, 9, 8, 6, 4, or 2 frames in duration" that "accelerate their change as the phrases move [from] the longest to the shortest in fixed stages."[32] However, these phrases adjoin one another without any visible division, so the effect is one of "a seemingly endless series of irregular accelerations" followed by "a transparent halo-like square" that "seems to hover off the screen for a fraction of a second" accompanied by "momentary illusions of color" until "the floating image slowly… rejoins the actual screen."[33]

In a recent interview, Kubelka divulges that although his film was named after the painter, "*Arnulf Rainer* has nothing to do with Arnulf Rainer, because he is an abstract expressionist, if you want to call him that… It bears his name only because he paid some money. And he was of course very disappointed when he saw it. *Arnulf Rainer* is a purely metric cool construction."[34]

This cool, calculated decision-making process is at the heart of the film, and indeed the reason why Sitney calls Kubelka "the second forefather of structural film"[35] (after Warhol, for his long-form fixed-frame films) despite the complexity of the film's form.

In an attempt to arrive at a definition for structural film, Sitney states that "structural film insists on its shape, and what content is has is minimal and subsidiary to the outline," citing Tony Conrad's *The Flicker* and Paul Sharits' *Ray Gun Virus*—both of

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[32] *Ibid*.

[33] *Ibid*, 287 – 8.

[34] Alberte Pagán, "An Architecture of Emotion: Peter Kubelka Interviewed."

[35] P. Adams Sitney, "Structural Film" in *Film Culture Reader*, 327.

which are comprised of flickering fields of solid color—as the "clearest" examples of structural film.[36]

Tony Conrad's *The Flicker* (1965) "had its origin in several striking improvisation sessions" where filmmaker Jack Smith's "superstar drag queen Mario Montez posed and pouted in front of a flickery old projector," causing "such a compelling and luminous… visual spectacle" that "it immediately posed the question, as to how, or whether, such a visual presence might ever be delivered in film."[37]

> From my studies of neurophysiological psychology in college, I knew that the psychoactive frequencies of flickering light span a range from about 6 fps (flickers per second) to about 40 fps. Higher frequencies are not resolved; they appear as continuous light. Slower frequencies do not have the uncanny look of flicker; they are more aptly thought of as on and off.

The elective course in neurophysiological psychology that Conrad attended as a Harvard student presented W. Grey Walter's research on epilepsy using stroboscopic light.[38] In his book *The Living Brain*, Walter describes stroboscopic light as generating "a vivid illusion of moving patterns whenever one closed one's eyes and allowed the flicker to shine through the eyelids," stating that this illusion was "most marked when the flicker is between 8 and 25 flashes per second" and typically taking the form of "a pulsating check or mosaic,often in bright colors" though "at certain frequencies—around 10 per second—some subjects see whirling spirals, whirlpools, explosions, Catherine wheels."[39]

In 1958, artist and writer Brion Gysin discovered this effect by accident while on a bus ride through tall trees as the sun set; as he closed his eyes to avoid the blinding light, he experienced "an overwhelming flood of intensely bright patterns in supernatural

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[36] *Ibid*.

[37] Tony Conrad, "Retrospect I" in *Buffalo Heads: Media Study, Media Practice, Media Pioneers, 1973 – 1990*, 543.

[38] John Geiger, *Chapel of Extreme Experience*, 73.

[39] W. Grey Walter, *The Living Brain*, 101.

colors" exploding behind his eyelids, "a multi-dimensional kaleidoscope whirling through space."[40] He wrote of this discovery to William Burroughs, who in turn gave Gysin a copy of *The Living Brain* in order to aid in the research and development of Gysin and Ian Summerville's "simple flicker machine" known as The Dream Machine, which consisted of a cylinder with slits that was to be placed on a moving 78 rpm turntable platter with a 100 watt bulb dangled inside such that "the light would flicker through the slits at a precise rate per second".[41] Conrad had heard of this device, and admired its simplicity, though he had not met Gysin or Summerville prior to beginning his own investigations into the flicker.[42]

Figure 7. Gysin and Burroughs at The Dream Machine. Photo by Charles Gatewood.[43]

[40] John Geiger, *Chapel of Extreme Experience*, 11.

[41] *Ibid*, 49.

[42] *Ibid*, 74.

[43] http://www.danadanadana.com/burroughs23/wsb/index.htm

It is perhaps worth noting Somerville's suggestion that "flicker may play a part in cinematic experience"—despite the fact that "the frame speed of film is three to four times faster than the average alpha rhythm," he believed that film "may include flicker frequencies as a subharmonic."[44] In contrast to Kubelka's interest in flicker as a tool to explore the formal structure of film, Conrad's investigations into flicker also stemmed from a desire to create harmonic relationships, based on his history as a musician:

> From my work with pitched sound I knew that frequency interactions among different pitches were perceived as "harmony" largely because of, or in the company of, their resolution as common harmonics of a lower "fundamental" frequency—a frequency closely related to the numerical *difference* between the frequencies of the two pitches. With a flicker *spectrum* of two octaves to play with, from 6 fps to 12 fps to 24 fps (the speed of film projection), was it conceivable that frequency interactions among different frequencies would result in detectable harmonic relationships? This question, with the accompanying intimation that there might be a completely unexplored compositional modality open to harmonic exploration and compositional development, thrilled me to the core. The 47 flicker patterns in *The Flicker* exercise this experiment.[45]

Ultimately, Conrad was "not satisfied that" he had "in the end demonstrated any workable harmonic principle at work in the flicker spectrum;" instead, "most people had strong (if elusive) impressions of swirling color patterns" that were "intriguingly unpredictable."[46] It is worth noting that the soundtrack accompanying *The Flicker* consisted of "homemade electronic music composed indissolubly of tones… bordering closely on the lower range of audibility and of very rapid rhythms, rhythms whose speed is comparable in frequency to the tones."[47]

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[44] *Ibid*, 73.

[45] Tony Conrad, "Retrospect I" in *Buffalo Heads: Media Study, Media Practice, Media Pioneers, 1973 – 1990*, 543.

[46] *Ibid*.

[47] Tony Conrad, "Tony Conrad On The Flicker" in *Film Culture 41*, 1 – 3.

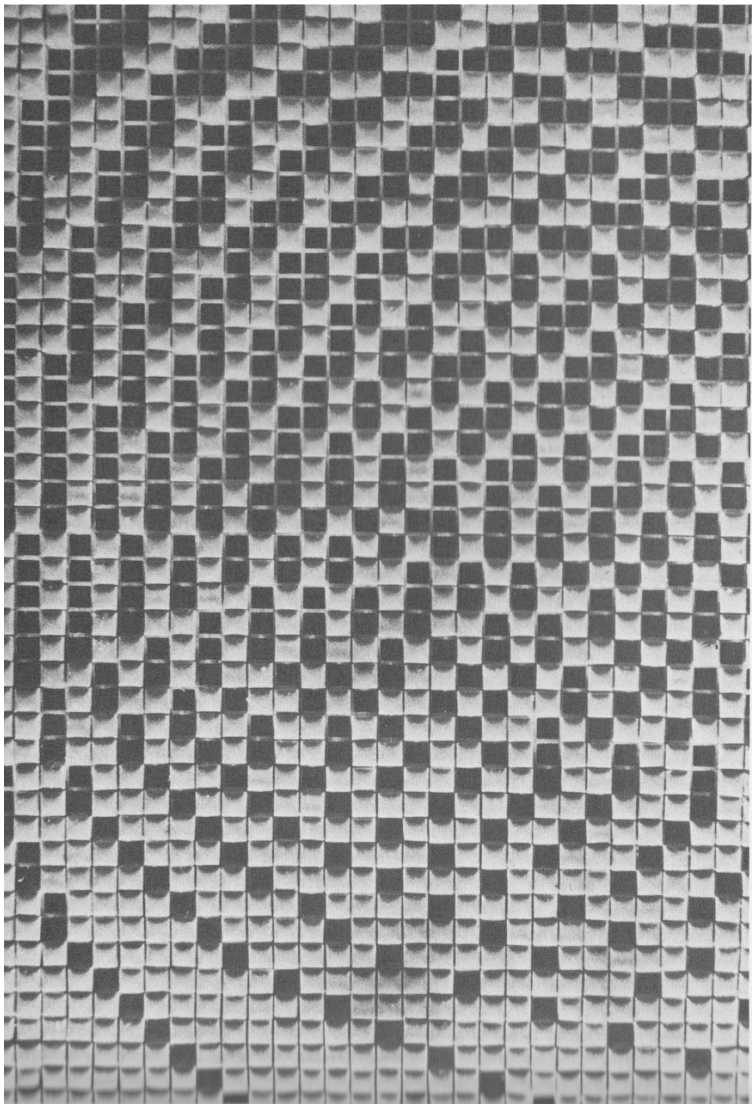

Figure 8. Exposure timing sheet used by Conrad for *The Flicker*. Photo by Robert Adler.[48]

In an essay entitled "Hearing:Seeing," written in 1975, Paul Sharits posed the question: "can there exist a visual analogy of that quality found in a complex aural tone, the mixture of a fundamental tone with its overtones?"[49] Sharits had, by that point, spent the past decade looking for answers to this question through his distinctive brand of practice-based research, beginning with his early "flicker films" such as *Ray Gun Virus* (1966), which—as opposed to Kubelka's and Conrad's works previously mentioned—

[48] *Film Culture No. 41*, Summer 1966, Plate 1.

[49] Paul Sharits, "Hearing:Seeing" in *The Avant-Garde Film: A Reader of Theory and Criticism*, 257.

featured flickering images of alternating solid colors. Sharits proposed that the use of "clusters of differentiated single frames of solid colour can appear to almost blend," and that such "rapidly alternating colour frames can generate, in vision, horizontal-temporal 'chords' (as well as the more expected 'melodic lines' and 'tonal centres')."[50]

However, instead of creating sonic analogues for these visual "chords," the soundtrack for *Ray Gun Virus* consists only of the sounds of the film's sprockets played at "full volume, thus assaulting [viewers] at both perceptual as well as visceral levels."[51] Sharits claimed that this strategy worked "towards establishing an accurate representation of technological modularity, framing—and thereby noting—the ultimate matrix of 16mm film's capability for visual representation (there being one sprocket hole for each fame of image along the filmstrip)."[52] Throughout his career, Sharits continued to develop new strategies for creating visual analogies of complex aural tones, first through the use of superimposition in order to obtain "chordal depth," "counterpoint," "harmonics, resonances and a sort of 'overtonality' within the frame'" before settling on the use of multiple screens in installations such as *Shutter Interface* (1975), which was comprised of four "different but related five- to six-minute long color flicker films" projected with portions overlapping.[53] Such pieces, which he called "locational works," allowed him to "begin composing in ways at least related to the ways a composer might approach, say a quartet: one screen could state a theme and another could answer it, elaborate upon it; the screens could respond to this dialogue, vary it, analyze it, recapitulate it, etc."[54]

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[50] Paul Sharits, "Hearing:Seeing" in *The Avant-Garde Film: A Reader of Theory and Criticism*, 256.

[51] Melissa Ragona, "Paul Sharits's Cinematics of Sound" in *Lowering the Boom: Critical Studies in Film Sound*, 174.

[52] *Ibid.*

[53] Stuart Liebman, "Apparent Motion and Film Structure: Paul Sharits' Shutter Interface" in *Millenium Film Journal* Vol. 1 No. 2, 107.

[54] Paul Sharits, "Hearing:Seeing" in *The Avant-Garde Film: A Reader of Theory and Criticism*, 259.

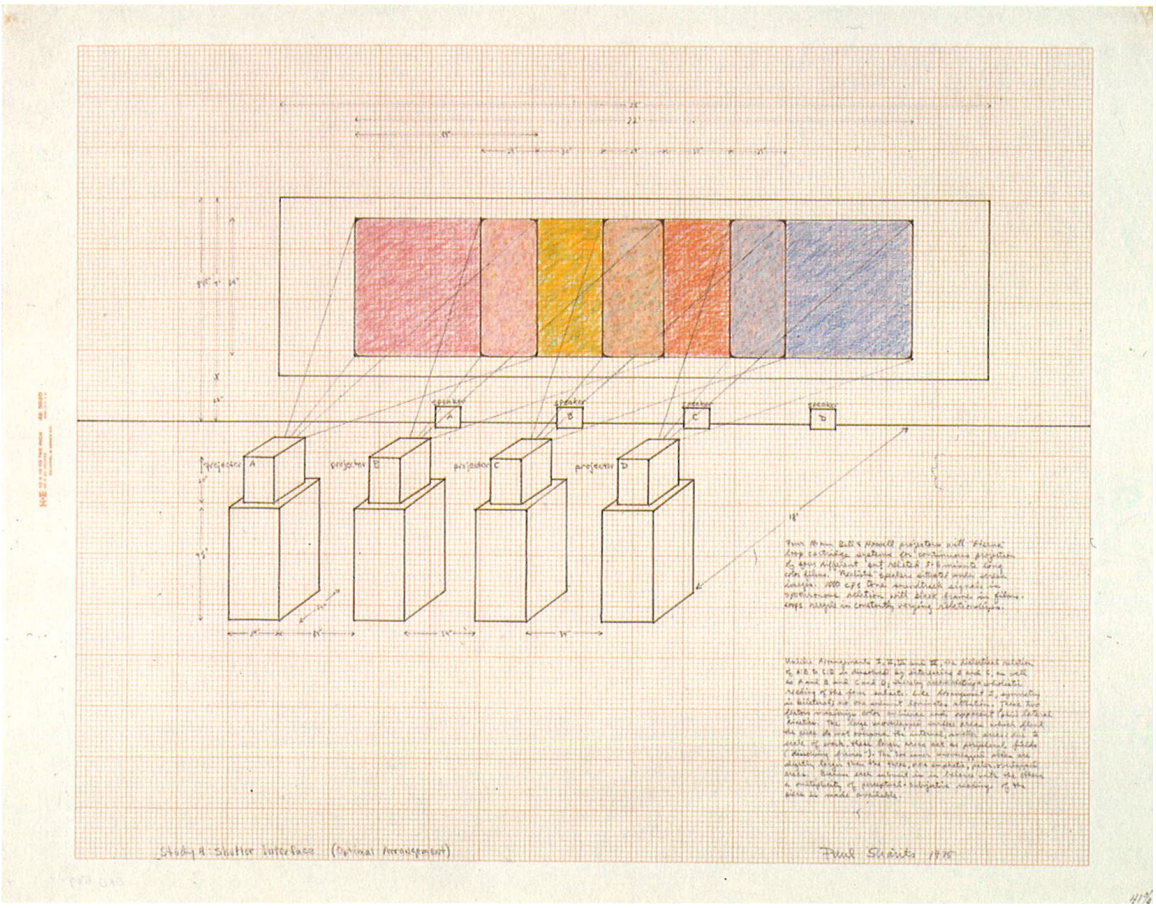

Figure 9. Paul Sharits, *Shutter Interface (Optimal Arrangement)*, 1975.[55]

However, despite the interests of Conrad or Sharits in creating a visual analog for sonic properties, Sitney claimed boldly in his 1974 opus *Visionary Film* (a fairly encyclopedic reference on the history of experimental and avant-garde film) that "Kubelka is the only film-maker I shall discuss in this book who affirms the absolute equality of importance between images and sound in cinema… with *Arnulf Rainer* he succeeded in making a graphic film which gave equal importance to sound and visuals."[56] Despite such acclaim, Sitney goes on to state that Kubelka's first film, *Mosaik im Vertrauen*, and *Unsere Afrikareise*, his most recent film at the time of *Visionary Film*'s publication, displayed a

[55] Chrissie Iles, *Into the Light: The Projected Image in American Art,* 145.

[56] P. Adams Sitney, *Visionary Film: The American Avant-Garde, 1943 – 2000*, 289.

more "fully developed" use of "sound montage" due to their use of "synch events."[57] It is my belief, however, that the equivalence of sound and vision displayed in *Arnulf Rainer* may in fact be due to the *asynchrony* of these materials. In my personal artistic practice, I have found that the implementation of strategies which involve matching sound to image, or image to sound, often results in works that tend to privilege one sense above the other. *Arnulf Rainer*, on the other hand, creates a dialogue between sound and image without explicitly foregrounding either sense, and perhaps more importantly—without attempting to create cinema based upon the rules of western art music. It is a purely cinematic work which leverages the strengths of the cinematic apparatus: projection of sound and projection of image as distinct entities, calling attention to its process and delivery mechanism.

This insistence upon developing "non-illusionist" approaches to cinema was echoed by structural / materialist filmmakers on both sides of the Atlantic—Paul Sharits claimed that he wished "to abandon imitation and illusion and enter directly into the high drama of: celluloid two-dimensional strips/individual rectangular frames/the three-dimensional light beam/environmental illumination/the two-dimensional reflective screen surface/the viewer's retina screen, optic nerve and individual psycho-physical subjectivities of consciousness."[58] Peter Gidal, however, was less interested in generating direct physical reactions, and more interested in "the mental activation of the viewer," looking towards filmmaking practice that "is not only structural but also structuring," which requires that each viewer form "an equal and possibly more or less opposite 'film' in

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[57] *Ibid*.

[58] Paul Sharits, "General Statement: 4th International Film Festival. Knokke Le Zoute" in *Structural Film Anthology*, 90.

her/his head, constantly anticipating, correcting, re-correcting—constantly intervening in the arena of confrontation with the given reality…"[59]

It is important to note that this act did not take place strictly within the direct perception of the work, but signaled a break with the "dominant" form of cinematic production, and that modifications to the physical apparatus were symbolic for more wide-reaching changes to the ways in which film was delivered and the channels through which it was received. Indeed, discussions of the cinematic "apparatus" in critical / theoretical discussions often "not simply 'the cinema machine' in a literal sense (e.g., the basic camera-projector mechanism), but this literal machine in the context of a larger social and/or cultural and/or institutional 'machine,' for which the former is only a point of convergence of several lines of force of the latter."[60] Structural / materialist films were not shown in cineplexes in shopping malls, but in screenings at small theaters and alternative art spaces, often run by practicing artists, such as those organized by Ken and Flo Jacobs through the Millennium Film Workshop in New York, which featured not only "strange films" but "the practice of dialogue after the screenings," allowing "for the filmmaker to get some feedback and for the audience to maybe get some questions answered or thinking stirred."[61]

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[59] Peter Gidal, *Structural Film Anthology*, 3.

[60] Philip Rosen, *Narrative, Apparatus, Ideology*, 282.

[61] Lindley Hanlon and Tony Pipolo, "Interview with Ken and Flo Jacobs" in *Millenium Film Journal: 20th Anniversary Special Edition* Nos. 16/17/18, 29.

Figure 10. Marcel Duchamp, *Rotary Demisphere (Precision Optics)*, 1925.[62]

The ultimate goal of all of these strategies was to allow the viewer to become an active participant in the work, rather than a passive receiver of visual information. Marcel Duchamp, whose *Anemic Cinema,* "a study of his rotary spirals with words printed on them," has been cited by Sitney as a "direct ancestor" of structural / materialist film,[63] perhaps put it best:

> All in all, the creative act is not performed by the artist alone; the spectator brings the work in contact with the external world by deciphering and interpreting its inner qualifications and thus adds his own contribution. This becomes even more obvious when posterity gives its final verdict and sometimes rehabilitates forgotten artists.[64]

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[62] http://www.moma.org/collection/works/81432

[63] P. Adams Sitney, "Structural Film" in *Film Culture Reader*, 329.

[64] Marcel Duchamp, "The Creative Act" in *The Writings of Marcel Duchamp*, 140.

Ken Jacobs' Paracinematic Performance

"Paracinematic" performance is a field of practice defined by Ken Jacobs (who coined the term) as an "*equivalent* cinema created by other than filmic means or by using film in other than standard ways; equivalent, or *parallel to*" traditional cinema.[65] Jacobs' work in this field began with the staging of *THE BIG BLACKOUT OF '65: THIRTIES MAN*, an elaborate shadow play he put together with his wife Flo ("dancing onstage in the role of His Girl")[66] and the painter Noel Sheridan (who had "a background in Irish theater and supplied the shadow for Thirties Man") as part of the "Expanded Cinema Festival" presented by Jonas Mekas at the Film-Maker's Cinematheque in 1965; the work would be presented again at MoMA in 1967.[67] Future shadow plays would be presented under the name *Apparition Theater of New York*; by 1969, Jacobs had begun incorporating 3-D techniques into these performances:

> …two parallel light sources, filtered through polarizing filters, are used to cast overlapping shadows of the performance onto the screen. Audiences view the work in voluminous depth through polarizing spectacles. Within the basic setup outlined above, performance vary in form: the live action sometimes takes place in front of as well as behind the screen, and film projections are also incorporated. Aside from the occasional restaging, Jacobs stopped creating new Apparition Theater of New York performances in 1982 because of the impractical level of commitment they required from venues and performers.[68]

These performances ended in 1969, when "Yoko Ono and John Lennon were up for staging a shadow-show in a proper theater" and "the Feds came down on them, determined to deport John"—John and Yoko "went into seclusion to pull themselves

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[65] Ken Jacobs, "Painted Air: The Joys and Sorrows of Evanescent Cinema", 40.

[66] *Ibid*, 42 – 43.

[67] William Rose, "Annotated Filmography and Performance History" in *Optic Antics: The Cinema of Ken Jacobs*, 267.

[68] *Ibid*.

together, and… that was it for The Apparition Theater of New York."[69] However, 1969 was an eventful year for Jacobs; after leading a week-long seminar at the State University of New York at Binghamton, "students petitioned the Administration to hire Ken Jacobs" and despite "his lack of a high school diploma, the Administration—during that special period of anguish and possibility—decided that, as a teacher, he was 'a natural.'"[70] He was given a full-time teaching appointment, earned full professorship in 1974 and, "together with Larry Gottheim, organized the SUNY system's first Department of Cinema, teaching every kind of film but specializing in avant-garde cinema appreciation and production."[71]

Jacobs' teaching appointment turned out to be essential to the development of his personal work. His 1969 film *Tom, Tom, The Piper's Son*—in which a 1905 film of the same name is played through fully, analyzed and deconstructed, then played again such that it can be viewed with a new set of eyes (this formal analysis is extremely cursory, but is a topic that we will return to shortly)—turned a pedagogical exercise into a work of art. Jacobs has claimed that he wants "to give the viewer as much freedom as possible to reflect on what they have seen,"[72] and indeed many of Jacobs' works, including *Ontic Antics Starring Laurel and Hardy*, use similarly didactic strategies and focus on creating a means of engaging his audience through his unique take on the formal analysis of archival film footage. Jacobs calls his process "mining" and in an interview with Harry Kreisler of UC Berkeley's Institute of International Studies, explained this process as follows:

> I usually take short lengths of film and pore over them, or pour into them. Dig into them. So it's mining. And I'm looking for things that literally you just don't see when it zips by at 24 frames per second, normal sound speed. Film is a relation of frame to frame to frame, and I am also declaring relations of one frame with another frame. I want to see what can be done

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[69] Ken Jacobs, "Painted Air: The Joys and Sorrows of Evanescent Cinema", 46 – 47.

[70] Michael Zryd, "Professor Ken" in *Optic Antics: The Cinema of Ken Jacobs*, 252.

[71] *Ibid*.

[72] *Ibid*, 257.

> between those two frames and then, maybe frame A and frame B, and then frame B frame C. Okay? It definitely is a dig. What I'm after, of course, is vital, interesting, amusing, crazy-making stuff.[73]

This type of "close viewing" is at the core of Jacobs' practice, and his access to high-quality analytic projectors at SUNY Binghamton (which he had requested for use in his classes, as they allow a user to sit still on a frame and advance / reverse a single frame at a time without burning the film) led to a new stage in his artistic practice: the beginning of his Nervous System performances in 1975. These performances utilized two analytic projectors, each projecting identical prints (typically of archival film footage) and, beginning in 1980, spinning propellors mounted in front of the lenses to create stroboscopic performances with an illusion of depth: [74]

> The Nervous System consists, very basically, of two identical prints on two projectors capable of single-frame advance and "freeze" (turning the movie back into a series of closely related slides.) The twin prints plod through the projectors, frame… by… frame, in various degrees of synchronization. Most often, there's only a single frame difference. Difference makes for movement, and uncanny three-dimensional space illusions via a shuttling mask or spinning propellor up front, between the projectors, alternating the cast images. Tiny shifts in the way the two images overlap create radically different effects. The throbbing flickering (which takes some getting used to, then becoming no more difficult than following a sunset through passing trees from a moving car) is necessary to create "eternalisms:" unfrozen slices of time, sustained movements going nowhere unlike anything in life (at no time are loops employed). For instance, without discernible start and stop repeat points a neck may turn… eternally.[75]

The addition of the external propellor to alternate between images came from a suggestion by Alphonse Schilling, who had used this technique in his own slide projector

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[73] Henry Kreisler, "Conversations with History: Ken Jacobs," 3.

[74] Michele Pierson, "Introduction: Ken Jacobs — A Half-Century of Cinema" in *Optic Antics: The Cinema of Ken Jacobs*, 16 – 17.

[75] Ken Jacobs, "Notes on The Nervous System" in *Films That Tell Time: A Ken Jacobs Retrospective*, 24.

performances.[76] Jacobs recalls that trading technical discoveries with Schilling, and "when toying with the Pulfrich Effect led Alphonse to the exterior shutter, standard design in early projectors, he urged me to apply it to my efforts," but when Jacobs presented his first work using this technique (1980's *THE IMPOSSIBLE: Chapter Four, "Schilling,"* the title "declaring [Jacobs'] debt to him"), "he blew up, saying, 'I only meant for you to use it in your studio.'"[77] Jacobs and Schilling had very different ideas of how this technology should be used, however—"Alphonse had been giving what he called 'demonstrations,' exquisite and ingenious mind-blowing illustrated lectures using the shutter with stereo-slides, but—working with film-strands never intended to produce stereo-phenomena—I was creating symphonies. And I wasn't about to stop."[78]

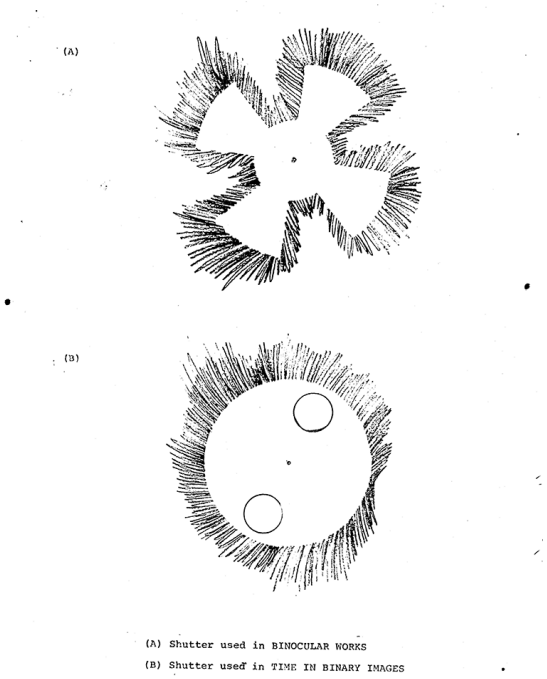

Figure 11. Alphons Schilling's shutter designs, ca. 1977.[79]

[76] William Rose, 270.

[77] Ken Jacobs, "Painted Air: The Joys and Sorrows of Evanescent Cinema", 48 – 49.

[78] *Ibid*, 49.

[79] http://www.vasulka.org/archive/Artists6/Schilling,Alphons/ElectronicSpaces,etc.pdf

Jacobs continued to use the Nervous System in performances for the next 25 years, but in 1990, he began presenting performances with a new system that he calls the Nervous Magic Lantern; this has been his exclusive performance platform since 2000. [80] Though the inner makings of the Nervous Magic Lantern itself are somewhat guarded secrets (Jacobs recalls "blocking anyone from studying it" at a "very well attended recent show"[81]), the basic ingredients of the apparatus are known: "painted transparencies, wax paper, and other small objects"[82] are placed between "a bright theater lamp" and "an arrangement of lenses," in front of which "an external spinning shutter, such as that used in the Nervous System" is mounted; the apparatus is manipulated by Ken and Flo "live throughout each performance, concealed from view behind a lightproof enclosure."[83]

Although Jacobs has stopped performing with his Nervous System, he has begun making new works using digital video that follow a similar logic to his Nervous System performance, along with digital reworkings of the performances themselves. This technique, which Jacobs has called Eternalism, "a method for creating an appearance of sustained three-dimensional motion-direction of unlimited duration, using a finite number of pictures," was granted a US Patent (No. 7,030,902) in 2006:

> The method uses three pictures, A, B and C, two of which are substantially similar pictures having images, A, B, and one that is dissimilar, usually a solid color, C. Continuous movement is created by repetitively viewing the series A, B, C. Additionally, each picture can be blended or superimposed to create a blended A/B, C/A and B/C and then the blend put together with the others, in a series, C/A, A, A/B, B, B/C, C. This series is then repeated a plurality of times to create an illusion of sustained, ongoing motion with a degree of three-dimensionality…[84]

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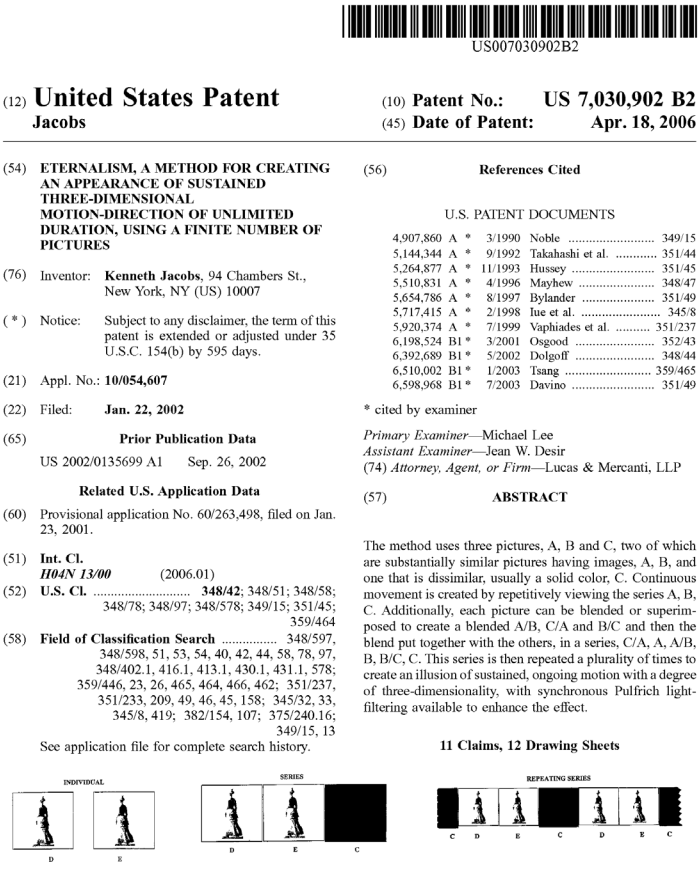
[80] William Rose, 273.

[81] Ken Jacobs, "Painted Air: The Joys and Sorrows of Evanescent Cinema", 49.

[82] Michele Pierson, 18.

[83] William Rose, 273.

[84] Ken Jacobs, *United States Patent No. 7,030,902*, 1.



US007030902B2

(12) **United States Patent**
Jacobs

(10) **Patent No.: US 7,030,902 B2**
(45) **Date of Patent: Apr. 18, 2006**

(54) **ETERNALISM, A METHOD FOR CREATING AN APPEARANCE OF SUSTAINED THREE-DIMENSIONAL MOTION-DIRECTION OF UNLIMITED DURATION, USING A FINITE NUMBER OF PICTURES**

(76) Inventor: **Kenneth Jacobs**, 94 Chambers St., New York, NY (US) 10007

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,907,860	A *	3/1990	Noble	349/15
5,144,344	A *	9/1992	Takahashi et al.	351/44
5,264,877	A *	11/1993	Hussey	351/45
5,510,831	A *	4/1996	Mayhew	348/47
5,654,786	A *	8/1997	Bylander	351/49
5,717,415	A *	2/1998	Iue et al.	345/8
5,920,374	A *	7/1999	Vaphiades et al.	351/237
6,198,524	B1 *	3/2001	Osgood	352/43
6,392,689	B1 *	5/2002	Dolgoff	348/44
6,510,002	B1 *	1/2003	Tsang	359/465
6,598,968	B1 *	7/2003	Davino	351/49

* cited by examiner

Primary Examiner—Michael Lee
Assistant Examiner—Jean W. Desir
(74) *Attorney, Agent, or Firm*—Lucas & Mercanti, LLP

(57) **ABSTRACT**

The method uses three pictures, A, B and C, two of which are substantially similar pictures having images, A, B, and one that is dissimilar, usually a solid color, C. Continuous movement is created by repetitively viewing the series A, B, C. Additionally, each picture can be blended or superimposed to create a blended A/B, C/A and B/C and then the blend put together with the others, in a series, C/A, A, A/B, B, B/C, C. This series is then repeated a plurality of times to create an illusion of sustained, ongoing motion with a degree of three-dimensionality, with synchronous Pulfrich light-filtering available to enhance the effect.

11 Claims, 12 Drawing Sheets

Figure 12. Patent for Ken Jacobs' "Eternalism" technique.[85]

In addition to the use of Eternalism in the digital recreation of previous Nervous System performances and the generation of new digital video works (beginning with his 1999 short *Flo Rounds a Corner*[86], produced at Harvestworks in New York) Jacobs applied his Eternalism methodology to stereographic photography in works such as *Capitalism: Child Labor* and *Capitalism: Slavery* (both from 2006), which use the effect to powerfully animate and bring to life still images of slaves working in a cotton field, and children working in a massive factory during the Industrial Revolution (accompanied by a soundtrack by Austin, TX based analog synthesizer guru Rick Reed, whose grating drone echoes the insistence and monotony of life in the early industrial factories).

[85] *Ibid.*

[86] William Rose, 265.

Figure 13. Two frames from Ken Jacobs' *Capitalism: Child Labor* (2006).[87]

As in his film works, Jacobs uses the additional dimension of time, added to these still photographs, to lead the viewer through the photographs—attention is given to the downturned head of the young girl in the fields, the weight of the giant cotton basket carried on another's shoulders, the bare feet of the children in the factory, the unpleasant scowl of the factory supervisor. Ken Jacobs the filmmaker, despite his emeritus status, is still Ken Jacobs the professor.

In contrast with the succinct eloquence of *Capitalism: Child Labor* (running a grand total of nearly fourteen minutes) and *Capitalism: Slavery* (clocking in at just under three minutes), *Tom, Tom, The Piper's Son* is a sprawling affair, stretching the original ten minutes of footage out over two hours. Nevertheless, its overall structure could be said to follow a similar arc: *Capitalism: Child Labor* shows alternating views of a stereographic photograph then spends the rest of its duration dissecting the images, while the structure of *Capitalism: Slavery* simply reverses the order, first dissecting the stereograph, then showing the original image, while *Tom, Tom* begins with the presentation of a film from 1905 of the same name in its entirety, is followed by an exposition upon each of the seven

[87] http://www.eai.org/title.htm?id=12750

scenes of the original film using various formal devices such as "repetition, slow motion, freezes, and so on,"[88] and ends with a full reiteration of the original film.

However, such an analysis does not take into account Jacobs' disinterest in "coolly" following a narrative trajectory or compositional form, unlike other "structural" films emerging around the time of *Tom, Tom*'s making, later remarking that his work "is not formalist cinema; order interests me only to the extent that it can provide experience."[89] Nonetheless, P. Adams Sitney, the critic responsible for coining the term "structural film" (albeit somewhat reluctantly) included *Tom, Tom* under this umbrella in his defining essay *Structural Film* from 1969, stating that due to "the directness of the mechanism he employs, *Tom, Tom* must be considered within the structural sensibility despite Jacobs's tendency to rupture the forms of all his films."[90] Sitney was clearly bothered by his inability to easily compartmentalize Jacobs' work based on his personal agenda, which insisted upon simplicity of structure:

> Between the two versions I saw, there was a marked difference of architecture. Both successfully violated the symmetry by appendixing a series of slow-motion details after the second presentation of the original film. The latest version, however, has color inserts of a shadow play, which violently interrupts the continuity of the black-and-white film. Visually, they are relaxing (so Jacobs describes their function), but structurally, they are extremely disorienting.[91]

Understanding such disruptions must be understood in relationship to Ken's early films with Jack Smith, in which he was "interested in immediacy… Whimsy was our achievement, as well as breaking out of step,"[92] as well as his history as a painter: "my

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[88] Eivind Røssaak, *The Still / Moving Image: Cinema and the Arts*, 85.

[89] Ken Jacobs, "Disorient Express" in *Time After Time — In and Around the Nervous Magic Lantern and Nervous System of Ken Jacobs*.

[90] P. Adams Sitney, "Structural Film" in *Film Culture Reader*, 336.

[91] *Ibid*.

[92] Ken Jacobs, "Little Stabs at Happiness" in *Time After Time — In and Around the Nervous Magic Lantern and Nervous System of Ken Jacobs*.

approach to film is that of a painter (abstract-expressionist) rather than a dramatist."[93] This immediacy and willingness to "break out of step" are found not only in Jacobs' finished works, but throughout the process he uses to make them.

Unlike most other "structural" films of the time, *Tom, Tom* was not made using an optical printer to rephotograph the film as it was manipulated with the assurance that the projector and camera would remain synchronized throughout this process. Instead, Jacobs used a separate projector and camera, resulting in out-of-sync footage that caught black frames from the projector and therefore included "flicker" as a formal device.[94] Perhaps even more importantly, Jacobs was freed to move naturally towards / away from the projection, framing images by hand in a way that could be considered reminiscent of action painting:

> "I had decided, with the examples of jazz improvisation and of action painting which would build on one impulsive stroke, and let things hang out… The off-moments, vagaries, 'tis-human-to-errs, such beatings around the bush also delineated the bush… Follow the impulses, I thought, and let appearances fall as they may."[95]

Jacobs studied with Abstract Expressionist painter Hans Hofmann, and Hofmann was indeed an incredibly influential figure during his developmental years, encouraging him to explore his ideas in both painting and film,[96] as well as introducing him to the means for creating the illusion of depth through what Hofmann called "Push and Pull:"

> Depth, in a pictorial, plastic sense, is not created by the arrangement of objects one after another toward a vanishing point, in the sense of the Renaissance perspective, but on the contrary (and in absolute denial of this doctrine) by the creation of forces in the sense of push and pull.[97]

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[93] Ken Jacobs, "The Sky Socialist" in *Films That Tell Time: A Ken Jacobs Retrospective*, 19.

[94] Eivind Røssaak, *The Still / Moving Image: Cinema and the Arts*, 84.

[95] Ken Jacobs, "Little Stabs at Happiness" in *Films That Tell Time: A Ken Jacobs Retrospective*, 18.

[96] Michele Pierson, 5.

[97] Hans Hofmann, "The Search for the Real in the Visual Arts" in *Search for the Real and Other Essays*, 43.

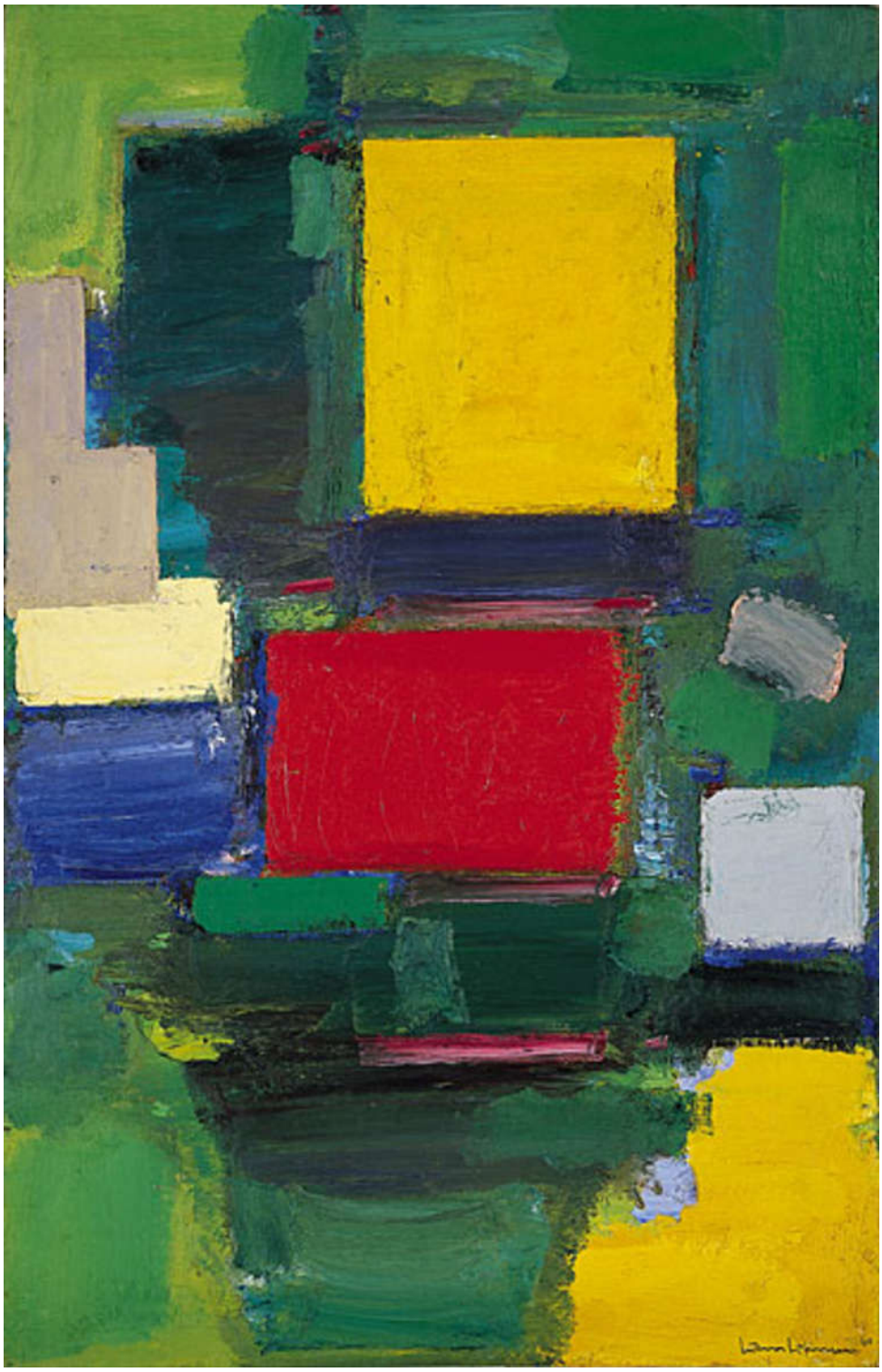

Figure 14. Hans Hofmann, *The Gate* (1959 – 60).[98]

[98] https://en.wikipedia.org/wiki/File:Hans_Hofmann%27s_painting_%27The_Gate%27,_1959–60.jpg

Linkages to abstract expressionism manifest in the optical "Push and Pull" of Jacobs' filmic manipulations, which create depth illusions as described by Hans Hofmann, as well as "'quotes' in freeze-frames that resemble well-known paintings by Hofmann and Franz Kline" throughout *Tom, Tom, The Piper's Son*.[99]

Figure 15. Franz Kline, *Buttress* (1956).[100]

Figure 16. Still from Ken Jacobs' *Tom, Tom the Piper's Son*.[101]

[99] Eivind Røssaak, "Acts of Delay" in *Optic Antics: The Cinema of Ken Jacobs*, 101.

[100] http://www.moca.org/collection/work/buttress

[101] http://www.eai.org/title.htm?id=8382

Despite Jacobs' insistence that he is not "a dramatist," *Tom, Tom* is not simply a formal work, revealing only the surface or materiality of the film, but through "close-viewing," also presents the actors (many of whom do not seem to be trained actors) as vulnerable and undeniably human. In his 1999 work *New York Street Trolleys 1900*, itself a demonstration of his Nervous System, Jacobs remarks that "the people of the street" are "unsuspecting that they are going to be plunged a hundred years ahead in time." *Tom, Tom* achieves the same result, thanks to his careful examination of its actors. Incredibly, the only reason that the original film survived a hundred years was due to a loophole in copyright law at the time of the film's making:

> Before 1912, U.S. copyright law made no provision for motion pictures, but for a fifty-cent fee one could copy a still photography… It was the Edison Company that in 1894 hit upon the curious idea of copyrighting films as "photography"… They reformatted whole films, *Tom Tom* included, onto hug rolls of photographic paper and documented entire movies… By this lucky "quick of copyright law" more than three thousand films from between 1894 and 1915 were saved from extinction. These films, preserved in the Library of Congress' Paper Print Collection, now provide the fullest surviving view of the origins of American filmmaking.[102]

Figure 17. Still from *Tom, Tom the Piper's Son*.[103]

[102] *Ibid*, 108.

[103] http://www.eai.org/title.htm?id=8382

Jacobs' version of *Tom, Tom, The Piper's Son* was added to the Library of Congress' National Film Registry in 2007, so it should be preserved for at least a hundred years as well. The issue of preservation is a little trickier when it comes to Ken's performance works that utilize his Nervous System or Nervous Magic Lantern. Nervous System performances are intricately scored and highly rehearsed events, performed in conjunction and through careful deliberation with Flo:

> *Flo*: …We worked together on the Nervous System pieces. I'd take the notes for all the cues and iron out the cues for all the performances.
> *Ken*: Flo's taste would operate then.
> *Flo*: He'd eliminate frames or sound, and we'd refine the cue sheets…
> *Amy*: And during the performance?
> *Ken*: I did the main reel and I had the cue sheets glued to the projector.
> *Flo*: I was on the other side operating the second reel.[104]
> *Flo*: I helped him with the refining. He started off using analytic projectors that had frame counters. He would go down through the frames and work out sequences, and we'd write down the frame numbers and get things refined and refined and refined. So basically it was like working out scores, and getting closer and closer and closer to the actual frames we'd use and when the sound would come in. The cue sheets would keep changing, changing, as things would get tighter, tighter. And after I'd get tired, Ken would work until four in the morning. And then the next day, when he'd have gotten things really shaped, then I would come in and write things down.
> *Ken*: Flo's wrath was terrible if I didn't follow the cues.
> *Flo*: Because I wanted a perfect work. Unless the improvisation was good. I just couldn't stand it when mistakes happened. I like good accidents, but not mistakes.
> *Ken*: It was hard.[105]

Very few examples of these performances exist, and many of those that do exist are only available for screening or exhibition rentals. Most of these examples are digital recreations made using software. Out of over twenty Nervous System works performed multiple times between 1975 and 2000, only two examples are available to view in the form of recordings made directly from the screen in a performance at the time of writing:

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[104] Amy Taubin, "Flo Talks!" in *Optic Antics: The Cinema of Ken Jacobs*, 151.

[105] *Ibid*, 156.

the first, *New York Street Trolleys 1900*, is a 10:30 video demonstration of a Nervous System performance by the same name and features narration by Jacobs, who explains the ways in which he is manipulating the apparatus as well as his reasons for doing so; the second is taken from a performance of *New York Ghetto Fishmarket 1903*.

Figure 18. Still from *New York Ghetto Fishmarket 1903* (2007) feat. the Nervous System.[106]

The introductory credits from the *New York Ghetto Fishmarket 1903* DVD maintain that the recording is a "longer, digital version of the piece" in which "only the oncoming 'night vision'" (beginning after the introductory credits at around 9:00, and lasting for approximately five minutes) "is recorded from the screen and not computer re-invented."

The DVD is available from John Zorn's Tzadik label, and features Catherine Jauniaux on voice, toy instruments and electronics, and Tom Cora on cello; *New York Street Trolleys 1900* is only available for institutional purchase or screenings, though a low-quality preview of this piece may be viewed through Electronic Arts Intermix's online "Video Viewing Room," and a higher quality version may be viewed by appointment in their physical viewing room in New York. While these short segments may be of interest

[106] http://www.tzadik.com/index.php?catalog=3004

due to their direct representation of the "crazy-making stuff" of Nervous System performances, they exist only as demonstrations or excerpts and are not illustrative of the form of the original works.

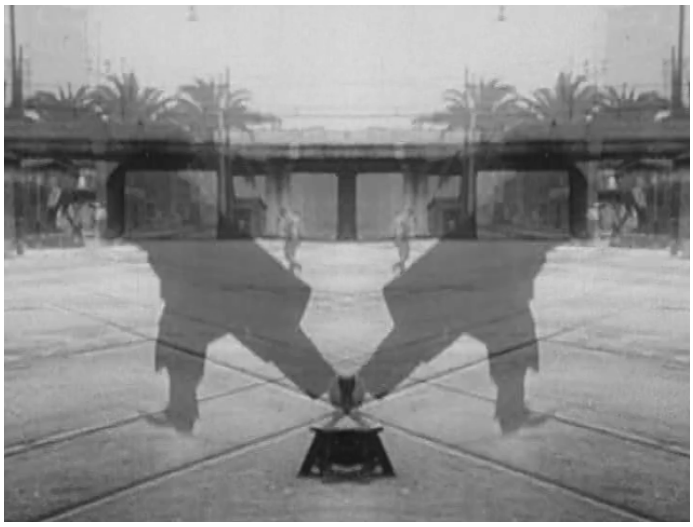

Figure 19. Still from Jacobs' *Ontic Antics Starring Laurel and Hardy: Bye, Molly* (2005).[107]

More illustrative, perhaps, is the digital articulation of Jacobs' Nervous System performance *Ontic Antics Starring Laurel and Hardy*, 2005's *Ontic Antics Starring Laurel and Hardy: Bye, Molly*, the realization of which sticks "closely to remembered scores for past performances."[108] In this piece, Jacobs explores Lewis Foster's 1930 Laurel and Hardy film *Berth Marks*,[109] subjecting the "ontic" (real, factual) properties of Foster's film to a variety of "antics" through the use of his Nervous System apparatus. Following Jacobs' strategy of exposition prior to statement of a theme, the first fifty-odd minutes of the piece are spent pulling apart *Berth Marks* and putting it back together in novel and often, hilarious, ways (unlike *Tom, Tom*, *Ontic Antics* does not negotiate the entire terrain of the

[107] http://www.eai.org/title.htm?id=12563

[108] Michele Pierson, 18.

[109] William Rose, 273.

original film, but it does highlight the primary sections of *Bert Marks* in a fairly linear progression).

In many cases, humor is engaged through the use of mirror images: Hardy, suspended in air, "eternally" falls off of a ladder to a train that has departed, simultaneously jittering back and forth in impossible rhythms; Laurel and Hardy's images flicker back and forth across the screen's center-line and thus the two trade places, attire and actions—tripping over a cello in huge sprawling motions, putting on a hat while gesturing wildly like a dual-headed Saint Vitus. Not content to let viewers anticipate form, a colorized refashioning of the footage appears momentarily at around the nineteen minute mark and as soon as it has arrived, quickly departs, never to appear again.

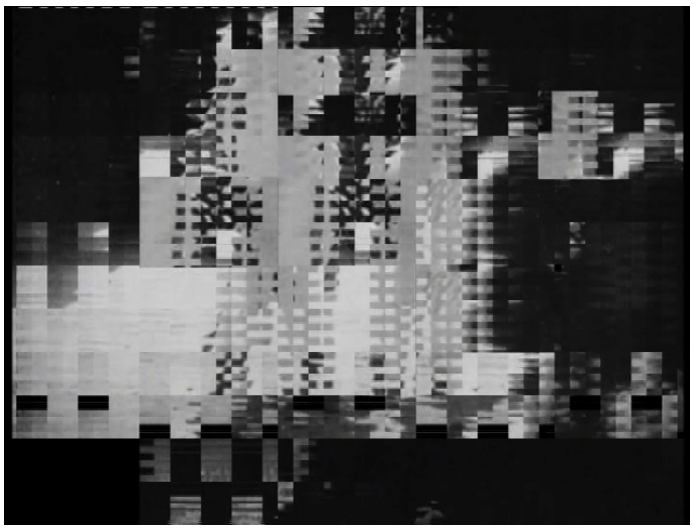

Figure 20. Still from "Coda" section of Jacobs' *Ontic Antics*.[110]

The digital reworking of *Ontic Antics* includes an additional 17-minute "coda" in which Jacobs' "eternalisms" become almost illegible through further digital manipulation—history is again torn up by its roots: not even Jacobs' processes are sacred.

[110] *Ibid*.

Film critic / historian Paul Arthur once said that *Ontic Antics* felt "too damn long,"[111] but to me he seems to be missing the point. It is precisely the way that Jacobs manipulates time as a sculptural material that makes the work interesting: At times, the "eternalism" indeed seems as though it will never end, while at others, it is pulled away just as the viewer is sinking into its hypnotic rhythm. Again, Hofmann's "Push and Pull" surfaces, but through the activation of the fourth dimension rather than the second.

However, Jacobs is no stranger to the world of experimental music or the post-Cagean notion of silence; his 1968 performance *THE BIG BLACKOUT OF '65: Chapter Four "Evoking the Mystery"* included sounds from "the movement of bodies both inside and outside the walls of the Washington Square United Methodist Church to open the performance up to the indeterminate flow of life."[112] Indeed, many of his Nervous Magic Lantern performances are collaborations with improvisers, experimental musicians and sound artists such as John Zorn, Ikue Mori, Black Dice, Rick Reed, and Aki Onda.[113]

Such improvisations evolve naturally, with Jacobs creating his unique brand of moving images while the musicians he works with adhere to their distinctive sound palettes: "I enjoy seeing and hearing what comes of each combination."[114] These improvisations exist distinctly within visual and auditory realms without an attempt to create artificial connections or "synæsthetic" approaches to the media: "Playing live, I don't attempt to illustrate the sounds… It's this abstract imagery and these personal sounds… and together they form this odd juncture with each other."[115]

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[111] Paul Arthur, "'A Panorama Compounded of Great Human Suffering and Ecstatic Filmic Representation': Texts on Ken Jacobs" in *Optic Antics: The Cinema of Ken Jacobs*, 35.

[112] Michele Pierson, "Jacobs' Bergsonism" in *Optic Antics: The Cinema of Ken Jacobs*, 200.

[113] William Rose, 273.

[114] Alessio Galbiati, "Ken Jacobs: The Demiurgo Of The Moving Image" in *Digimag: The Digicult's Project Journal*, Issue 32, 1.

[115] Andy Beta, "Two Artists Light the Way Into the Mind" in *The Wall Street Journal, December 11, 2012*, A26.

Nervous Magic Lantern performances bring to fruition the full breadth and depth of Jacobs' history as an improvising performer, cinematic artist, and painter. Writer David Davidson describes a recent Nervous Magic Lantern performance in Toronto:

> The Nervous Magic Lantern has a rotating propeller that serves as a shutter over the lens, which gives the image a strobe-light effect. For Jacobs, the light source magnifies these various plastic slides that he changes sporadically over the hour-long performance. The light stops being projected between the slides and the room is in pitch-black. I counted around twelve changes. These plastic slides, which the light passes through and are then projected onto the screen, are all different. They are hand-painted… formalist and non-representational—though one can always tease out specific images from them.[116]

It is important to set aside a moment here to note that the mechanism behind the Nervous Magic Lantern is not the point: "I don't want people to think that they understand it because they see its parts. It is completely mystifying to me, doing it, and I don't want an easy answer for them."[117] Davidson continues:

> [The] plastic slides are doubled and can be indented, bubbled, scratched and further manipulated. The pulsing image gives of a sense of three-dimensionality. While Jacobs can, and does, move the slides around to give the image a sense of motion… that seems infinite as the objects always seem to be moving while never actually going anywhere.[118]

Jacobs' Nervous Magic Lantern performances have either been performed silently or in collaboration with musicians / sound artists. *Celestial Subway Lines / Salvaging Noise* is the result of documentation from four improvised performances with John Zorn and Ikue Mori in 2004 ("each time I do it, I improvise. I can't repeat what I did a previous time").[119] The work begins with a clangorous din of mechanical sound and imagery resembling organic matter of unknown origin: a forest floor, smoldering embers in a dying fire.

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[116] David Davidson, "Ken Jacobs and Experimental Cinema (Toronto 2011)" in *Toronto Film Review*, 1.

[117] Ken Jacobs, "Roundtable on Experimental Digital Cinema" in *October Summer 2011*, 60 – 61.

[118] David Davidson, 1.

[119] Ken Jacobs, "Roundtable on Experimental Digital Cinema", 61.

Figure 21. Still from Ken Jacobs' *Celestial Subway Lines / Salvaging Noise* (2004).[120]

The image slowly strobes in and out, with an almost gentle throbbing motion, equal parts light and darkness. "Not enough is said about darkness," Jacobs once said: "Give it a role… and entwined with hits of light we see things never seen before." Suddenly, the light stops and the music changes, now the sound of a piano, and tiny, bell-like sounds emerge.

When the image returns, we see what appears to be rocks at the bottom of a riverbed, coming into and out of focus. Chromatic aberrations at the edges of the field lend subtle coloration to the black-and-white image in the center of the screen. Scraping noises emerge, and the image slowly fades.

As the chaos builds, we start to see a new image—this time, looking more like macro photography of a tree branch—the sounds ebb and flow, alternating between silence and dense, textural noise. A new image appears—shining coils of gold and steel wire, and a low droning sound comes to the foreground.

[120] http://www.tzadik.com/index.php?catalog=3004

Figure 22. Still from Ken Jacobs' *Celestial Subway Lines / Salvaging Noise* (2004).[121]

Fragments of colored light, a ludicrously decorated christmas tree seen through a gauzy veil. Sporadic bleeps and blurps, building in complexity, joining into a dense wall of noise. Grainy detail of limestone. Constantly shifting, changing, disorienting:

> Disorienting because that's how you get to thinking, otherwise you take things for granted. Oh, I see that, I know what that is. And disorientation makes you struggle for uprightness again. You have to seek what's going on: where am I? Then your mind is brought to work, you're activated.[122]

A woman's voice soars above: incantations, summoning the dead to life. Lost in the throbbing glow of the Nervous Magic Lantern.

> It has a spinning shutter, which creates a flicker of light, not unlike a Dream Machine. I don't know what the flicker does to our brains, but it does something. As science learns more about the brain, maybe they'll eventually be able to explain what the effect is, but I'm not interested in the science of it; I'm only interested in the experiential aspect of it.[123]

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[121] http://www.tzadik.com/index.php?catalog=3004

[122] Henry Kreisler, 3.

[123] Andy Beta, A26.

We have all but forgotten our desire to decode the origins of the image, and simply bask in its slow metamorphoses: pure, unbridled experience. And then—a burst of thunder, accompanied by ghastly images: a family portrait, perhaps, a hundred years old, floating in Jacobs' trademark 2½-D. The sound of footsteps, a typewriter clattering away. Leaves in a forest flickering in the darkness? Left with an utter inability to put together the pieces of the puzzle. Someone behind me coughs loudly. And again. Searing noise. The electrostatic generator comes to life, transitioning into a seething mass, clusters of light.

Figure 23. Still from Ken Jacobs' *Celestial Subway Lines / Salvaging Noise* (2004).[124]

A new nebula, glimpsed for the first time, an exciting scientific discovery. The sounds of a hand-cranked rock tumbler, churning at breakneck speed. The nebula fades from view, the churning slows and a gentle plucking of strings carries us into the darkness. "Crazy-making stuff" indeed.

[124] http://www.tzadik.com/index.php?catalog=3004

CHAPTER 2: SONIC INFLUENCES

Foundations of Techno

"Techno" as a musical movement is widely understood to have been the creation of three artists, often referred to as the "Belleville Three" due to their upbringing in Detroit's suburb of the same name in the early 1980s: Juan Atkins (aka "The Originator"), Derrick May (aka "The Innovator") and Kevin Saunderson (aka "The Elevator"),[125] but in order to properly understand this movement, it is necessary to understand some of its prehistory as well: In the late 1970s and early 1980s, Detroit was home to a burgeoning social scene in the form of dance parties organized by high school students at social clubs such as the wildly successful club known as Charivari (a "preppy" night whose attendants' attire was inspired by European fashion, named after a "small chain of hip clothing stores in New York City" due to "the sound of the word and its association with the store") held at the "Park Avenue Club," the third floor of the Women's City Club in northwest Detroit.[126]

Figure 24. Crowd at the Park Avenue Club in the early 80s. Photo by Todd Johnson.[127]

[125] Dan Sicko, *Techno Rebels: The Renegades of Funk*, 84.

[126] *Ibid*, 14 – 16.

[127] *Ibid*, 21.

At the time, the field of disco music was expanding to incorporate electronic elements, and work of "Italo-disco" producers such as Giorgio Moroder, Claudio Simonetti (formerly of the prog rock band Goblin, responsible for soundtracks accompanying the classic horror films of Dario Argento and others), Maurizio Dami aka "Alexander Robotnick" (whose hit *Problèmes D'Amour* was "one of the first to use a TB-303"[128]) could be heard at these parties alongside New Wave artists such as Visage, Telex and Liasons Dangereuses, Düsseldorf-based former prog rockers Kraftwerk (described by "second wave" Detroit techno producer Carl Craig as being "so stiff they were funky"[129]) and classic midwest funk bands like Parliament / Funkadelic.[130] In fact, the latter two groups were so influential to the development of techno that Derrick May's off-the-cuff quip that techno "is just like Detroit—a complete mistake. It's like George Clinton and Kraftwerk stuck in an elevator" became something of a shorthand for its explanation.[131]

However, Dan Sicko, author of the seminal techno reference *Techno Rebels: The Renegades of Electronic Funk*, claims that "techno and house owe as much to its electronic upgrade of traditional disco as they do to the rhythms of Kraftwerk"[132] and traces the formation of techno to DJing techniques used at parties such as the aforementioned Charivari: "DJs would work two copies of [Italo-disco group] Kano's 'Holly Dolly,' repeating the sparse intro over and over again and doubling up on the chorus of 'Holly… Dolly.'"[133] Upon hearing this evolution of the disco sound, a group which came to be known as A Number of Names (a name given to them by Charles Johnson aka "the

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[128] *Ibid*, 25.

[129] Bill Brewster and Frank Broughton, *Last Night a DJ Saved My Life*, 344.

[130] *Techno Rebels: The Renegades of Funk*, 24 – 26.

[131] *Ibid*, 11.

[132] *Ibid*, 23.

[133] *Ibid*, 29.

Electrifying Mojo" due to the fact that the large number of musicians who showed up at his radio show didn't yet have a name), created "Sharevari" (the spelling of its name changed to "avoid conflicts"), one of two recordings debatably holding the title for the first Detroit Techno track— the other recording was Cybotron's "Alleys of your Mind."[134]

Figure 25. The Belleville Three: Kevin Saunderson, Juan Atkins, Derrick May, ca. 1988.[135]

Cybotron was a duo comprised of Juan Atkins, of "the Belleville Three," and Rick Davis (aka "3070"), a classmate of Atkins' at a local community college, a Vietnam veteran with "an Aladdin's cave of sound equipment."[136] The two bonded over an interest in the

[134] *Ibid*, 28.

[135] http://www.elbedroom.mx/wp-content/uploads/2015/04/detroit21.jpg

[136] Bill Brewster and Frank Broughton, 345.

writings of Alvin Toffler[137], who is perhaps best known for his 1970 bestseller, *Future Shock*, but whose later book *The Third Wave* lent Atkins the word "techno," as Sicko explains:

> …the term "techno"—often cited as coming directly from Alvin Toffler's book The Third Wave—connotes a connection to future and futurism. In his book, Toffler outlines his concept of "techno rebels"—people who are cautious of new, powerful technologies and want to temper the breakneck pace of technological advancement. As he asserts, "The techno-rebels contend that technology need not be big, costly, or complex in order to be 'sophisticated.'"[138]

"Alleys of Your Mind" was a "local hit, selling over 10,000 copies in Chicago and Detroit, aided by regular airings courtesy of the Electrifyin' Mojo,"[139] eventually leading to a record deal with Berkeley, CA based Jazz label Fantasy, who was interested in pushing forward "electro" due to its interest in how the "'switched-on' funk variant… [exaggerated] the electronic sounds that Midwestern groups like Parliament-Funkadelic had perfected…"[140] Their first full-length album, 1983's *Enter*, featured both "Alleys of Your Mind" and their follow-up single "Cosmic Cars," as well as a handful of new tracks, including the classic track "Clear." Following the success of "Clear," Cybotron put out their next single "Techno City," featuring lush pads, a vocal hook, more traditional song structure, and requisite 1980s guitar solo. Atkins disagreed with this decision: "I was against that record… It's a great record, but it wasn't the one to follow 'Clear.'"[141]

This difference of opinions led Atkins to found his own label, Metroplex in 1985, and release his first solo recording under his new pseudonym, Model 500 entitled "No

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[137] *Ibid*.

[138] Dan Sicko, 12.

[139] Bill Brewster and Frank Broughton, 345,

[140] Dan Sicko, 45.

[141] *Ibid*, 47.

UFOs."[142] His friends Derrick May and Kevin Saunderson would follow suit, establishing their own labels Transmat in 1986, and KMS in 1987, accordingly. The output of these labels would soon catch the attention of Neil Rushton, owner of an English house music record label called Kool Kat, who began licensing their records for distribution in Europe, and helped put together a compilation of the new Detroit sound for Virgin's 10 Records subsidiary. The compilation, initially slated to be called *The House Sound of Detroit* contained a track by Juan Atkins called "Techno Music," which "instantly prompted [Rushton] to change the compilation's title to *Techno! The New Dance Sound of Detroit*" and thus, the Techno genre was born (or at least named).[143]

Figure 26. Berlin's long-running Tresor club, ca. 2003.[144]

[142] *Ibid*, 48.

[143] *Ibid*, 68.

[144] https://commons.wikimedia.org/wiki/File:Tresor_-_Berlin.jpg

Over the course of the next decade, techno started to spread its tentacles throughout the United States and abroad, resulting in the formation of influential clubs such as Berlin's Tresor (named for the club's location in a former department store's vaults; "tresor" translates to "vault" or "safe"),[145] which would also become a record label that would release records by "second wave" Detroit techno artists, starting with their first release in 1991, the self-titled album by X-101, a group comprised of "Mad" Mike Banks, Jeff Mills, and Robert Hood.

Figure 27. Mike Banks & Underground Resistance ca. 2006. Photo by Photophunk.[146]

The group was comprised of founding members of the "concept and movement known as Underground Resistance (UR), a kind of covert musical operation set on toppling the industry establishment,"[147] as witnessed in the form of an etching on the reverse side of an early single-sided UR record, 1992's *Kamikaze* on the World Power Alliance label (an Underground Resistance subsidiary):

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[145] Dan Sicko, 119.

[146] http://theguardian.com/music/2014/dec/15/underground-resistance-review-dance-techno

[147] *Ibid*, 99.

> The World Power Alliance was formed somewhere in Detroit, Michigan, USA on May 22, 1992 at 4.28pm by various elements of the Worlds Underground Legions. The Alliance is dedicated to the advancement of the human race by sonic experimentation. The World Power Alliance was designed to bring the World's minds together to combat the mediocre audio and visual programming being fed to the inhabitants of Earth, this programming is stagnating the minds of the people building a wall between races. This wall must be destroyed, and it will fall. By using the untapped energy potential of sound, the WPA will smash this wall much the same as certain frequencies shatter glass. Brothers of the underground transmit your tones and frequencies from all locations of this world. Wreak havoc on the programmers! This is war! Long live the underground.

Figure 28. Jeff Mills performing at X Avant 5 in Toronto, 2010. Photo by Basic Sounds.[148]

Underground Resistance would continue to push the envelope, releasing pivotal works by artists such as Drexciya, Suburban Knight, and The Aztec Mystic. Jeff Mills would go on to establish his own label, Axis, initiating its artist roster with a record by H&M (Hood and Mills), 1992's *Tranquilizer* EP, one of only a handful of releases on Axis (out of over one hundred records and counting) to feature an artist other than Mills himself. Another notable exception was Hood's 1994 double-record set, *Minimal Nation*. This record cemented a new trend towards "minimal" techno, "a strain of techno that has

[148] https://www.flickr.com/photos/basic_sounds/5091971702/

survived by shedding characteristics rather than collecting them… breaking [techno] down and building it back up,"[149] as well as artists who approach "a reduction of the 'song' component to mere fractions of a bar… [by] cramming notes into smaller spaces, techno seems to become synonymous with repetitions—one of the characteristics that generally turns people off to dance music."[150]

This reductive approach can be found throughout the evolution of techno up to today, manifesting in the works of artists such as Basic Channel (Moritz von Oswald and Mark Ernestus' group and record label), who pioneered "dub techno," a variant of techno "starting from the principles of Jamaican 'dub' and working back to the four-count beat conducive to club play,"[151] as well as a number of artists associated with the Basic Channel label and its Chain Reaction sublabel such as Fluxion, Vainquer, and Porter Ricks.

Figure 29. Ernestus & von Oswald performing at Mutek, 2007. Photo by Basic Sounds.[152]

[149] Dan Sicko,140.

[150] *Ibid*, 141.

[151] *Ibid*, 120.

[152] http://www.flickr.com/photos/basic_sounds/530751336/in/set-72157600311451149/

Even more dramatic turns towards minimalism in techno include the early works of Pan Sonic (formerly Panasonic) and Mika Vainio. Vainio's 1994 album *Metri* (recorded under the pseudonym Ø) witnesses two extreme examples: "Twin Bleebs," featuring two "bleebs" (sine tones with short envelopes) a semitone apart from each other, coming into and out of phase with one another (a'la Steve Reich's "phase" works from the 1960s) while a single quarter-note kick drum repeats steadily throughout the track, and "Kuvio," which sets a single quarter-note kick in opposition to a syncopated three-note cell with shifting accents, creating seemingly endless varieties of metric modulation via a quintessentially simple means.

Figure 30. Mika Vainio, ca. 2006. Photo by Randy Yau.[153]

[153] https://commons.wikimedia.org/wiki/File:Mika_Vainio_(Pan_Sonic).jpg

As Vainio explains:

> "The way we are doing music," says Mika, "the machines are as important as we are. It goes both ways. When we are building the tracks we have some ideas in our minds; they're still playing us as well. Sometimes it's very difficult, if you have a really specific idea, to make a certain kind of track, it's often very difficult to force the track into that direction. It's often a lot easier and more enjoyable when you just let it grow by itself, in a way. Just go, and follow it."[154]

On the opposite end of the spectrum, a more "maximal" approach to techno emerged from the Netherlands in the early 1990s. This form of techno was known as "gabber," described by Bill Brewster and Frank Broughton as "impossibly fast, with bpms regularly reaching well beyond the 200 mark" while "[a] spin-off, 'speedcore', takes tempos right up to 300bpm."[155] Rhythmic patterns as dense as this (especially when incorporating distorted percussion elements as commonly seen in these genres) may become overwhelming and begin to blur between rhythm and our next topic of inquiry: noise.

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[154] http://www.phinnweb.org/scrapbook/panasonic_wire.html

[155] Bill Brewster and Frank Broughton, 366.

A Brief History of Noise

The history of "noise," it is often said, began in 1913, when the Futurist painter Luigi Russolo saw a performance of his Futurist compatriot Balilla Pratella's orchestral composition *Musica Futurista* at the Teatro Costanzi in Rome, and was so taken by this performance that he "quickly wrote his own manifesto, *The Art of Noise*."[156] In his manifesto, Russolo states that: "Ancient life was all silence. In the 19th Century, with the invention of machines, Noise was born. Today, Noise is triumphant and reigns sovereign over the sensibility of men."[157] Throughout his manifesto, Russolo continues to elaborate on the ways in which noises such as the "the throbbing of valves, the bustle of pistons, the shrieks of mechanical saws, …the varied hubub of train stations, iron works, thread mills, printing presses, electrical plants, and subways"[158] should find their way into this new art, while remaining adamant that although "the characteristic of noise is that of reminding us brutally of life, the *Art of Noises should not limit itself to an imitative reproduction*" but that it will "achieve its greatest emotional power in acoustical enjoyment itself, which the inspiration of the artist will know how to draw from the combining of noises."[159]

Russolo went on to invent, with Ugo Piatti, a number of noise-making devices he referred to as "Intonarumori" (or "noise-intoners"), broken down into nine separate sub-categories: "Howlers," "Roarers," "Cracklers," "Rubbers," "Bursters," "Gurglers," "Hummers," and "Whistlers."[160] These "Noise Instruments," as he called them:

> take the form of boxes of various sizes, usually constructed on a rectangular base. At the front end, a trumpet serves to collect and reinforce the noise-sound. Behind, there is a handle to produce the motion that

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[156] Thom Holmes, *Electronic and Experimental Music*, 38.

[157] Luigi Russolo, *The Art of Noises*, 23.

[158] *Ibid*, 26.

[159] *Ibid*, 27 – 28.

[160] *Ibid*, 75.

> excites the noise. On the upper part, a lever with a pointer is moved along a scale graduated in tones, semitones, and fractions of a tone. Through its displacements, this lever is used to determine the highness, that is, the pitch of the noise, which can be read on a graduated scale… The noise instruments are played by gripping the lever with the left hand and turning the handle… By adjusting the lever, the pitch is changed as desired… not only leaps of tones and semitones but also gradual enharmonic passages between one pitch and another… Moving the handle more rapidly or less rapidly produces a greater or lesser intensity in the noise: thus, soft and loud passages can be obtained.[161]

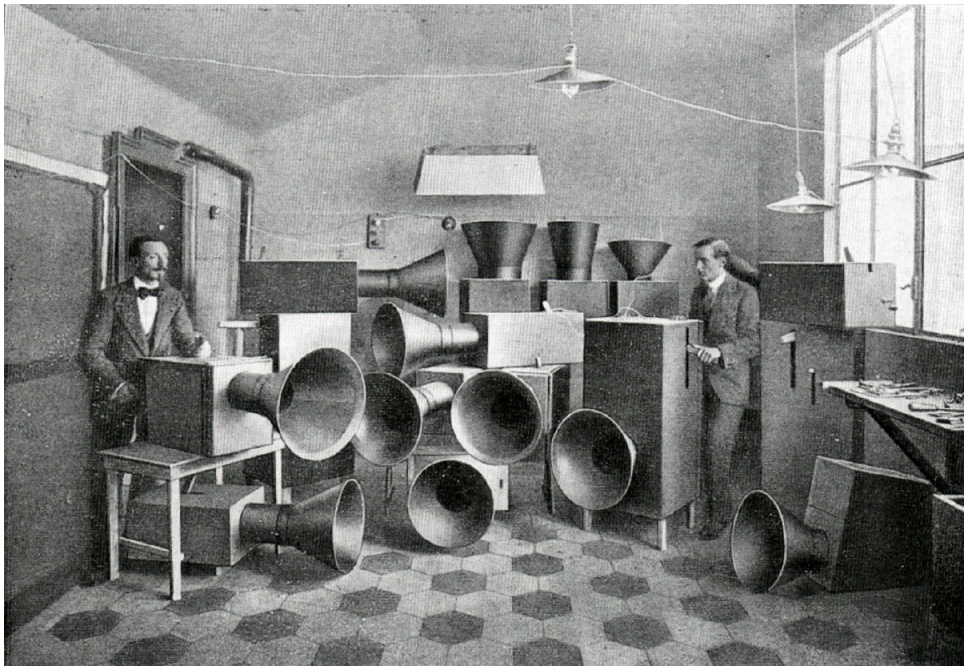

Figure 31. Russolo (left) and Piatta (right) with their "Intonarumori," ca. 1914.[162]

Russolo was well ahead of his time, stating that musical "sounds," "defined as the result of a succession of regular and periodic vibrations," were "sharply divided from noises… caused by motions that are irregular, as much in time as in intensity" in what amounted to as "an absurd division… which has no reason to exist at all."[163] The "*real* and *fundamental* difference between sound and noise," he claimed, "can be reduced to this

[161] *Ibid*, 76.

[162] *Ibid*, 22.

[163] *Ibid*, 37.

alone: *Noise is generally much richer in harmonics than sound.*"[164] Unfortunately, his rallying cry for acceptance of this expanded sonic language would lie dormant for a number of years—"not one of Russolo's instruments… has survived. Some are known to have been destroyed during the Second World War; the rest have simply disappeared."[165]

Figure 32. Arsenij Awraamov, conducting *Symphony of the Factory Sirens*, 1922.[166]

Others would follow in Russolo's footsteps, knowingly or not. In 1922, composer Arsenij Awraamov's *Symphony of the Factory Sirens* was premiered in Baku, Russia; this

[164] *Ibid*, 39.

[165] Barclay Brown, "The Noise Instruments of Luigi Russolo" in *Perspectives of New Music*, p. 36.

[166] Sigfried Zielenski, *Deep Time of The Media: Toward an Archaeology of Hearing and Seeing by Technical Means*, 233.

piece was written for "hooters, factory sirens, fog horns, machine guns, and steam whistles…" and was conducted from "the roof of a tall building… by signaling with flags."[167] French Composer Edgar Varèse, who had known Russolo, as well as the founder of Futurism, Filippo Tommaso Marinetti, was often "referred to as 'the futurist composer,' a label he resented and rejected."[168] "Italian Futurists," Varèse would say, "slavishly imitate only what is superficial and most boring in the trepidation of our daily lives! …The futurists imitate, an artist transmutes."[169]

Despite his repudiation of the Futurists' tactics, Varèse would himself incorporate the sounds of sirens into compositions such as *Amériques: Americas, New Worlds*[170], as "the beautiful parabolas and hyperbolas of sound the sirens gave me and the haunting quality of the tones made me aware for the first time of the wealth of music outside the narrow limits imposed by keyboard instruments,"[171] and in 1936, Varèse would call for the use of electronics in his treatise "New Instruments and New Music:"

> …the new musical apparatus I envisage, able to emit sounds of any number of frequencies, will extend the limits of the lowest and highest registers, hence new organizations of the vertical resultants: chords, their arrangements, their spacings—that is, their oxygenation. Not only will the harmonic possibilities of the overtones be revealed in all their splendor, but the use of certain interferences created by the partials will represent an appreciable contribution. The never-before-though-of use of the inferior resultants and of the differential and additional sounds may also be expected. An entirely new magic of sound![172]

In fact, this "new magic of sound" (which would come to be known as additive synthesis) had been made possible some forty years prior by inventor Thaddeus Cahill

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[167] *Ibid*.

[168] Louise Varèse, *Varèse: A Looking-Glass Diary Volume I: 1883 – 1928*, 105.

[169] *Ibid*, 106.

[170] *Ibid*, 150.

[171] *Ibid*, 42.

[172] Christoph Cox and Daniel Warner, eds. *Audio Culture: Readings in Modern Music*, 18.

with his massive dynamo-driven Telharmonium, patented in 1895 and developed over the course of the next fifteen years, growing by 1910 to the size of a small factory, with its mainframe 65 feet long and 13 feet wide, consuming up to 1.57 megawatts of power, and costing over $200,000 (roughly $5 million by today's standards).[173]

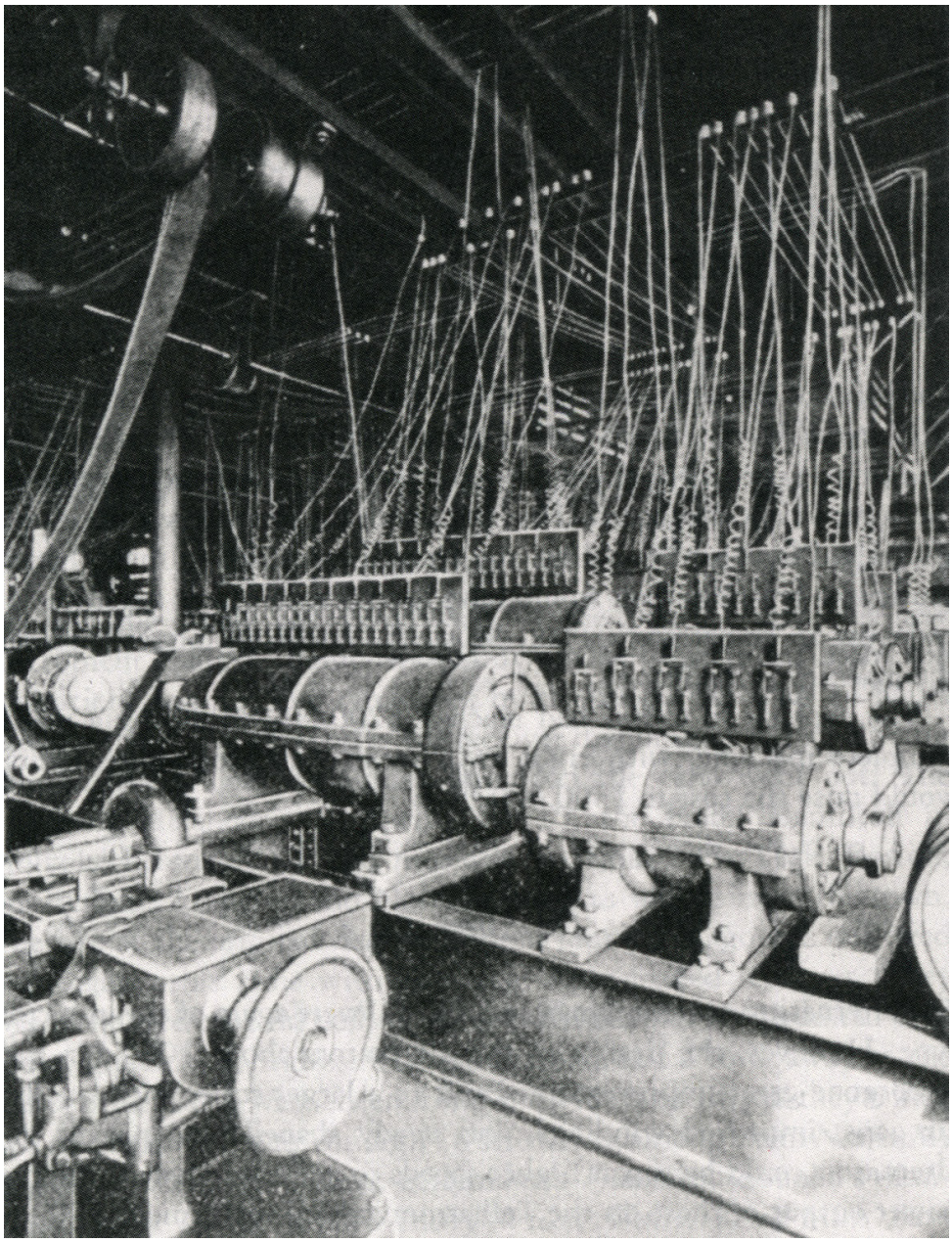

Figure 33. Thaddeus Cahill's Telharmonium, ca. 1910.[174]

[173] Reynold Weidenaar, *Magic Music from the Telharmonium*, 233 – 235.

[174] *Ibid*, 234.

Varèse had, in fact, seen the Telharmonium demonstrated, and was well aware of Cahill's research:

> All through his writings one finds over and over again predictions about the music of the future which have since come true. In fact there is hardly a development that he did not foresee, as for instance this extraordinary prophecy: "I almost think that in the great new music, machines will be necessary and will be assigned a share in it. Perhaps industry, too, will bring forth her share in the artistic ascent." How right he was, for it is thanks to industry that composers today compose by means of electronic machines invented for industry's benefit but adopted by composers, with the assistance of engineers, for theirs.[175]

Unfortunately, Cahill's visions were too far ahead of their time in terms and not financially viable. The Muzak-like subscription model he had hoped to fund the Telharmonium with failed, and his company went bankrupt by 1918.[176] Varèse, meanwhile, would have to work with sirens and orchestral instrumentation to simulate the possibilities of this instrument until the 1950s, when Varèse would begin to work with magnetic tape, building up a library of recordings, beginning with his piece *Déserts*, which would include (somewhat ironically, perhaps) sounds from "iron mills, saw mills, and various other factories in Philadelphia."[177]

In his "credo" (1937's *The Future of Music: Credo*), American composer John Cage would echo Varèse, stating that "the use of noise to make music will continue and increase until we reach a music produced through the aid of electrical instruments which will make available for musical purposes any and all sounds that can be heard," and argue that "in the past, the point of disagreement has been between dissonance and consonance, it will be, in the immediate future, between noise and so-called musical sound."[178]

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[175] Louise Varèse, 50.

[176] *Ibid*, 255.

[177] Peter Manning, *Electronic and Computer Music*, 79.

[178] John Cage, *Silence: Lectures and Writings*, 3 – 4.

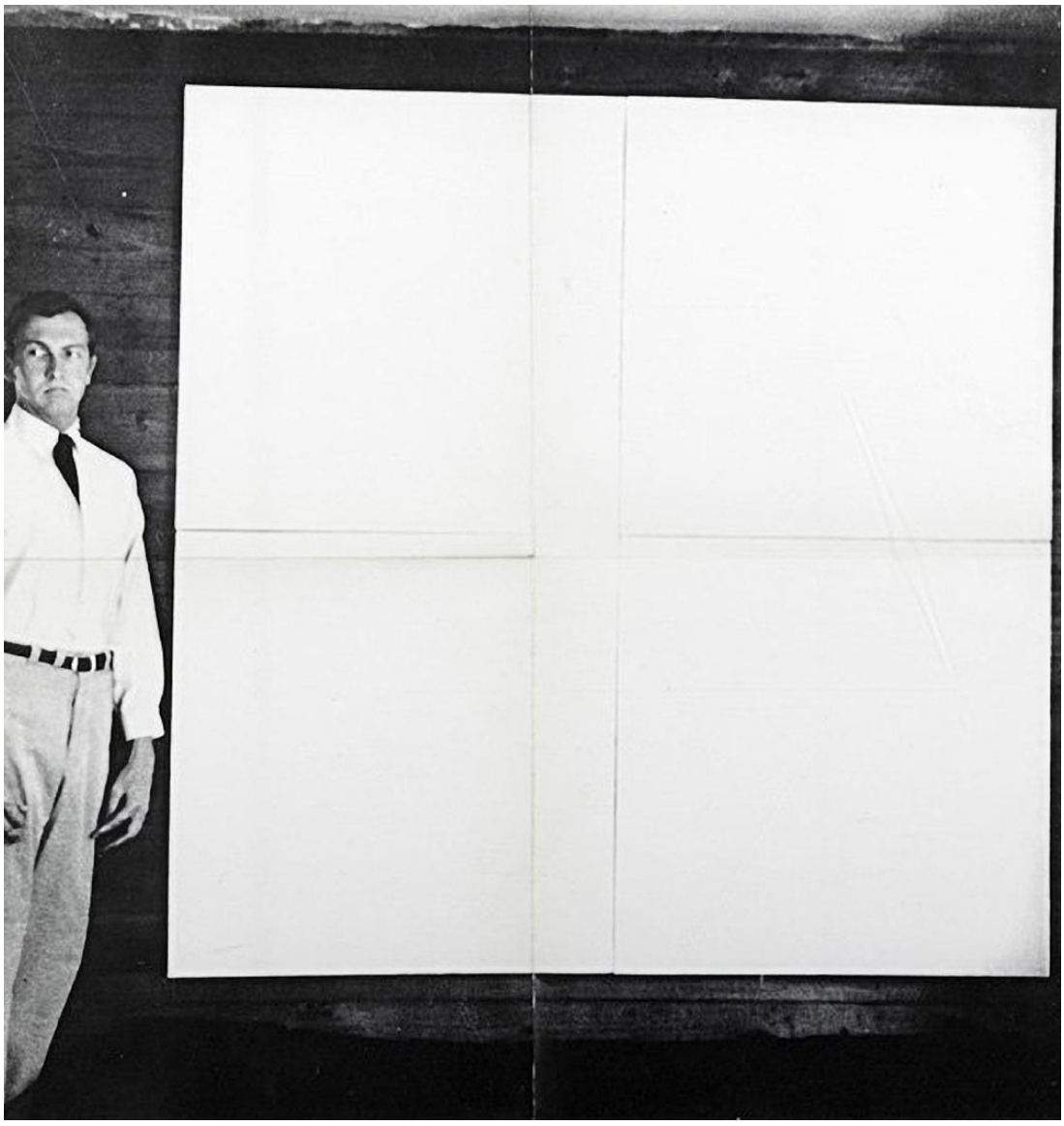

Figure 34. Robert Rauschenberg *White Paintings* Leo Castelli Gallery Invitation, 1951.[179]

This prediction would become reality through discussions of the works of Cage himself, perhaps most importantly, through his 1952 work *4′33″*. This piece is comprised of a simple set of instructions, which require the performer to be "tacet" (silent) for the three movements, whose combined time must total four minutes and thirty-three seconds. This piece was brought into being as a response to Robert Rauschenberg's white

[179] https://edwardkurstak.com/shop/white-paintings-by-robert-rauschenberg/

paintings in 1951 ("When I saw those, I said, 'Oh yes, I must; otherwise, I'm lagging, otherwise music is lagging…'"[180]), and his experience at Harvard's anechoic chamber:

> There is always something to see, to hear. In fact, try as we may to make a silence, we cannot. For certain engineering purposes, it is desirable to have as silent a situation is possible. Such a room is called an anechoic chamber, its six walls made of special material, a room without echoes. I entered one at Harvard University several years ago and heard two sounds, one high and one low. When I described them to the engineer in charge, he informed me that the high one was my nervous system in operation, the low one my blood in circulation. Until I die there will be sounds. And they will continue following my death. One need not fear about the future of music.[181]

This piece ushered into existence, almost single-handedly, the "idea that all sounds can be music."[182] In a concert hall performance of *4′33″*, this might equate to audience members shuffling around in their seats, clearing their throats, traffic passing by outside, dogs barking, and so forth—that is, quiet sounds that usually fall outside the scope of what is considered musical, but it also means confronting noises that may be unpleasant to audiences as well:

> I have always sought out loud sounds, when I can find them, and I have asked people to make them louder… most people run away from those situations. They put their fingers in their ears or protect themselves, something like that. I didn't find it necessary. The loudest one I think I heard was in a research center for architecture near London. They had a reverberation chamber, and I was able to hear very low sounds very, very loud. And I kept indicating I wanted it louder; finally, it was as though I was being massaged by the sound. It was quite a marvelous experience. Because the Japanese aesthetician, when I talked to him about hearing with the ears, you know, he said, "Remember that one can also hear with his feet."[183]

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[180] John Cage, Robert Shattuck, and Alan Gillmor, "Erik Satie: A Conversation," *Contact*, no. 25 (Autumn 1982), 22. Cited in Douglas Kahn, *Noise, Water, Meat: A History of Sound in the Arts*, 168.

[181] John Cage, *Silence: Lectures and Writings*, 8.

[182] *Ibid*, 226.

[183] John Cage, *Conversing with Cage*, 246.

Dick Higgins, student of Cage's at the New School in the 1950s (and prominent future Fluxus artist), seemed to be of the opposite opinion about Cage's acceptance of loud sounds; in Douglas Kahn's *Noise, Water, Meat: A History of Sound in the Arts*, the author recounts a story Higgins told him: "It was in the air in the late 1950s to consider the balances of sounds. The small sounds that John Cage tended to favor didn't seem complete to a lot of people. Many of us wanted sounds to have a real physicality that couldn't be perceived in the small sounds…"[184] As an answer, Higgins created his *Loud Symphony* (1958), which involved "correspondences between a simple line of gesture and the harsh pealing of speaker feedback… It was also an early example of what by now must constitute a genre of feedback pieces, including Steve Reich's *Pendulum Music* (1968), and innumerable noise works."[185]

The use of feedback and sound as a physical phenomenon have indeed become ubiquitous throughout musical practice since this time, ranging from the work of Jimi Hendrix to free improviser Derek Bailey ("an early and regular user of feedback as an essential component of his music… [he] would use extreme volume, but not dwell in it, and alternate between unamplified playings and scratchings and the power of the amplifier"[186]) and Alvin Lucier, whose work *Bird and Person Dyning* (1975) takes an interesting approach to the physicality of sound using feedback:

> I got this electronic bird in the mail once… I had this idea to put binaural mikes in my ears and to hear that bird, and to move my head and pan the sound of the bird around in space… I started the birdcall and I put the amplifier on, and I walked out into the room. And my volume was a little bit too high and I started to get feedback, and before I could run to the amplifier and stop the feedback I discovered that these beautiful interference patterns were occurring between the sounds of the birdcall and the strands of feedback… And so then I learnt to control the feedback

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[184] Douglas Kahn, 227.

[185] *Ibid*, 227 – 228.

[186] Paul Hegarty, *Noise / Music: A History*, 51.

and to search for places in a room where the feedback is such that it does cause these beautiful phantom images.[187] …[Because] of the disparity between the frequency range of the feedback and that of the birdcall, the phantoms must be some form of harmonically related beat frequencies caused by the interaction of a fixed frequency signal (feedback strand) and a search tone (birdcall). Whatever these phenomena might be called, including resultant tones, heterodyne components or inter-aural harmonics occurring only in the brain of the listener, the results are spectacular. Listeners can hear them vividly.[188]

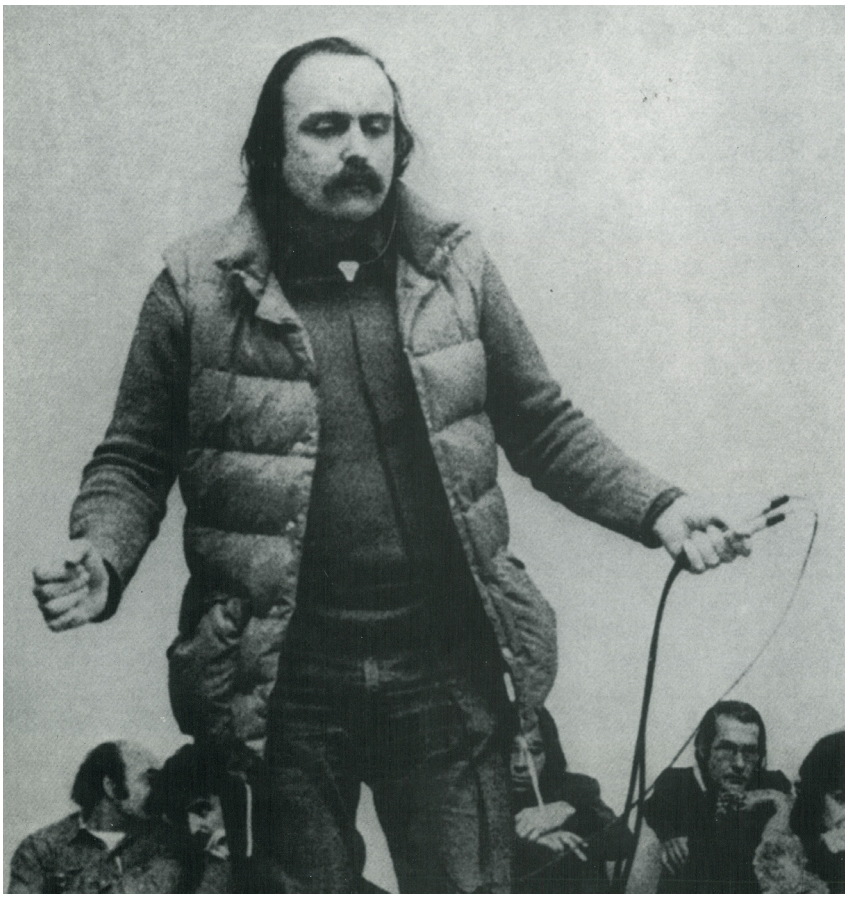

Figure 35. Alvin Lucier performing *Bird and Person Dyning*, ca. 1973.[189]

A performance of this piece "simply consists of the performer moving slowly around the space searching for phantoms," Lucier explains: "I usually move through the

[187] Alvin Lucier interviewed by Michael Parsons, "Beats that can Push Sugar" in *Resonance Magazine* vol. 4, no. 1. https://web.archive.org/web/20060208054446/http://www.l-m-c.org.uk/texts/lucier.html

[188] Alvin Lucier, "My Affairs with Feedback" in *Resonance Magazine* vol. 9, no. 2, 24.

[189] Alvin Lucier, *Bird and Person Dyning,* Cramps Records CRSLP 6111, LP. 33⅓ rpm, 1975.

audience, toward the birdcall and speakers, stopping briefly when I hear heterodyning. I tip my head from left to right, to fine tune the results and move them to various points in space. The spatial relationships between the binaural microphones and the loudspeakers determine the geographical locations of the phantom birdcalls."[190]

I have not witnessed a performance of this piece firsthand, so I cannot attest to the spatial nature of these phantom sounds, which Lucier describes as "[coming] from inside my head and at the same time… located in various parts of the room,"[191] but the recording of *Bird and Person Dyning*, released in 1976 by the Cramps Records label out of Altavilla Vicentina, Italy, is indeed a piece of striking beauty, though its high pitches might seem off-putting to some listeners, especially at high volumes. But as Cage once explained, "Some people object to loud sounds. They're afraid of hurting their ears… My attitude toward loud sounds has not changed. I shall listen to them whenever I get the chance…"[192]

In the late 1970s and early 80s, artists such as Throbbing Gristle and Whitehouse would take this approach to raw physicality of sound to its logical conclusion. Throbbing Gristle ("Yorkshire slang for an erect penis"[193]) arose from the ashes of the performance art group COUM Transmissions, whose *Prostitution* exhibition at the ICA in London included used tampons and nude photographs of COUM member Christine Newby, aka Cosey Fanni Tutti,[194] and earned them title "Wreckers of Civilisation" by conservative politician Nicholas Fairbairn.[195]

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[190] *Ibid*, 25.

[191] *Ibid*, 24.

[192] John Cage, "The Future of Music," in *Empty Words: Writings '73 – '78*, 177.

[193] Simon Reynolds, *Rip It Up and Start Again: Postpunk 1978 – 1984*, 128.

[194] Simon Dwyer, "Throbbing Gristle" in *RE/Search #4/5*, 62.

[195] Simon Reynolds, 128.

Figure 36. Throbbing Gristle, London, 1978.[196]

Throbbing Gristle, whose label Industrial Records would give "industrial music" its name ("If we had a royalty for every time the word 'industrial' was used, we'd be doing all right!"[197]), would go on to "investigate military research into the use of infrasound as a nonlethal weapon, where certain frequencies would trigger vomiting, epileptic seizures, and even involuntary defecation,"[198] and ultrasonic frequencies to target "some troublesome neighbours; according to the group, the neighbours' dogs began to bark and both people and animals exhibited aggressive irritability. Unsurprisingly, the unwanted neighbours moved shortly after the sonic attacks."[199] Performances by Throbbing Gristle

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[196] http://www.throbbing-gristle.com/tg-files/remasteredpromo.html

[197] Genesis P-Orridge, "Throbbing Gristle" in *RE/Search #6/7*, 16.

[198] Simon Reynolds, 128.

[199] Jack Sergeant, "Sonic Doom."

were extreme affairs, featuring not only "very high powered low frequency audio signal to make people do things that they wouldn't want to do—making people feel ill and dizzy"[200] but also "sadistic assaults" of lighting on their audiences: "convulsive strobes, high-power halogen lamps aimed in people's faces,"[201] and lyrics that reference totalitarianism and sexual depravity.

Figure 37. Whitehouse live in Hamburg, 1984, courtesy of Susan Lawly.[202]

In 1980, William Bennett would found his group Whitehouse, following in the footsteps of Throbbing Gristle's extreme live performances; Genesis P-Orridge has Whitehouse for having misunderstood their intentions: "The subtle distinction between the two groups was a thin line—between a neutral or ambivalent *presentation* of horror, atrocity, cruelty, and unambiguous and blatant reveling in evil."[203] Whitehouse proclaimed itself "the most brutal and extreme music of all time,"[204] and was the results of Bennett's attempts at "creating a sound that could bludgeon an audience into submission."[205] Using

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[200] Charles Neal, *Tape Delay: Confessions from the Eighties Underground*, p. 222.

[201] Simon Reynolds, 131.

[202] http://www.susanlawly.freeuk.com/picturefiles/whlive010.jpg

[203] Simon Reynolds, 135.

[204] Whitehouse, *Birthdeath Experience* (liner notes).

[205] Whitehouse, *The Second Coming* (liner notes).

sound as a means of domination, and trading in traditional tools of sadomasochism for loudspeakers and electronic equipment, this new aesthetic would come to be known as "power electronics," a term Bennett coined to describe Whitehouse's work,[206] whose performances involved Bennett "[screaming] things such as 'It's your right to kill, it's your fucking nature' and after roughly fifteen minutes of skull-splitting noise, crowd ruckus, flying bottles, and bloodshed, the police would usually arrive and pull the plugs."[207]

Meanwhile, in Japan, a burgeoning noise scene was also coming to the fore. Rising out of the "electronic futurism of 'New Japan'" in the 1980s and 1990s, artists like Hijokaidan and Hanatarashi "made an art out of destroying electronic gear on stage."[208] Hiroshige Jojo, the group's leader once said that he "loved the moment when Jimi Hendrix smashed the guitar—but the rest of his music is so normal."[209] Hijokaidan's performances stretched such moments to the duration of an entire performance, resulting in chaotic bath of noise and destruction in which group members "augmented their Noise by smashing up stage equipment, shattering floorboards, and attacking the audience with fire extinguishers."[210] Hanatarashi took such acts of destruction to an even more extreme conclusion, and in one legendary performance, even drove an abandoned backhoe into the Toritsu Kasei Super Loft venue in Tokyo:

> We got on this thing and rode it—bang!—through the doors of the hall. It'll spin a full 360 degrees, so we were spinning and driving through the audience, chasing them around, when suddenly there was this wall we spun into and opened a rather large hole in. The wind came blowing in. The shovel part got stuck in the hole and, trying to get out, we pushed a switch that started the tractor tipping up, like it was about to go over backwards… Nobody got hurt, but it cost us several thousand bucks to pay

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[206] David Novak, *Japanoise: Music at the Edge of Circulation*, 179.

[207] Simon Reynolds, 136.

[208] David Novak, 173.

[209] *Ibid*, 177.

[210] *Ibid*, 177.

for all the damage. We'd also broken the backhoe and had to pay for that… the place was all concrete walls and no windows. We smashed everything.[211]

Figure 38. Legendary Hanatarashi performance, 1985. Photo by Satoh Gin.[212]

The artist who would come to be most widely associated with this new sound emerging from Japan, however, is Masami Akita, also known as Merzbow. Taking his name from Kurt Schwitters' *Merzbau* (also known as *The Cathedral of Erotic Misery*), an architectural assemblage which, from 1923 – 1937, grew throughout his apartment and eventually "spread over the whole house… in the adjoining rooms, on the balcony, in two rooms of the cellar, on the second floor, in the attic…"[213]

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[211] *Ibid*, 177 – 178.

[212] *Ibid*, 178.

[213] John Elderfield, *Kurt Schwitters*, 222 – 223.

Figure 39. Kurt Schwitters' *Merzbau*, ca. 1930.[214]

In the 1980s, Akita became involved with the mail art network which "included home tapers like Maurizio Bianchi, Jupitter Larser of Haters, and Trax of Italy," recording tapes "very cheaply and then packaged them with pornography… [just as] Kurt Schwitters made art from objects picked up off the street, I made sound from the scum that surrounds my life."[215] Since these humble beginnings, Merzbow has become one of the most prolific noise artists alive, with over three hundred releases to his credit.

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[214] Elizabeth Burns Garmard, *Kurt Schwitters' Merzbau: The Cathedral of Erotic Misery*, xii.

[215] Chad Hensley, "The Beauty of Noise: An Interview with Masami Akita of Merzbow" in *Esoterra 8*, http://esoterra.org/merzbow.htm

Audiences in the United States would be introduced to his work and those of his contemporaries, initially through the home taping networks Akita was involved with, and then eventually through small record labels like Ron Lessard's RRRecords, who "simply transferred [the tapes'] contents to the retail-ready formats of LP and CD, which enabled the cassettes to enter a wider distribution of record stores."[216] Throughout the 1990s, the popularity of Japanese noise music would reach a fervor in America, with major record labels like Warner Brothers releasing albums by Eye Yamatsuka (formerly of Hanatarashi)'s Boredoms, and releases on larger "independent" labels like Zeni Geva, who appeared on Dead Kennedys' record label Alternative Tentacles, and Ruins, who appeared on both John Zorn's Tzadic label and Kramer (of Butthole Surfers and Bongwater fame)'s label Shimmy Disc. Many artists involved with Noise, however, thought that the culture was being unfairly represented: Eye Yamatsuka, for instance, insisted that "Boredoms was not Noise, just 'noisy.'"[217]

Compilations of what would come to be known commercially as "Japanoise" would frequently include "images of sexual bondage and physical violence," whether or not the artists represented on the compilations had no say in the use of this imagery.[218] Mikawa Toshiji of Incapacitants explains that "Misunderstandings spread like a wave," and Japanese artists were forced to "define themselves in relation to a 'Japanese Noise' scene"[219] that was, in many ways, more aligned with Power Electronics, than with the Noise scene in Japan. Merzbow, for example, explains that he arrived at noise not via power electronics or industrial music, but instead, through his introduction to free jazz and electroacoustic music: "I saw the Cecil Taylor Unit in 1973 and it was very influential... I became very

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[216] *Japanoise*, 210.

[217] *Ibid*, 14.

[218] *Ibid*, 90.

[219] *Ibid*, 89 – 90.

interested in the pulse beat of the drums within free jazz... I also became interested in electronic kinds of sounds... like Pierre Henry, Stockhausen, François Bayle, Gordon Mumma and Xenakis."[220]

More recently, a new movement known as "onkyo" or "onkyoei" has sprung up in Japan, coming full-circle to Cage's interest in "small" sounds. By using sounds that linger at the threshold of perception, both in terms of audibility and the frequency range of human hearing, artists such as Sachiko M, Otomo Yoshihide, and Toshimaru Nakamura "emphasize the sensuality of hearing"[221] with the utmost economy of means. "Silence within noise music," says author Paul Hegarty, "is not about awareness of musicality beyond the music, but about shock, anticipation, and testing limits that are not just about hearing endurance in terms of excess volume."[222]

Figure 40. Toshimaru Nakamura live at Instants Chavirés, 2012. Photo by Pablo Porlan.[223]

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[220] Chad Hensley.

[221] Joanna Demers, *Listening through the Noise*, 109.

[222] Paul Hegarty, 148.

[223] http://www.instantschavires.com/IMG/jpg/pabloporlan_instantchavires_05.jpg

Indeed, silence can often be more "difficult" for audiences than loud sounds, which, via cultural signifiers associated with Rock & Roll, signal that the audience should in fact be having "a good time," despite any misanthropy presented by the musical content itself. However, in a post-Cagean world, it is perhaps naïve to consider "silence" in musical performance as anything other than opportunities for extra-musical sounds to emerge, forcing contemplation of the performance situation, rather than an absence of sound.

An interesting response to this dilemma has emerged in recent years, from two very disparate sources: the Austrian composer Peter Ablinger's works with *Rauschen* (or "white noise"), and French "Harsh Noise Wall" artist Romain Perot, aka Vomir. Ablinger, a composer sometimes associated with "Wandelweisers" such as Antoine Beuger, Jürg Frey, and Michael Pisaro, defines *Rauschen* as "the totality of sounds—'everything always' in its acoustic representation. Comparable to white light that contains all colours, white noise contains all frequencies, and—poetically speaking—all music."[224] Rauschen, he continues, "therefore is maximum density, maximum information. But it is also the opposite: no information, maximum redundancy. For me it is less than nothing, less than silence."[225]

Vomir, though reaching the same end, arrives through a very different means: rather than through a response to Cagean silence, he is informed by the history of Noise, having been introduced to the works of artists such as Merzbow and Keiji Haino, and beginning to experiment with noise guitar in 1996, but setting it aside in favor of electronic noise generators in order to arrive at "a distinctive and recurrent sound in [his] mind that [he] wasn't able to recreate on guitar," eventually discovering the works of "[harsh noise wall pioneers] The Cherry Point and The Rita," who would release his first "HNW" album in 2006.[226]

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[224] Peter Ablinger, *Rauschen*, http://ablinger.mur.at/rauschen.html

[225] *Ibid*.

[226] Russell Williams, "Anti-Musicality: An Interview with Romain Perrot of VOMIR."

Vomir's recordings and performances are reductive to the extreme, featuring a singular, unchanging blast of noise: "As far as I'm concerned, a wall can never be described as a 'success…' A noise wall *exists* when the static noise is full, continuous and consistent from start to finish without alteration or fluctuations. That is what I'm interested in."[227] A Noise Wall, proclaims Perot, "is the physical loss of conscience… the uninterrupted practice of mental noise… the militant purity in not-representation."[228]

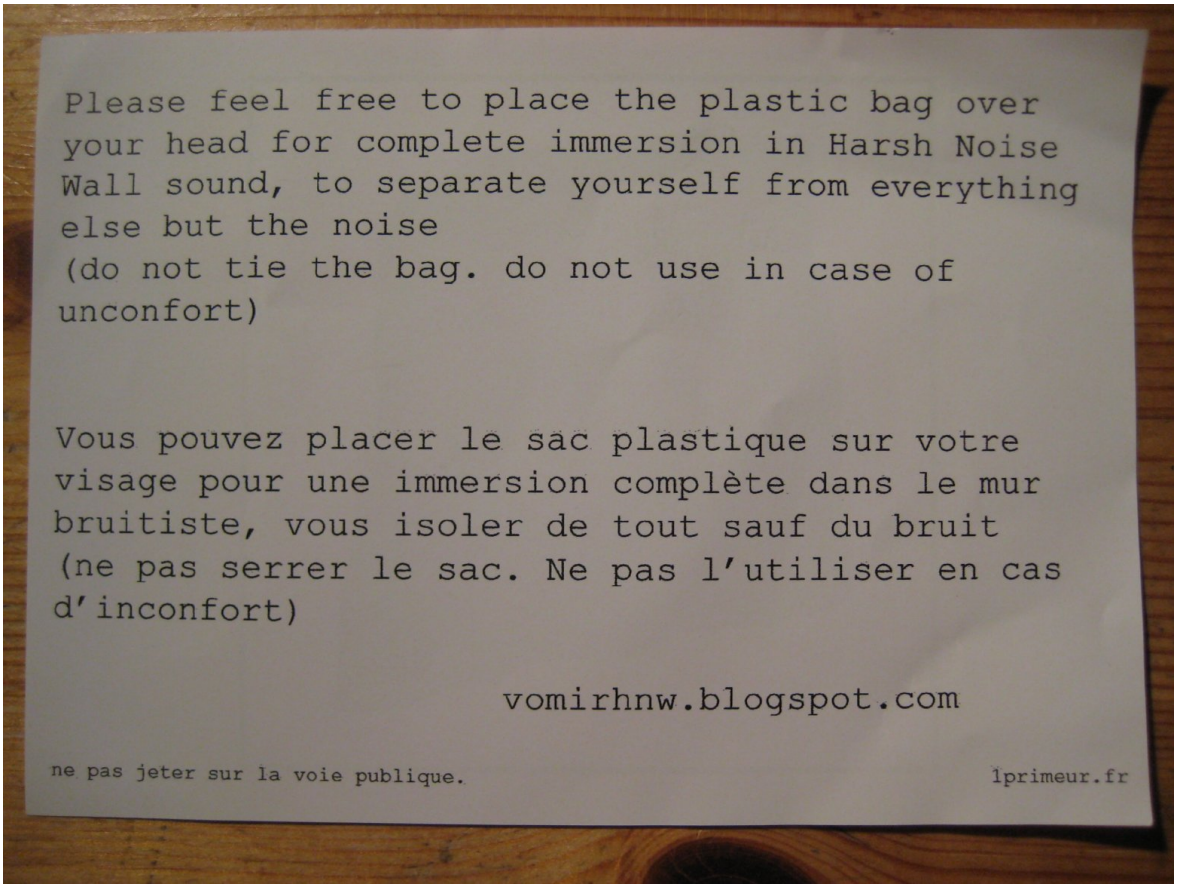

Figure 41. Audience instructions for Vomir performance at N.K. Projekt (Berlin), 2012.[229]

[227] *Ibid.*

[228] Romain Perot, *Manifeste du Mur Bruitiste*.

[229] https://bisaufsmesser.wordpress.com/2012/09/24/vomir/

CHAPTER 3: PROCESS

Structured Improvisation

My history as an improvisor is not rooted in conservatory training, nor in the study of traditional musical instrumentation, but rather in the practical application of electronics in an improvised setting with other improvisers. I have learned "on the job," so to speak, and more so than anywhere else, in the performance situations themselves. Cornelius Cardew once said that "improvisation cannot be rehearsed,"[230] and I have found this to be very much the case. What happens in "rehearsals" prior to a performance may have little or nothing to do with the actual performance, which is wrapped up in the moment.

> In 1968 I ran into Steve Lacy on the street in Rome. I took out my pocket tape recorder and asked him to describe in fifteen seconds the difference between composition and improvisation. He answered: 'In fifteen seconds the difference between composition and improvisation is that in composition you have all the time you want to decide what to say in fifteen seconds, while in improvisation you have fifteen seconds.' His answer lasted exactly fifteen seconds and is still the best formulation of the question I know.[231]

Early Mem1 performances would result from countless hours of rehearsals, which we would record and listen back to afterwards, each taking copious notes, then discussing these notes while skimming back through the recordings to highlight points of contention or to draw inspiration from in subsequent rehearsals. Over time, we would formulate a strategic plan for not only specific instructions for our roles within a given performance, but precise timings at which these roles would shift. This was essential for a "successful" performance, because achieving the desired results of our previously-agreed-upon progression for the performance relied upon my ability to capture certain sounds from Laura's output signal, my sole source material for live manipulation.

Over time, we became comfortable with the range of possibilities that might emerge from specific interactions, and it became unnecessary to rely upon timings. In

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[230] Cornelius Cardew, "Towards an Ethic of Improvisation."

[231] Frederic Rzewski, cited in Derek Bailey, *Improvisation: Its Nature and Practice in Music*, 141.

2008, we went on an East Coast tour with Providence-based guitarist Erik Carlson (aka Area C), and decided that, for the entirety of this tour, we would not have any preconceptions as to what should happen in a given performance. We would simply live in the shared moment, responding to each other's sounds, and allow our performances to unfold naturally. I can't say that all of these performances stand out as our greatest accomplishments, but they did allow us to leave behind some of our baggage, and forge a new path ahead in our performance practice.

Our current methodology falls somewhere between these two extremes: we will typically get together a few times before a given performance, and play without any preconceived notions of what should transpire. The Fraktur v.4 system is set to automatically record its output by default, to these rehearsals will be recorded. Depending on the amount of preparation time available prior to a given performance, we may take time to listen back to the recordings between rehearsals, or we may simply discuss what was successful immediately following a rehearsal. Over the course of a few rehearsals, we will gather together a pool of ideas to draw from in the performance, but do not specify an order of execution, or even agree upon which of these ideas will be pulled from the proverbial bag during the performance. They are simply possibilities that may or may not be realized in front of an audience. The one piece of the puzzle that we do tend to agree upon prior to the performance is its beginning: who will start, and with what—from that point onward, we are simply participants in a conversation, and we let it unfold as it may.

In solo performances, it is somewhat harder to maintain this attitude of living in the moment—the only person you are conversing with is yourself, and it's very easy for this conversation to devolve into questioning and self-doubt. I have tried multiple approaches to dealing with such issues, beginning with rigid structure.

For instance, *Pulse Shape 22*, my Master's thesis performance at Brown, was built on the foundation of data derived from nuclear weapons testing experiments. For performances of this piece, I was given an "energy level" to approximate sonically, and as the piece went along, it was necessary to keep an eye on a sort of graphical score, that would inform me of my current position within the piece, based upon a predetermined length of the performance.

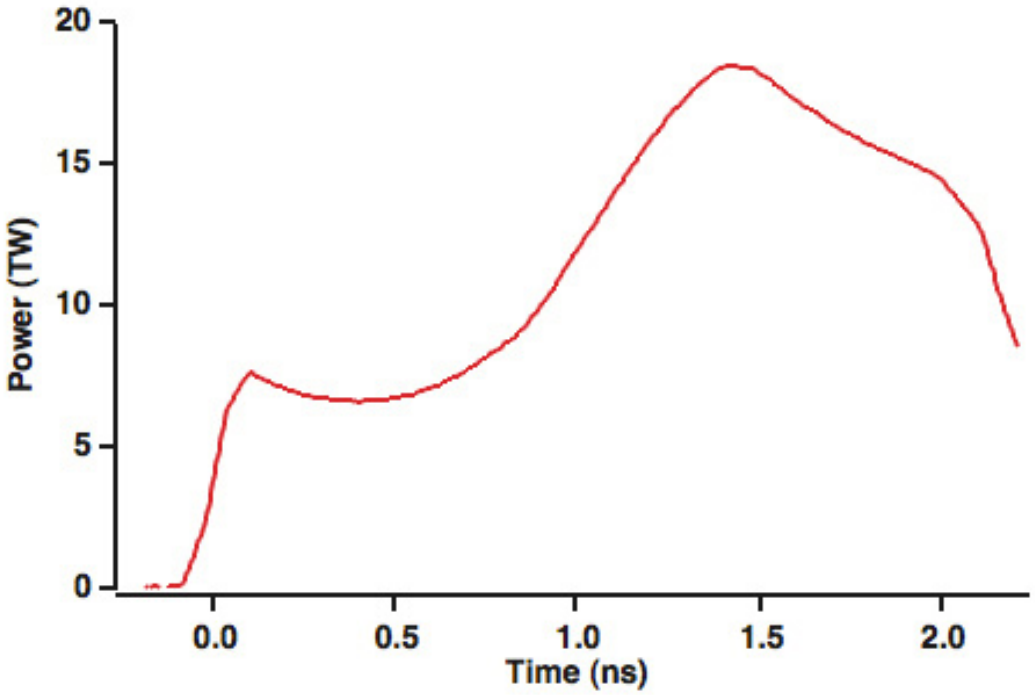

Figure 42. Energy accumulation data used as a graphical score for *Pulse Shape 22*.[232]

In some ways, this was comforting, as I was able to fall back on the score to tell me when to surge forward, or when to ease up. I could just keep an eye on the score and follow along. I never rushed ahead where I should not, and I never proceeded at a pace that was too leisurely. The score was always right—my job was simply to follow along.

[232] Los Alamos National Laboratory, "Tetrahedral Hohlraum High-Convergence Implosion Experiments on Omega ID4-FY98" (Rochester, NY, 1998), 7.

Figure 43. *Pulse Shape 22* performance, 2011. Photo by Laura Cetilia.

Unfortunately, over repeated performances of this piece, I began to find less and less inspiration: despite a sense of achievement in successfully realizing this score, I progressively became less invested in the moment. Performances became an act of labor, rather than of love. Perhaps Derek Bailey said it best: "Maintaining solo playing which becomes meaningful from an improvising point of view is an elusive business, not least because the easier it becomes to play solo the harder it becomes to improvise…"[233]

Alternative methods of dealing with structure have arisen in solo performances, in ways very much paralleling those in my work with Mem1. The focus of my solo practice sessions is not upon making decisions as to what a given performance will consist of, but rather, upon sharpening my skills and finding creative solutions and ways to deal with unexpected situations that may arise: "with solo improvisation, …there are definite

[233] Derek Bailey, *Improvisation: Its Nature and Practice in Music*, 112.

possibilities for practice. Not a pre-fixing of material nor preparing devices but something which deals with and, hopefully, can be expected to improve the ability to improvise."[234]

As with Mem1, the majority of my solo performances begin with an idea for a jumping-off point: either a simple patch on the modular synthesizer, an easily-programmable rhythm, a specific frequency chosen on a shortwave radio. However, these performances also begin with nothing pre-recorded, no wires pre-patched (apart from basic inputs and outputs), and the audience is given the ability to see the path open in front of them at the same time that I do. I do tend to have a few ideas I would like to hit upon in an evening, but I try to let the specifics of this unfolding path guide my actions, rather than forcing anything.

My dissertation performance was somewhat unique in that I did plan out a general arc, and it did begin with a handful of wires pre-patched. This was in fact the first (and so far, last) time that I have begun a performance with anything other than inputs and outputs pre-patched since introducing modular synthesis into my live performances back in 2009. Given the specific performance situation (an empty room with an indeterminate number people most likely arriving somewhat late), however, this seemed the most appropriate way to set the stage for the performance which was to ensue upon my entry into the room. Despite the fact that the general arc of the piece was preconceived, the details of its execution were left up to me to discover within the moment, through a sort of collaboration with a virtual performer: the Fraktur v.4 performance system itself.

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[234] *Ibid*, 110.

Interface as Composition

Using the Fraktur performance system, unlike a program like Ableton Live, for instance, or traditional hardware-based sequencers like my trusty old Akai MPC2000XL, it is not possible to simply call up pre-recorded material. All sounds are generated in real time, all rhythmic patterns defined by the performer in front of the audience without prior audition. In many ways, its interface can therefore be thought of as a composition[235]. It offers access to specific sonic possibilities, which may be arrived at through a process of patching, recording, and manipulation of specific parameters, and this process is indeed one that I have carefully sculpted through countless hours of use and modification over the past decade and a half.

The current version of Fraktur allows for a number of possible paths to be taken throughout the course of a performance, but all of these paths begin with an audio input of some variety. This input may be from another performer, as in the case of many Mem1 performances, or it may be from a shortwave radio, an oscillator within the modular synthesizer, or output from a drum synthesis algorithm elsewhere in the Fraktur v.4 ecology. In whichever case, I rarely choose to simply allow this sound to reach the physical audio outputs without first manipulating it in some way. Typically, this involves the process of sampling this input live, using either a looper, phase vocoder, or granulator, and then playing it back at a different pitch, speed, or bit depth, with specific frequencies being highlighted through the use of resonant state variable filters.

From this point, possibilities open up tremendously. Signals can be sent to the modular synthesizer for additional manipulation, fed back on themselves, or passed on for further manipulation via additional live samplers with different settings. Possibilities from

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[235] For more on this topic, cf. Norbert Schnell and Marc Battier, "Introducing Composed Instruments, Technical and Musicological Implications" in *Proceedings of the 2002 Conference on New Instruments for Musical Expression (NIME-02), Dublin Ireland, May 24 – 26, 2002.*

signals as simple as a single sine wave can quickly fan out in hundreds of possible directions, and my role as a performer is to rein in those possibilities, while drawing inspiration from the unexpected results that may emerge from the systems I create during a performance, based on a vocabulary and, perhaps, muscle memory, that I have shaped over the course of my history working with, and developing, this specific interface.

As detailed in the next section of this document, the Fraktur v.4 performance system is quite wide-ranging in its scope and abilities, but its functionality can be broken down into five primary components: live sampling and audio manipulation, signal generation using digital oscillators within SuperCollider, sequencing for both internal drum synthesis algorithms and voltages output to an analog modular synthesizer, gesture recording and playback for parameters throughout the entire Fraktur ecology, and signal generation and manipulation using analog modular synthesis techniques.

The application of techniques within these domains are interrelated, often requiring operation within multiple modes to generate interesting results. For instance, recording and playing back gestures associated with an inactive looper is unlikely to lead to interesting results, as is using live sampling techniques to manipulate a consistently silent input. However, passing a signal from the modular synthesizer to a phase vocoder, recording gestures associated with the functions available to that phase vocoder, then manipulating the ways in which those gestures are played back, is much more likely to generate results that are interesting, or at the very least, unexpected.

Given the constraints of this system, it is quite often the case that performances begin with "simple" systems that may be implemented quickly in front of an audience, but over time these systems grow in complexity and yield results that no one in the room (including, hopefully, myself) might have anticipated. This tendency follows a general strategy that was pointed out to me in a discussion I had with Paul DeMarinis during my

Master's studies at RISD, revolving around John Coltrane's performance of *My Favorite Things*, which begins simply enough with a statement of the theme, and slowly gets further and further away, to the point of unrecognizability. Giving a listener / audience member the ability to at least *think* that they understand what is happening at the beginning of a performance (whether this is actually true or not) makes the departure of this understanding more intriguing, or at least, more easily acceptable to a general listenership.

This strategy is also useful to me as a performer. In the moment of performance, systems may become tangled knots of wires and logic, and controls disappear in plain sight. Building layers of complexity upon a simple system throughout the duration of a performance—and then backing down in complexity to arrive at new, simple systems that could not have previously have been anticipated—can be very helpful in providing an intuitive road map during a performance. Likewise, switching between modes of operation can provide inspiration in moments at which I might become "stuck."

As Derek Bailey put it, solo performances lack "the more exciting, more magical side, which can only be discovered by people playing together."[236] Luckily, the Fraktur system also doubles as something of a virtual performer. Manipulating a new signal in manner that had been previously chosen based on the particular idiosyncrasies of prior source material may lead to new avenues of thought and exploration.

In a given Schaulust performance, for instance, I find myself moving fluidly between the generation of rhythmic patterns to manipulation of parameters associated with the drum synthesis engines which they activate, to using a modular synthesizer to manipulate these sounds and generate of related frequencies and rhythmic counterparts, to manipulation of the signals from the modular synthesizer using live sampling

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[236] Derek Bailey, *Improvisation: Its Nature and Practice in Music*, 112.

techniques, to recording parameters related to the live sampling playback, to manipulating these gestures…

This freedom to switch between modes of interaction with the Fraktur performance system gives me the ability to allow processes to run their course naturally. For instance, a simple 4 against 3 rhythm with a kick and snare can actually provide a lot of food for thought for an audience member, but it is very enticing to think of other rhythmic patterns that I could add to make this more interesting. Perhaps instead, it might be more interesting to vary the timbre of the kick drum slightly, or adjust the "damping" of the snare drum; recording the gestures associated with these changes, and shifting their playback slightly could result in unexpected emphases that would lead to new ideas for rhythmic patterns that I would not have come to otherwise. Allowing these sorts of processes to influence my playing is what allows me to maintain interest and motivation in a solo performance, where it might otherwise be lacking. I look forward to adding new features to this system to allow for even more unexpected twists and turns—and we'll return to those ideas in the final chapter, but first, let's have a look at the possibilities afforded by the current Fraktur v.4 ecology.

CHAPTER 4: THE WORK

Fraktur v.4 Performance System

The current iteration of the audio portion of my performance system, Fraktur v.4, is a hybrid analog / digital performance system built using SuperCollider, modern "Eurorack" format analog synthesis modules, and a handful of controllers.

Figure 44. Fraktur v.4 performance system.

As a performer of improvised music, I have come to appreciate the incredible flexibility given by the interface of analog modular synthesizers, which allow for live "patching," i.e. re-routing of audio and control signals in real time. This allows me to drastically alter my "patches" in response to collaborators and other stimuli. Real-time patching, then, has become my primary "instrument." In addition to this flexibility, analog modular systems also provide access to an overwhelming number of circuits that are often difficult to emulate with digital tools. However, modular synthesizers are limited in many regards, notably as related to physical space and cost of materials. I have therefore found it

helpful to offload many of these processes to a computer, controlled primarily via a Vestax VCM-600 USB MIDI Controller, to allow for more complex results while retaining the flexibility of the modular synthesizer interface in a relatively inexpensive and portable performance system.

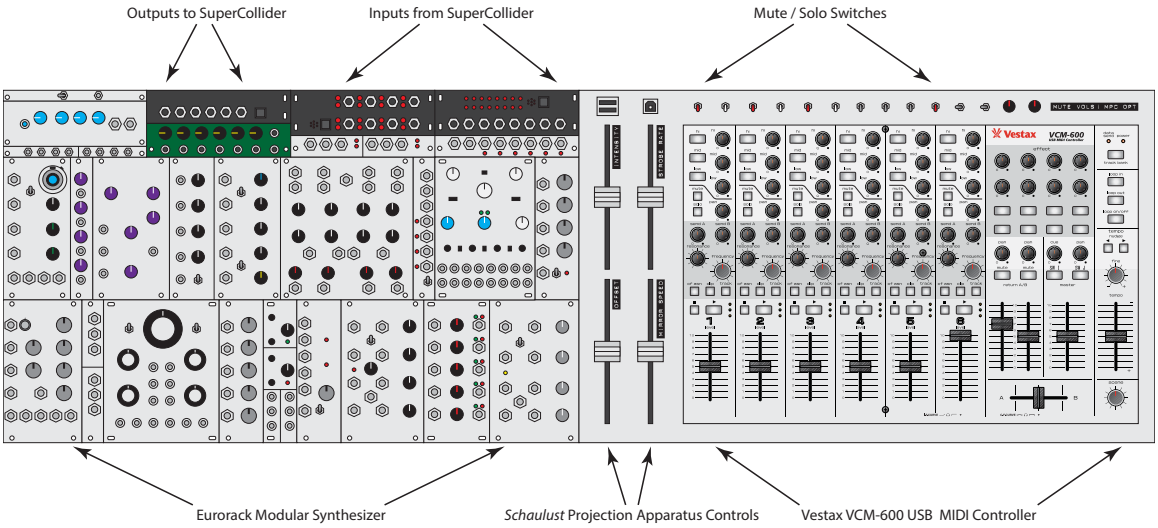

Figure 45. Overview of Fraktur v.4 performance system.

I do not propose that my efforts are necessarily unique in any way—hybrid analog / digital systems date back to the 1980s, with devices such as the Buchla 300 (1983), which allowed control of analog synthesizers through digital means[237], as well as digital samplers such as E-Mu's Emulator II (1984), which featured analog filters, envelopes and VCAs controlled by digital means.[238] However, such systems are now rare, relatively expensive and difficult to maintain. What I propose instead is the generation of a hybrid analog / digital system that utilizes current technologies: easily-obtainable Eurorack modules in conjunction with the (Free / Libre / Open-Source) SuperCollider programming language / environment.

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[237] Buchla and Associates, "Buchla Series 300: Digital Control for 200 Series Modules," 1.

[238] E-Mu Systems, "E-MU Systems: Product History," 1.

In examining the SuperCollider (or "SC") application's structure, it is important to note that SuperCollider is comprised of five components:

1. an audio server
2. an audio programming language
3. an interpreter for the language, i.e. a program able to interpret it
4. the interpreter program as a client for the server
5. the application including the two programs and providing mentioned functionalities[239]

The primary distinction here, as well as the most confusing one, perhaps, is the distinction between the Client and the Server. Much like a web server, which serves data living somewhere on the internet to a user's browser (which we'll call the client) when requests are made, SuperCollider "serves" audio based on the Client's requests as they are sent to the Server. The Server is often referred to as the "scsynth" and the Client as "sclang," or informally, as the "synth" and "lang."

The Client consists of an interpreter, which generates and sends requests that the Server understands (using the Open Sound Control protocol), based on the decidedly more readable SuperCollider programming language (though you can send these sorts of commands directly to the Server yourself if you're a glutton for punishment). The Client need not reside on the same machine as the Server—requests may be made from within the SuperCollider application itself using the programming language, from another application on the user's computer, or from another computer through the network, either locally or remotely.

SuperCollider ships with two distinct Servers: the "internal" server and the "localhost" server. The internal server runs within the SuperCollider application, while the localhost server runs as a separate process.[240] Since the localhost server runs separately

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[239] SuperCollider 3 documentation contributors, "Client vs Server" in *SuperCollider Guides*, 1.

[240] SuperCollider 3 documentation contributors, "SuperCollider 3 Server Tutorial" in *SuperCollider Tutorials*, 1.

from the language, it is more robust: "if the language app crashes, it (and thus possibly your piece) will continue to run."[241] However, this independence comes with a slight degree of latency,[242] and certain objects, such as the Scope (which allows users to view a graphical representation of the sound stream in real time), only work in conjunction with the internal server.[243] For the purposes of the Fraktur v.4 performance system, I have elected to use the internal server to allow for the least possible latency.

SuperCollider is an object-oriented programming language, and "all entities inside a program are some sort of object."[244] Integers (e.g. 5), floating-point numbers (3.96), individual characters ($x), Strings ("hello"), Symbols (\hello or 'hello'), Arrays (["hello", \hello, 3.96, 8]), Functions ({ "hello".postln; }), and Classes (the Integer class itself) are all objects. As in other object-oriented programming languages, there are "classes," such as the Integer class, and "instances" of those classes, such as the number 5,[245] and all functionality within the digital portion of the Fraktur v.4 performance system is obtained through custom classes I have built in the SuperCollider language.

In order to get sound out of SuperCollider, the Server must first be booted. As the server boots, a number of messages will be displayed in the Post Window, letting the user know that the Language has compiled properly, and describing various properties of the audio engine—the number of inputs and outputs, sample rate, block size, and so forth.

In SuperCollider, objects that are used to generate or process audio or control signals are known as Unit Generators, or UGens.[246] SuperCollider includes a vast library

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[241] SuperCollider 3 documentation contributors, "Server" in *SuperCollider Classes*, 1.

[242] SuperCollider 3 documentation contributors, "Client vs Server" in *SuperCollider Guides*, 1.

[243] Charles Céleste Hutchins, "Introduction" in *How to Program in SuperCollider*, 1.

[244] Iannis Zannos, "Programming in SuperCollider" in *The SuperCollider Book*, 128.

[245] *Ibid*, 128 – 129.

[246] SuperCollider 3 documentation contributors, "UGen" in *SuperCollider Classes*, 1.

of UGens, which are used inside of instances of the SynthDef class. For instance, there is a UGen known as SinOsc which may be used to create a sine wave. This UGen may be used at audio rate by sending the SinOsc UGen the message ".ar" or at control rate through the use of the message ".kr," followed by any desired arguments that the SinOsc object understands. For example: SinOsc.ar(200) will create an audio-rate sine wave oscillating at 200 Hz. Given the SinOsc UGen as an example, the default arguments are a freq of 440, a value of 0 for phase (a value between 0 and 1 representing the phase offset within the sine wave's cycle) , a value of 1 for mul (a constant multiplier for the output of the SinOsc UGen—in this case, acting as a volume adjustment), and a value of 0 for the add argument (a constant added to the signal output by the SinOsc UGen, acting here as a DC offset).

However, simply executing the code SinOsc.ar(200); is not enough to get SuperCollider to output the sound of a sine wave at 200 Hz. The SinOsc UGen must be included as part of a synthesizer definition, or "SynthDef," which is added to the Server, and then played using a new instance of a Synth object. The simplest way to do this is through the use of the Function.play convenience method[247]:

```
{SinOsc.ar(200)}.play;
```

This creates a temporary "autonamed" SynthDef, and creates a running Synth that uses this SynthDef to create an audio signal.[248] In order to be more explicit about this, a user can create a reusable SynthDef:

```
// first create the SynthDef:
SynthDef(\simple_oscillator, {
        Out.ar(0, SinOsc.ar(200));
}).add;

// then create an instance of the SynthDef:
x = Synth(\simple_oscillator);
```

---

[247] SuperCollider 3 documentation contributors, "Function" in *SuperCollider Classes*, 1.

[248] David Michael Cottle, "Beginner's Tutorial" in *The SuperCollider Book*, 22.

This code embeds the SinOsc within an instance of the Out object, allowing the signal to stream to the first ("left") channel of the computer's audio interface. Replacing the 0 with a 1 will stream the SinOsc's output to the second ("right") output of this interface. The second arguments to Out.ar is a variable named "channelsArray." This is important to note, as UGens implement what is known in SuperCollider as "multichannel expansion": if an array is passed as the second argument to Out.ar, it will output as many channels as are found in the array. For example, replacing the call to Out.ar(0, SinOsc.ar(200)); with Out.ar(0, [SinOsc.ar(200), SinOsc.ar(300)]); will cause SuperCollider to output a sine wave at 200 Hz from the left channel of the audio interface as well as a sine wave at 300 Hz from the right channel. Since all UGens are capable of multichannel expansion, this could be accomplished just as easily by passing an array of frequency values to the SinOsc UGen: Out.ar(0, SinOsc.ar([200, 300])).

SynthDefs may also take arguments with or without values assigned—if no values are assigned, they default to 0; the arguments' values may also be changed in real time:

```
(
	SynthDef(\dual_osc, {
		arg freq1 = 100, freq2 = 200;
		Out.ar(0, SinOsc.ar([freq1, freq2]));
	}).add;
)

// make an instance w/o overriding the default values
x = Synth(\dual_osc);

// now change the values:
x.set(\freq1, 300);
x.set(\freq2, 500);

// stop the Synth and "free" it from the server:
x.free;

// create a new instance w/ default values overridden:
y = Synth("dual_osc", [\freq1: 300, \freq2: 500]);
y.free;
```

Multiple instances of a Synth can be called at any given time—e.g. assuming that the "dual_osc" SynthDef has been added to the Server, three separate instances can be creaded by executing the three following lines of code:

```
x = Synth(\dual_osc, [\freq1: 100, \freq2: 200]);
y = Synth(\dual_osc, [\freq2: 300, \freq2: 400]);
z = Synth(\dual_osc, [\freq1: 500, \freq2: 600]);
```

Since SuperCollider simply adds the audio signals to each each other, the more instances of the SynthDef that are playing concurrently, the more the signal "clips." To avoid this, signals may simply be multiplied by the inverse of the number of SynthDef instances:

```
(
	SynthDef(\no_clip, {
		arg freq1 = 100, freq2 = 200, vol = 1;
		Out.ar(0, SinOsc.ar([freq1, freq2]) * vol);
	}).add;
)

(
	// make three instances at 1/3 volume each:
	x = Synth(\no_clip, [
		\freq1: 100, \freq2: 200, \vol: 0.33
	]);

	y = Synth(\no_clip, [
		\freq1: 300, \freq2: 400, \vol: 0.33
	]);

	z = Synth(\no_clip, [
		\freq1: 500, \freq2: 600, \vol: 0.33
	]);
)

// now change the values:
x.set(\freq1, 400);
x.set(\freq2, 700);

// stop the Synths and "free" them from the server:
x.free; y.free; z.free;
```

Here is an example of a basic oscillator, implemented as a custom class:

```
Basic_Oscillator {

	var	<> freq,
		<> vol,
		osc;

	*new {
		arg	freq = 400,
			vol = 1;

		^super.newCopyArgs(
			freq,
			vol
		).init;
	}

	init {
		osc = SinOsc.ar(freq) * vol;
		^osc;
	}
}
```

The custom class must start with the name of the class (in this case, Basic_Oscillator), followed by the names of the variables used within the class. In this case, there are two variables: "freq" and "vol." When declaring these variables, one may define whether or not they can be viewed outside of the class, as well as whether or not they can be changed outside of the class. If the variable is to be viewed outside of the class, the author of the class must add a "<" symbol prior to the name of the variable (the arrow points to the left, hinting that the data can go out). If the variable is to be able to be changed from outside of the class, the author must add a ">" symbol prior to the name of the variable (the arrow points to the right, hinting that data can come in). If the data held in the variable is to be able to be viewed as well as changed, the author may simply use both symbols, as in the case of the "<> freq" and "<> vol" variables in the example above.

If the variables are to remain "private," as in the case of our "osc" variable, this may be accomplished simply by omitting both the "<" and ">" symbols.

When an instance of the custom class is created, the "*new" method is called. If there are arguments that should be set from outside of the class, the author should create the "args" and declare their default values . Once the arguments have been declared with default values, a new instance of the class is created, and the values from the arguments passed along to the "init" method. The "init" method is where all the heavy lifting happens (though other "helper" methods can be created as necessary). In this case, the "osc" variable will output the result of a sinewave oscillator running at a rate set by the "freq" variable multiplied by the value of the "vol" variable (thus setting the volume). A carat ("^") followed by the value to be returned is used to pass the output of the Basic_Oscillator back to the line of code from which it was called. In order for the Basic_Oscillator to be used, it must be saved as a SuperCollider Class file (using the name of the class) somewhere that SuperCollider can find it. This is typically in a user's home directory, under "Library -> Application Support -> SuperCollider -> Extensions."

Files stored in this directory are compiled upon startup, but the class library may also be recompiled by selecting "Library -> Recompile Class Library" from the menu at the top of the screen, or by clicking [Shift] + [Cmd] + L. Once the library has been compiled, custom classes may be utilized within SuperCollider programs. For example:

```
(
	SynthDef(\basic, {
		arg freq = 400, vol = 1;
		Out.ar(0, Basic_Oscillator(freq, vol));
	}).add;
)

x = Synth(\basic);
```

In this example, the Basic_Oscillator class has been utilized within the SynthDef, in much the same way as any other object within the SuperCollider programming language. You may notice that this class does not have separate implementations for audio rate and control rate versions; this would require creating what is known as a Pseudo UGen, which references the UGen class as a "parent" class. For further discussion on the topic of Pseudo UGens, please refer to Dan Stowell's "Writing Unit Generator Plug-ins," Chapter 25 in *The SuperCollider Book*.

Fraktur v.4

The core of the Fraktur v.4 platform is the Fraktur4 object, which is called upon to create instances of all other necessary objects. A Fraktur4 object is instantiated by selecting a single line of code in the SuperCollider programming environment:

```
z = Fraktur4(rec: 1, channels: 4, inputs: ["doepfer"], use_strobe: 1);
```

Once this line of code is run, SuperCollider takes care of setting up the physical inputs and outputs for audio and control signals, allocating buffers, creating SynthDefs and sending data to an OpenFrameworks application used as a graphical user interface for the software. In order to simplify matters, I have created a number of copies of the SuperCollider application, each with a different Fraktur4_Startup file contained in the SCClassLibrary directory for use in different performance scenarios. These Fraktur4_Startup files simply contain a call to instantiate the Fraktur4 object according to the needs of the given project.

In the example above, the *rec* variable determines whether or not to begin recording multichannel audio files automatically (yes, in this case), the *channels* variable determines the number of audio channels (quad, stereo, or mono), the *inputs* variable is an array comprised of strings associated with audio inputs used (in this case, just the

modular synthesizer; other options include “cello” for Mem1 performances, “mpc” for integration with an MPC2000XL sequencer, and so on), and the *use_strobe* variable, which determines whether or not SuperCollider should send data to the Schaulust projection apparatus.

The Fraktur4 class utilizes a number of SynthDefs for audio and control voltage input, manipulation, and output, defined at startup. From the viewpoint of user interaction, the Fraktur4 class may be broken down into six workspaces.

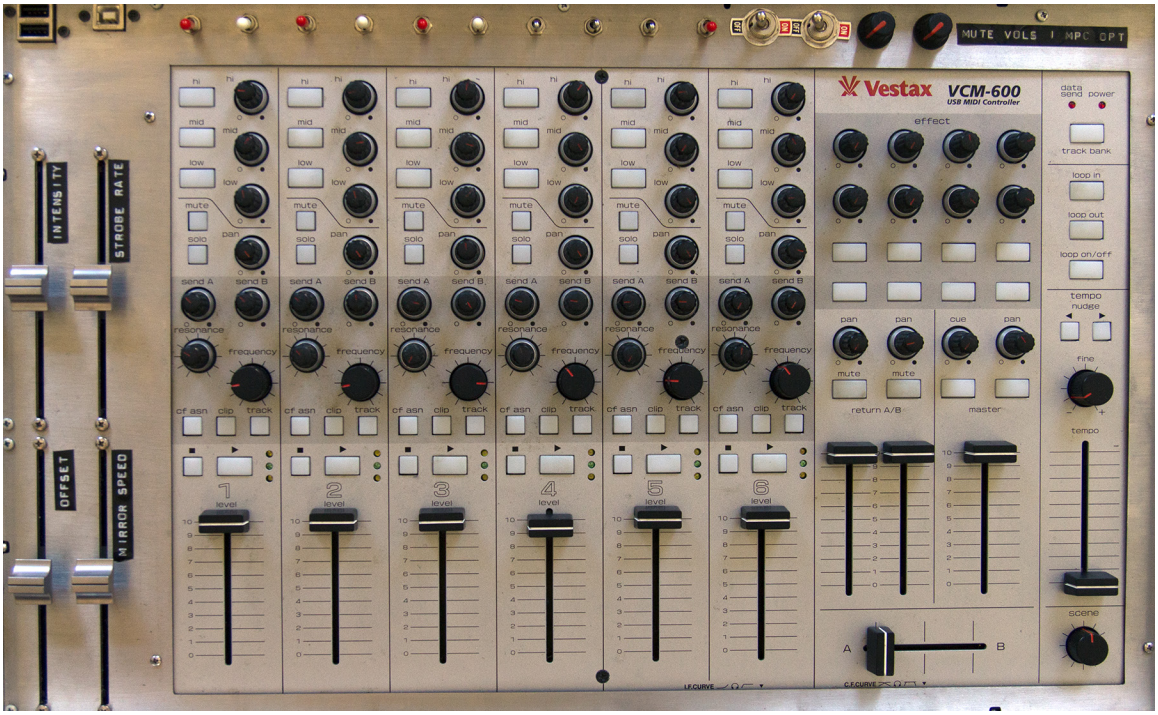

Figure 46. Vestax VCM-600 and surrounding controls.

The first two workspaces, shown in Figure 46 above, are comprised of the controls found in the six channels on the left side of the Vestax VCM-600, and are defined by the state of the *track_bank* button in the upper right: The first *track_bank* consists of controls over audio parameters, while the second consists of controls over a number of step sequencers that output voltages to the analog modular portion of the Fraktur performance system, as well as a number of SynthDefs used for synthesis of drum sounds. The third

workspace, also shown in Figure 46, is comprised of the controls surrounding the VCM-600, which are used to set parameters of the lighting system, mute / solo states, and levels associated with audio signals sent over optical connections.

Figure 47. Akai LPD8 and Korg NanoKontrol2.

The fourth and fifth workspaces, shown in Figure 47, are currently found in the form of two separate control surfaces: an Akai LPD-8 drum pad / knob controller, which is used to control a custom drum sequencer, and a Korg Nanokontrol2 fader box, which is used to control a gesture recorder and playback engine, though I have begun initial steps towards combining these two functions into a single controller, the Pioneer DDJ-SP1. The final workspace, as shown in Figure 48, is comprised of the "master" controls to the right of the six numbered channels on the VCM-600; these controls may be used for a number of functions, depending on the currently selected channel to the left or mode of operation defined through various buttons contained in this section itself.

A detailed per-channel breakdown of Fraktur v.4 controls accessible via the VCM-600 USB Midi Controller may be found in *Appendix E*, and may serve as a helpful reference as you continue reading this chapter, as may the block diagram for the entire Fraktur v.4 ecology, found in *Appendix F*.

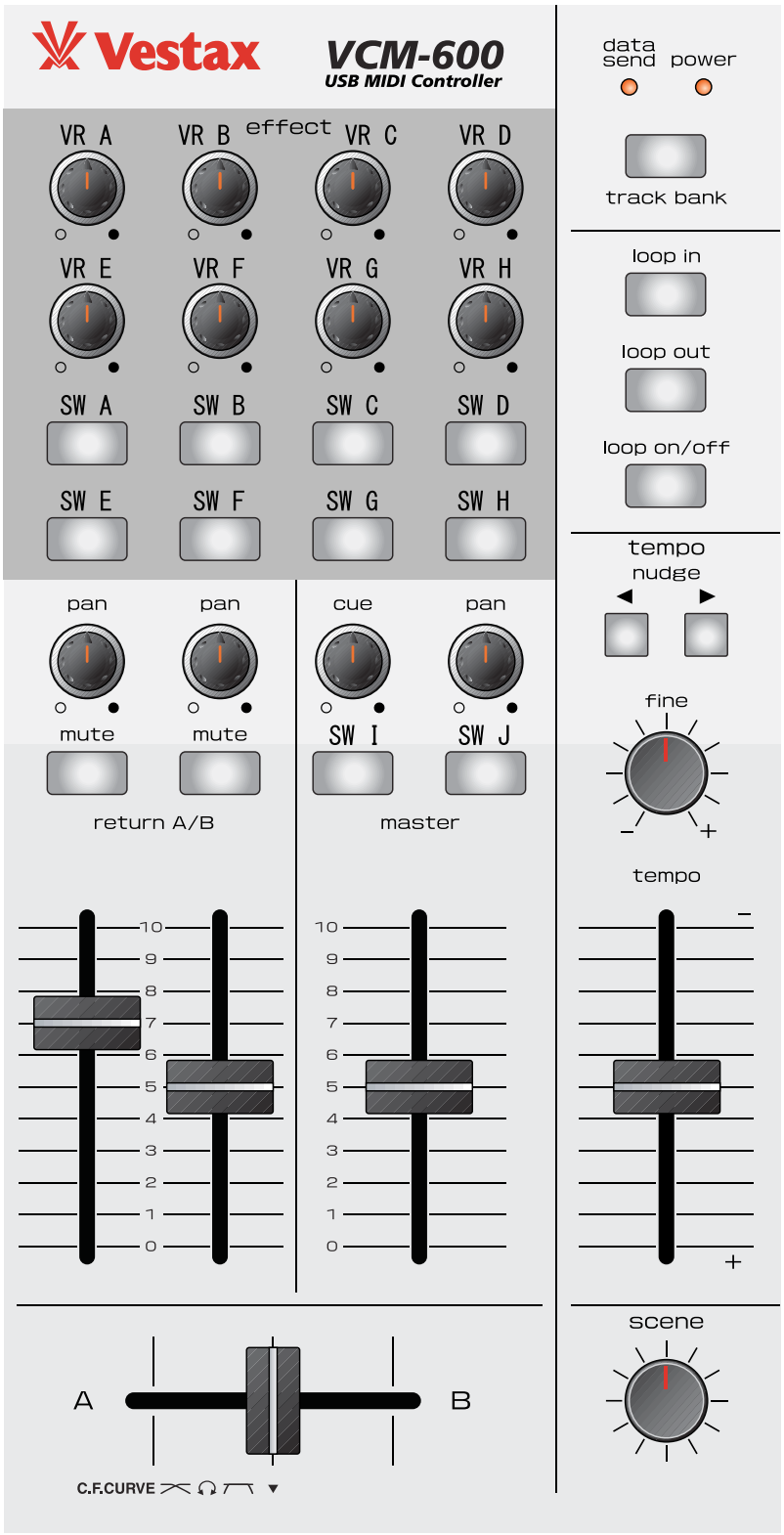

Figure 48. "Master" controls section of the VCM-600.[249]

[249] *Vestax Multitrack Remix Controller VCM-600*, 21.

Fraktur4_Looper

The first four channels found in the first *track_bank*, shown in Figure 49, are all implementations of a single class: the Fraktur4_Looper. Each is comprised of an instance of the Fraktur4_Looper_Recorder class, which handles buffer recording, an instance of the Fraktur4_Looper_Player, which handles buffer playback, and an instance of the Fraktur4_Channel_Effects class, which allows for the application of various effects to the output of the looper.The Fraktur4_Looper_Recorder allows a user to record dynamic-length loops, or loops of pre-determined, or "fixed," length (to allow for easy synchronization of beat-based music) and is capable of overdubbing into previously-recorded buffers.

Through the use of its feedback parameter, sounds may slowly fade out or increase in volume over repeated iterations. A user may also choose to record from the beginning of the loop, or to pick up from where they left off recording into the buffer most recently (this is only noticeable in fixed-length mode or when overdubbing in dynamic recordings).The Fraktur4_Looper_Player class handles playback of recorded audio within bounds of the start and endpoints chosen by the user. It also allows the user to play the buffer in reverse and change its playback speed, and outputs the current playback position to allow for purposes of auto-panning in stereo or quadraphonic space.

Figure 49. An example of the controls for a Fraktur4_Looper.[250]

[250] *Ibid.*

In addition to these "buffer-munging" features, Fraktur4_Looper also features a number of "channel effects" hosted in the Fraktur4_Channel_Effects class: time domain granular pitch shifting using SuperCollider's PitchShift class, bit-rate reduction using SuperCollider's Decimator class, lowpass, bandpass, and highpass filtering using SuperCollider's SVF class, and reverb using my Fraktur4_Reverb class.

The Fraktur4_Reverb class is based on AdCVerb class from IXI Software[251] in conjunction with Eli Fieldsteel's *Infinite Hold Reverb*.[252] The core of the Fraktur4_Reverb class is comprised of eight parallel allpass filters, whose outputs are fed both to the output and back to the input, based on the desired amount of feedback within the "circuit." Before passing the incoming signal into the allpass filter, it is passed to a filter to limit (or not, as determined by the user) the energy of higher frequencies, to allow for a more natural (and less metallic-sounding) decay over time, and then fed into a comb delay line with linear interpolation. The feedback loop itself features soft clipping via SuperCollider's softclip method available to any audio signal.

The Fraktur4 object features four instances of the Fraktur4_Looper class, each of which may be controlled individually, and are capable of being spatialized in stereo or quadraphonic space in one of two ways: By default, each Fraktur4_Looper is passed a random panning position on the X axis of a quadraphonic soundfield when it is instantiated within an instance of the Fraktur4 object. The sound will then automatically pan on the Y axis over the course of two cycles of the loop's playback: first from front to back, then from back to front. For stereophonic mixes, the loops simply auto-pan from left to right and back again over the same amount of time. A user may also choose to set

---

[251] For more information, cf. David Bausola, Enrike Hurtado and Thor Magnusson, "ixiQuarks - version 7."

[252] For more information, cf. Eli Fieldsteel, "Infinite Hold Reverb in SuperCollider."

the position within the quadraphonic soundfield using a Magic Trackpad, and record their motions within this space using the gesture recorder previously mentioned.

Figure 50. Apple's *Magic Trackpad*.[253]

Fraktur4_Pvoc

In addition to traditional time domain based manipulation of audio buffers, the Fraktur performance system also features manipulation within the frequency domain. Four phase vocoders are made available using the Fraktur4_Pvoc class, which on the surface, operates very similarly to the Fraktur4_Looper class, but allows the pitch and playback speed to be controlled independently via SuperCollider's PV_BufRd and PV_BinShift classes. The Fraktur4 object features four instances of the Fraktur4_Pvoc class, each with a different number of "frames," allowing for a greater variety of sonic possibilities. With a higher number of frames, the results will be more accurate in terms of pitch, but less accurate in terms of timing. Likewise, with a lower number of frames, the results will be more accurate in terms of timing, but less accurate in terms of pitch; the four sizes utilized are 1024, 512, 256, and 128 frames.

[253]http://manuals.info.apple.com/en_US/Magic_Trackpad_UG.pdf

Fraktur4_Oscillators

The Fraktur v.4 ecology includes three separate oscillator types: The first (Fraktur4_Oscillator1) utilizes a digital emulation of a "triangle core" oscillator with variable cycle via SuperCollider's VarSaw class, while the second (Fraktur4_Oscillator2) utilizes a digital emulation of a sine wave oscillator via SuperCollider's SinOsc class, and the third (Fraktur4_Oscillator3) utilizes SuperCollider's VOsc class for wavetable synthesis.

There are two instances of Fraktur4_Oscillator1 and Fraktur4_Oscillator2, and a single instance of Fraktur4_Oscillator3. Each of these classes features three instances of the corresponding oscillators; the first and third may be "spread" from the central frequency to allow for a "thicker" sound; as they are spread in frequency, they are also spread in space using SuperCollider's Pan2 class. These classes also feature two low frequency oscillators or "LFOs" with variable width and amplitude.

In the case of Fraktur4_Oscillator1 and Fraktur4_Oscillator2, these LFOs may be used to change the central frequency of the class' three oscillators, and the first LFO affects the frequency of the second. Additionally, there is a "feedback" control for each of these LFOs, determining how much of its output is fed back into the first LFO's frequency control. In the case of Fraktur4_Oscillator3, the LFOs are used separately to control not only the frequency of the oscillator, but also its phase, the position (or "index") within the wavetable, and the specific wavetable selected; the controls used for feedback in the Fraktur4_Oscillator1 and Fraktur4_Oscillator2 are utilized for setting the starting values for index and wavetable selection. The output of each of these classes is then routed through an instance of the Fraktur4_Channel_Effects class for further processing.

Fraktur4_Accumulator

The combined signals from all Fraktur4_Loopers, Fraktur4_Pvocs, Fraktur4_Oscillators, and desired amounts of synthesized drum sounds and external sound sources, are passed on the source material for manipulation in three separate Fraktur4_Accumulator objects. A Fraktur4_Accumulator is identical to a Fraktur4_Looper, except that it records into and plays back four separate buffers, which maintain the same spatialization within the quadraphonic sound field as when recorded. This allows for counterpoint between moving and "frozen" versions of the signals with different types of manipulation applied.

Fraktur4_Granulator

The combined signals from all Fraktur4_Loopers, Fraktur4_Pvocs, Fraktur4_Oscillators, and Fraktur4_Accumulators, as well as the desired amounts of synthesized drum sounds and external sound sources, are fed into a Fraktur4_Granulator_Recorder and stored in a buffer which is then manipulated via a Fraktur4_BMSwarmGranulator. The Fraktur4_BMSwarmGranulator class is a real-time granulator based on the BMSwarmGranulator granulation engine developed by Scott Wilson at the University of Birmingham, which features spatialization based on the classic "boids" flocking algorithm, and is an incredibly full-featured, user-friendly, and wonderful-sounding granulator.[254] The output of the Fraktur4_BMSwarmGranulator is then routed through an instance of the Fraktur4_Channel_Effects class for further processing.

Figure 51. Fraktur4_Granulator controls.[255]

[254] For more information, cf. Scott Wilson, "Spatial Swarm Granulation."

[255] *Vestax Multitrack Remix Controller VCM-600*, 21.

Fraktur4_Controller

Mapping of physical controls found in the first *track_bank* and many controls associated with the drum synthesizers found in the second *track_bank* of the Fraktur performance system are defined in the Fraktur4_Controller class. This is perhaps one of the most complex classes within the entire Fraktur4 ecology, as it not only distributes the data from external controllers to points throughout every module, but also keeps track of which loopers are currently active within a given channel and makes sure that the output of the Magic Trackpad and other controls found in the "master" control section to the right of the first six channels do not get re-distributed to a new channel without the user's desire.

Routing Buttons

The buttons labeled *low*, *mid*, and *hi* at the top left of a given channel determine the routing of the rest of the controls in that channel.

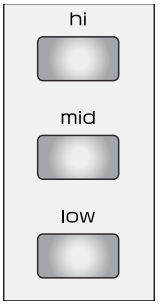

Figure 52. Routing buttons[256]

Within the first *track_bank*, the *low* buttons on Channels 1 – 4 activate controls for the Fraktur4_Loopers, the *mid* buttons on Channels 1 – 4 activate controls for the Fraktur4_Pvocs, and the *mid* buttons on Channels 1 – 4 activate controls for Fraktur4_Oscillators. Three Fraktur4_Accumulators are found on Channel 5; the Fraktur4_BMSwarmGranulator is controlled by parameters associated with the *low* button

[256] *Ibid*.

on Channel 6, while the controls associated with the *mid* and *hi* buttons are used to set attributes of SynthDefs used for drum synthesis. SynthDefs for individual drum sounds are associated with the Channels 5 and 6 within the second *track_bank*. In Channel 5, the *low* button activates controls for a kick drum, the *mid* button a boomier, sub-bass kick, and the *hi* a combination clave and rim shot, depending on the desired mode of operation. In Channel 6, the *low* button activates controls for a snare drum, the *mid* button a hi-hat with variable amounts of open- or closed-ness, and the *hi* a clap. *Low* buttons are selected as defaults for each channel, so upon the initial launch of the application, controls are routed to the Fraktur4_Loopers, the first Fraktur4_Accumulator, and the Fraktur4_Granulator in the first *track_bank*, and kick drum and snare SynthDefs in the second *track_bank*.

When *low*, *mid* or *hi* buttons are pressed, an LED behind the button lights up to show that this instance is actively receiving control data. If more than one routing button is lit, incoming control messages will be passed to multiple destinations. For example, if a user is to bring down the *level* fader at the bottom of the channel after activating *hi*, *mid*, and *low* buttons, the volume will be brought down for all three audio sources associated with that channel. Deselecting all controls allows a user to reset the positions of other controls without concern for "jumping" to a new position that was not anticipated. A user may also use a shortcut to avoid audition while setting controls to a new position: simply pressing the *scene* button down will temporarily disengage the output of any other controls from the VCM-600 (apart from special cases affiliated with Fraktur v.4's step sequencers, as we shall see later).

Filter Type Buttons

Throughout the first *track_bank* and drum synthesizers found in the second *track_bank*, buttons labeled *mute* and *solo* below the routing buttons select the type of filter applied to the channel, which is indicated by the light state of the LEDs behind these two buttons.

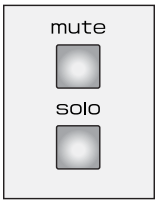

Figure 53. Filter Type buttons.[257]

If neither the *mute* nor the solo button is lit, the SVF filter will be of a lowpass variety. If either the *mute* or *solo* button is lit, the SVF filter will be of a bandpass variety. If both the *mute* and *solo* buttons are lit, the SVF filter will be of a highpass variety. It is worth noting that three SVF filters are actually active in each instance of a Fraktur4_Channel_Effects object, allowing for smooth and natural crossfading between filter types: a user must glide through a bandpass filter in order to get from a highpass to a lowpass filter, or vice-versa.

Filter Controls

The state variable filters found throughout the first *track_bank* and drum synthesizers found in the second *track_bank* are controlled through the use of Apple's Magic Trackpad via Batuhan Bozkurt's MultiTouchPad Quark. This object allows a user to gather and store information from the Magic Trackpad, and can be used to keep track of multiple concurrent gestures. I am using this object simply to gather where on the x and y axes of the Magic Trackpad a user's finger is currently located. When the user touches the Magic Trackpad, the touchAction method of the MultiTouchPad is triggered. While the user is interacting with the Magic Trackpad, the setAction method of the MultiTouchPad is

[257] *Ibid.*

updated, and the location on the x axis used to set the state variable filter's cutoff frequency, while the y location sets its resonance. When the user releases his or her finger from the Magic Trackpad, the untouchAction method of the MultiTouchPad is triggered. I am using the touchAction method to determine which Fraktur4_Looper, Fraktur4_Accumulator or Fraktur4_BMGranulator receives the data throughout a given interaction: the most recently used channel receives the data). As long as the user does not remove his / her finger from the trackpad, the filter controls are applied to this channel. Once a user releases his / her finger from the Magic Trackpad and touches it again, the most recently used channel will begin receiving the data.

This allows the user to control parameters of other loopers, accumulators or the granulator while still maintaining control over the filter of one channel. This is especially convenient when recording into an accumulator: the user may perform a filter sweep on a given looper, and record the resulting sounds into an accumulator. Using the Magic Trackpad instead of a MIDI controller to set the cutoff frequency and resonance of the filter allows for much higher precision control over these variables. I have also added functionality to allow for these controls to be set via OSC using multitouch surfaces, and often utilize my iPhone as a controller rather than the Magic Trackpad, using a custom Fraktur4Win application, which I will discuss in greater depth below.

Volume and Gain

As in most mixing consoles, the fader at the bottom of the channel (labeled *level*) sets its volume, and the knob at the top (labeled *hi*) sets its gain. Volume is simply mapped linearly to values between 0 and 1, as the VCM-600 features an *if_curve* knob which controls the curve of the *level* faders within the unit itself. Gain is mapped exponentially to values between 0 and 20 using SuperCollider's built-in lincurve with a curve of 4, and

are used in Fraktur4_Channel_Effects. It is worth noting that the volume parameter is not used at the end of the chain, but is instead used to set the input volume of the Fraktur4_Reverb, after the application of all other effects. This allows the reverb to be "rung" by turning up the channel momentarily to send a short burst of sound into the reverb "circuit." This is the case throughout the entire first *track_bank*, as well as for the drum synthesizers found in the second *track_bank*.

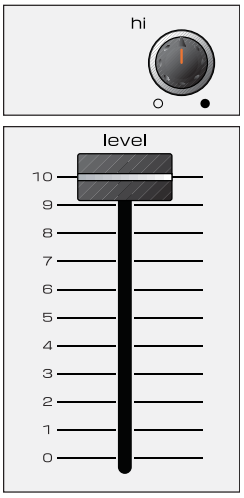

Figure 54. Volume and Gain controls.[258]

Start- and Endpoints

The knobs just below the gain are used to control the start- and endpoints within a given Fraktur4_Looper_Player or Fraktur4_Accumulator_Player.

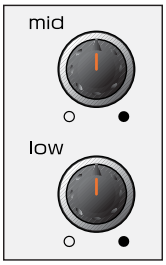

Figure 55. Start- and Endpoint controls.[259]

[258] *Ibid.*

[259] *Ibid.*

The *mid* knob controls the endpoint, and is divided into eight equally-spaced control value ranges, each of which gets smaller by a power of two. At the far right end of the knob, the value would be 1 (thus the full length of the loop is played back), the next step down would be 0.5 (thus only playing back half of the loop's length), 0.25, and so on down to 0.0078125 (or 2^{-7}). The *low* knob selects the startpoint, which is linearly mapped from an incoming MIDI value between 0 and 127 to a value between 0 and 1. This creates an offset within the looper, allowing a user to "scrub" through the buffer or loop a specific portion of the buffer as desired. Care has been taken to ensure that the offset will never allow a user to go beyond the limits of the loop length as defined by the endpoint; for example, if the length of the loop defined by the endpoint is 0.5, and the user "scrubs" beyond 0.5, the startpoint will never advance beyond halfway through the loop's length. Likewise, if the endpoint is set to a low value and the startpoint is later in the loop, say 0.0078125 for the endpoint and 0.75 for the startpoint, and the user changes the endpoint to a larger value, say 0.5, the perceived startpoint will move backwards to 0.5. This is accomplished through a handful of logical conditions in the Fraktur4_Controller class.

Abstracted out from its context, the conditions for the *mid* knob look like this:

```
temp_end_amt = 2.pow((scaled * 7).round - 7);
temp_max = 1;

temp_dest = dest + (num_channels * states[dest].selected);
temp = states[temp_dest].real_start + temp_end_amt;

if (temp >= temp_max, {
    temp_end = temp_max;
    this.looper_set(dest, \end, temp_end);
    this.state_set(dest, \end, temp_end);

    temp_start = temp_max - temp_end_amt;
    this.looper_set(dest, \start, temp_start);
    this.state_set(dest, \start, temp_start);
}, {
    this.looper_set(dest, \end, temp);
    this.state_set(dest, \end, temp);
```

```
        this.state_set(dest, \end_amt, temp_end_amt);
        this.looper_set(dest, \start, states[dest].real_start);
        this.state_set(dest, \start, states[dest].real_start);
    });
```

while the conditions for the *low* knob look like this:

```
    temp = scaled + states[dest].end_amt;
    temp_max = 1;
    temp_dest = dest + (num_channels * states[dest].selected);

    if (temp >= temp_max, {
        temp_end = temp_max;
        this.looper_set(dest, \end, temp_end);
        this.state_set(dest, \end, temp_end);

        temp_start = temp_max - states[temp_dest].end_amt;

        this.looper_set(dest, \start, temp_start);
        this.state_set(dest, \start, temp_start);
        this.state_set(dest, \real_start, scaled);
    }, {
        this.looper_set(dest, \start, scaled);
        this.state_set(dest, \start, scaled);
        this.state_set(dest, \real_start, scaled);

        this.looper_set(dest, \end, temp);
        this.state_set(dest, \end, temp);
    });
```

The looper_set method handles setting variables within the Fraktur4_Looper or Fraktur4_Accumulator, while the state_set method holds the current state of a Fraktur4_Looper or Fraktur4_Accumulator within an instance of a Fraktur4_Channel_State object for later recall and comparison.

Bitrate Reduction

The knob just below the startpoint knob labeled *pan* is used to control the amount of bitrate reduction throughout the first *track_bank* and drum synthesizers found in the second *track_bank*.

Figure 56. Bitrate Reduction control.[260]

This control is mapped exponentially from the incoming MIDI value between 0 and 127 to a value between 0 and 1 using SuperCollider's lincurve method available to any instance of a SimpleNumber class.

Feedback

The next two knobs down, labeled *send A* and *send B* are dedicated to feedback controls for Fraktur4_Loopers and Fraktur4_Accumulators. The knob labeled *send A* sets the feedback amount prior to any processing, while *send* B sets the feedback amount post-processing.

Figure 57. Feedback (Pre, L) and Feedback (Post, R) controls.[261]

Fine Tune

The knob labeled *resonance*, is used for fine tuning when a Fraktur4_Looper or Fraktur4_Accumulator is recording into the buffer with overdubbing enabled. The knob's is scaled linearly from incoming MIDI values between 0 and 127 to values between 0 and 1.2. This allows the user to increase the volume of previously recorded material on each successive playback. As in the Fraktur4_Reverb mentioned previously, the resulting signal

[260] *Ibid.*

[261] *Ibid.*

is passed through SuperCollider's softclip method, which is available to any audio signal, to ensure that the buffer does not contain a signal that has been digitally distorted or "hardclipped."

Figure 58. Fine Tune control.[262]

Playback Rate

The knob just below *send B*, labeled *frequency*, is used to set the amount of rate of playback for the buffer.

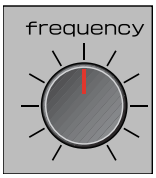

Figure 59. Playback Rate control.[263]

The values are scaled exponentially to values between 2^{-7} and roughly 2^{7}. The exact procedure is 2.pow((val + 1).linlin(0, 128, 7, -7))), thus allowing the center point of the knob (MIDI value 63) to act as an unaltered playback rate. If the Fraktur4_Looper or Fraktur4_Accumulator is set to fixed length record mode (see below), the playback rate is split into thirteen equally-spaced control value ranges between 2^{-7} and 2^{7} via the following operation: 2.pow((scaled * 13).round - 7)).

[262] *Ibid.*

[263] *Ibid.*

Dynamic / Fixed Length

The button labeled *cf asn* is used to set whether a given Fraktur4_Looper_Recorder or Fraktur4_Accumulator_Recorder is to use a fixed length (by default, 8 seconds) for the scaling operations when recording or playing back loops (helpful for beat-based music), or is to keep track of the amount of material recorded into a buffer to determine the length of the loop dynamically. If the button is not lit (the default behavior), the length is dynamic; if it lit, it is fixed.

Figure 60. Dynamic / Fixed Length button.[264]

Append Mode

The button labeled *clip* is used to set whether a given Fraktur4_Looper_Recorder or Fraktur4_Accumulator_Recorder is to start recording at the beginning of the buffer, or to append new material to the buffer beginning at the point at which the user stopped recording most recently. As previously mentioned, this is only noticeable in fixed-length mode or when overdubbing in dynamic recordings.

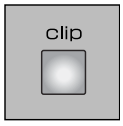

Figure 61. Append Mode button.[265]

[264] *Ibid.*

[265] *Ibid.*

Reverse

The button labeled *track* is used to set whether a given Fraktur4_Looper_Player or Fraktur4_Accumulator_Player is to play back its buffer normally (default) or in reverse. Pressing the button will engage or disengage the LED behind it; a lit LED means that it is playing in reverse.

Figure 62. Reverse button.[266]

Record / Overdub

The final two buttons on each channel are demarcated by a square and a right-facing triangle. The button on the left, demarcated by the square, will glow red when selected; this button is used to turn on / off recording in a given Fraktur4_Looper_Player or Fraktur4_Accumulator_Player. The button on the right, demarcated by a right-facing triangle, will glow green when selected, and is used to turn on / off overdubbing in a given Fraktur4_Looper_Player or Fraktur4_Accumulator_Player. In order for overdubbing to take place, the record button must also be engaged. This allows a user to turn on or off overdubbing without concern for disrupting the current recording "cycle," and also means that a user can set the overdub state without actively recording into the buffer.

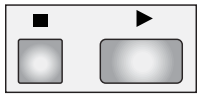

Figure 63. Record / Overdub buttons.[267]

[266] *Ibid.*

[267] *Ibid.*

Fraktur4_Granulator

The sixth channel of the VCM-600 is used to control the parameters of the Fraktur4_BMSwarmGranulator. A number of these controls (gain, volume, filter type, bitrate reduction and feedback) are identical to their counterparts on the first five channels; others have different functionality as afforded by the BMSwarmGranulator engine. The differences in functionality are noted below.

Granulator Duration and Offset

The knobs labeled *mid* and *low*, used for setting start and endpoints in the first five channels, are used to update the duration and offset parameters of the BMSwarmGranulator respectively. The scaling is basically identical as in the first five channels, although they are four times greater, as the BMSwarmGranulator expects values in terms of seconds, and the buffer used in this case is four seconds long.

Figure 64. Fraktur4_Granulator controls.[268]

Granulator Pitch

The knob labeled *send A*, used for controlling the time domain granular pitch shifting in the first five channels, is used in this case to set the pitch attribute of the BMSwarmGranulator rather than to control an instance of an external PitchShift object. As in the other channels, this control is mapped from a MIDI value between 0 and 127 to a value between 0.015625 and 2.

[268] *Ibid.*

Figure 65. Granulator Pitch control.[269]

Granulator Mix

The knob labeled *send B*, used for controlling the mix between the original signal and time domain granular pitch shifting in the first five channels, is used to set the mix between non-granulated signal and granulated signal. This is simply a linear mapping from a MIDI value between 0 and 127 to a value between 0.5 and 1; if the knob is all the way to the left, both signals will be heard (assuming that the volume is up on the granulator); if it is all the way to the right, only the output of the Fraktur4_BMSwarmGranulator is heard.

Figure 66. Granulator Mix control.[270]

Granulator Stretch

The knob labeled *frequency*, used for controlling the playback rate in the first five channels, is used to set the stretch parameter of the BMSwarmGranulator.
Its values are scaled inversely to the procedure found in the playback rate of a dynamic length looper: 2.pow((val + 1).linlin(0, 128, 7, -7))). The stretch parameter of the BMSwarmGranulator determines the relative length of playback of a buffer: a value of 1

[269] *Ibid.*

[270] *Ibid.*

means to play back the buffer at the normal speed, while a value of 2 means to take twice as long, and 0.5 means to play it in half the time. Thus, turning the knob all the way to the left means to take 128 times as long as the original recording to play back. Given that the buffer used in the Fraktur4_Granulator_Recorder is four seconds long, it would take over eight minutes to play back the buffer in its entirety at this speed. At the far right side of the knob, it would take 0.03125 (or 2^{-5}) seconds to play back the entire buffer. I have enabled looping in the duration of a SynthDef used to play back grains in the BMSwarmGranulator to allow for a continuous stream of sound when the stretch parameter is set to a value below 1.

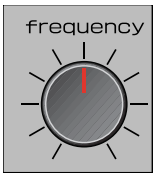

Figure 67. Granulator Stretch control .[271]

Disabled Granulator Controls

The Fraktur4_Granulator_Recorder incorporated into the Fraktur4_BMSwarmGranulator constantly records new material into a fixed-length buffer that is always four seconds in length; the Fraktur4_Granulator_Recorder is also capable of overdubbing. Therefore, the buttons found on the first five channels that enable or disable recording, overdubbing and appending, or select between dynamic and fixed length recording modes, have been disabled. Each grain in the BMSwarmGranulator is always played forwards, so the reverse feature has also been disabled.

[271] *Ibid.*

Additional Granulator Controls

The knobs labeled *VR D* and *VR H* in Figure 48 ("Master" controls) are used to control additional granulation parameters. The knob at the top, *VR D*, is used to control the delay parameter of the BMSwarmGranulator, corresponding to the delay time in seconds between each grain in a stream; this parameter defaults to 0 seconds, or a constant stream of grains. The MIDI values are mapped exponentially between 0 (at the far left side of the knob) and 30 seconds (at the far right) using SuperCollider's built-in lincurve method with a curve of 8. The lower knob, *VR H*, is used to control the delRan parameter of the BMSwarmGranulator. This value corresponds to a random amount of delay between each grain, and defaults to 0 seconds. The mapping here is the same as in the previous control: exponential from 0 to 30 seconds with a curve of 8.

Master Controls

There are a number of controls in the "Master" channel to the right of Channel 6. These are divided between controls for step sequencers found in the second *track_bank*, global input / output settings, and reverb / granulator parameters.

Input Volume

The faders labeled *return A* / *B* are used to control the volume of inputs to the most recently selected Fraktur4_Looper, Fraktur4_Accumulator, or Fraktur4_Granulator from external sound sources such as the "doepfer" (*return A*) "cello" (*return B*) if the corresponding *mute* buttons above them are disengaged. If the *mute A* button is engaged, the *return A* fader will control the volume of the input to the most recently selected Fraktur4_Looper, Fraktur4_Accumulator, or Fraktur4_Granulator from the *drum1* audio bus, containing a mix of kicks, sub-bass kicks, and claves / rimshots; the *mute B* button

causes the *return B* fader to control the input volume of this channel from the *drum2* bus, containing a mix of snares, hi-hats, and claps. These values are mapped exponentially to values between 0 and 1 using SuperCollider's built-in lincurve method with a curve of 4.

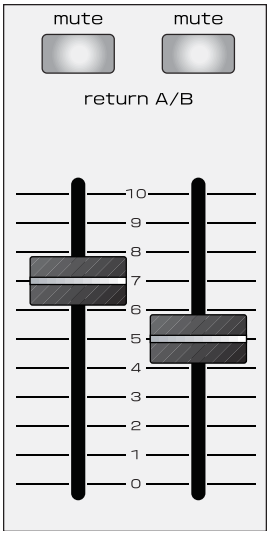

Figure 68. Input Volume controls.[272]

External Input Playthrough Volume / Gain

If the *mute A* button is disengaged, the *pan A* knob is used to control the playthrough volume of the analog modular. If the *mute B* button is disengaged, the *pan B* knob is used to control the gain of the "cello" input. If the *mute A* button is engaged, the *pan A* knob will control the playthrough volume of the *drum1* audio bus, which contains a mix of kick drums, sub-bass kicks, and claves / rimshots, while engaging the *mute B* button will cause the *pan B* fader to control the playthrough volume of the *drum2* audio bus, which contains a mix of snares, hi-hats, and claps. All values mentioned here are mapped exponentially to values between 0 and 1 using SuperCollider's built-in lincurve method with a curve of 4.

[272] *Ibid.*

Master Volume

The fader labeled *master* is used to control the volume of the final mix. If the button directly to the above left of the *master* fader is selected, the *master* fader is used to control the input volume of the most recently selected Fraktur4_Looper, Fraktur4_Accumulator, or Fraktur4_Granulator from the drums associated with the LPD8 pad controller (as well as the inputs on the first two channels, assuming "mpc" is in the array of values associated with the *inputs* argument to Fraktur4); if the button directly to the above right of the *master* fader is selected, it controls the input volume of the most recently selected Fraktur4_Looper, Fraktur4_Accumulator, or Fraktur4_Granulator from the third and fourth analog inputs from the audio interface (assuming "tx" is in the array of values associated with the *inputs* argument to Fraktur4). This value is mapped exponentially to values between 0 and 1 using SuperCollider's built-in lincurve method with a curve of 4.

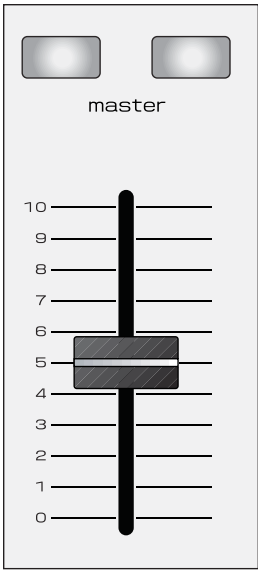

Figure 69. Master Volume controls.[273]

[273] *Ibid.*

Reverb Controls

The Fraktur4_Reverb found in any given instance of Fraktur4_Channel_Effects is controlled through a number of controls found in the "Master" channel. The knob labeled *fine* is used to set the reverb's revTime attribute, while the fader labeled *tempo* is used to set the wet / dry mix of the reverb via its mix attribute, the knob labeled *cue* above the *master* fader is used to set the reverb's feedback attribute, the knob labeled *pan* above the *master* fader is used to set the high frequency damping (or hfDamping), and the crossfader at the bottom of the channel is used to set the comb filter scaling in the reverb algorithm (or combScale). These controls are sent to the most recently used channel's reverb algorithm, and are scaled as follows: the revTime attribute is scaled logarithmically to a value between 0 and 100 using SuperCollider's built-in lincurve method with a curve of -2, while the mix is scaled to a value between 0 and 1 logarithmically using a curve of -3, the feedback is scaled logarithmically to a value between 0 and 1 with a curve of -3, the hfDamping is scaled linearly to a value between 1 and 0 (that is to say, turning the knob all the way to the left attenuates more high frequencies, but turning it all the way to the right ensures that more high frequencies are allowed through, thus enabling a more "metallic" sounding reverb), and the combScale is scaled logarithmically to a value between 0.01 and 2 using a curve of -2.

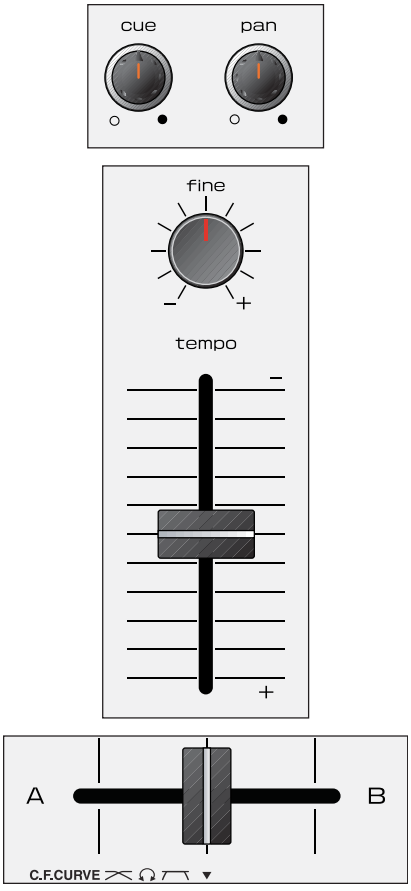

Figure 70. Reverb controls.[274]

[274] *Ibid.*

Sound File Recording Button

The button labeled *loop on / off* is used to start or stop recording an audio file to disk. The file is comprised of the number of channels associated with the spatialized sound (i.e. four channels for a quadraphonic instance of the Fraktur4 application, or two channels for a stereo instance), plus individual channels for each external input (one for the analog modular, two for cello in Mem1 performances, two for the MPC2000XL if utilized, and so on), and is saved in CoreAudio File (.caf) format to avoid file length limitations associated with .wav and .aiff files.

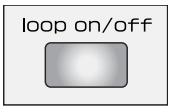

Figure 71. Sound File Recording button.[275]

Activity LEDs / Mutes

The switches labeled *SW E*, *SW F*, and *SW G* in Figure 72 are used to alert the user as to which of the three instances of Fraktur4_Loopers, Fraktur4_Accumulators, or Fraktur4_Oscillators are active in the first five channels, or whether the Fraktur4_Granulator or drum synthesizers in the sixth channel are active or not in the first *track_bank* and which individual drum voices are active or not in the second *track_bank*. An active state, denoted by a lit LED, is triggered when the volume control of a given looper, accumulator or granulator is greater than 0; this LED will become dim, denoting an inactive state, when the volume equals 0.

The routing buttons on a given channel correspond to the three activity LEDs reading from bottom-to-top, and left-to-right. That is to say, if the volume control is turned up while the *low* button on the first channel is selected, the switch labeled *SW E*

[275] *Ibid*.

will light up; if the *mid* button is selected, *SW F* will light up, and if the *hi* button is selected, *SW G* will light up. When switching between channels, the activity LEDs will change accordingly. For instance, if the volume control is up in the loopers associated with the *low* and *mid* buttons on Channel 1, and the user manipulates any control on the VCM-600 surface associated with Channel 2, the activity LEDs will immediately be updated to show which of the three loopers in the second channel are active. This allows a user to quickly scan through all sixteen channels for activity without need for a screen-based user interface.

These switches also may be manually engaged / disengaged to mute a given channel. In the first *track_bank*, muting (or un-muting) a channel takes the form of an eight-second fade. In the second *track_bank*, muting (or un-muting) a drum voice is immediate, to allow for alteration of rhythmic patterns through simply muting / un-muting voices.

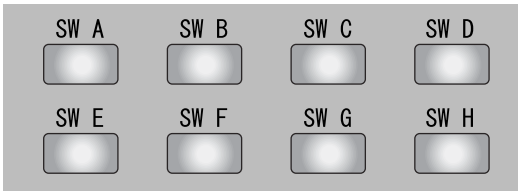

Figure 72. Activity LEDs / Mutes, and Auxiliary Send / Volume Mapping buttons.[276]

Auxiliary Sends

The switches labeled *SW A*, *SW B*, and *SW C* in Figure 72 are used to set whether or not the signals from Fraktur4_Loopers, Fraktur4_Accumulators, or Fraktur4_Oscillators are sent to the analog modular synthesizer using an optical connection from the MOTU 828mk3 audio interface to an Expert Sleepers ES-3 module. Engaging / disengaging these controls fade the associated signals into or out of the mix passed to the ES-3 over the

[276] *Ibid*.

course of eight seconds. It is worth noting that these auxiliary sends can be engaged while the direct output of the associated channel are muted. This feature is helpful in many occasions, including the development of complex feedback loops and processing of control voltages that are not intended to be heard directly.

Volume Mapping

The switch labeled *SW H* determines whether or not the *level* fader is used to determine the level of the most recently selected voice within the main mix, while the switch labeled *SW D* determines whether or not the *level* fader is used to determine the level of the most recently selected voice within the mix passed to the analog modular. This allows for different mixes to be sent for direct auditioning and processing via the analog modular.

Step Sequencers

The second *track_bank* contains controls for eleven step sequencers: one (up-to-) sixteen-step sequencer whose purpose is to send control voltages to the analog modular synthesizer over an optical connection, four (up-to-) four-step sequencers comprised of subsequences from the aforementioned sixteen-step sequencer, which also send control voltages to the analog modular over an optical connection, and six (up-to-) sixteen-step sequencers, each of which is associated with a different drum synthesis engine. By default, the control voltage sequencer is selected. In the following description of Fraktur v.4's step sequencers, we will assume that the user has engaged the *track_bank* button, unless otherwise specified.

Fraktur v.4's step sequencers are capable of being run at up to audio rates, and thus are implemented within a SynthDef that is added to the server at application launch. All step sequencers share a common timing engine found in my Fraktur4_Sequencer class,

although the actual data output differs between the Control Voltage step sequencer (which directly outputs an audio stream from the SynthDef to the analog modular), and Drum Synthesis step sequencers (which output triggers that are received in Fraktur4_Drummer, which in turn spawns new instances of SynthDefs with appropriate values for each of their associated parameters).

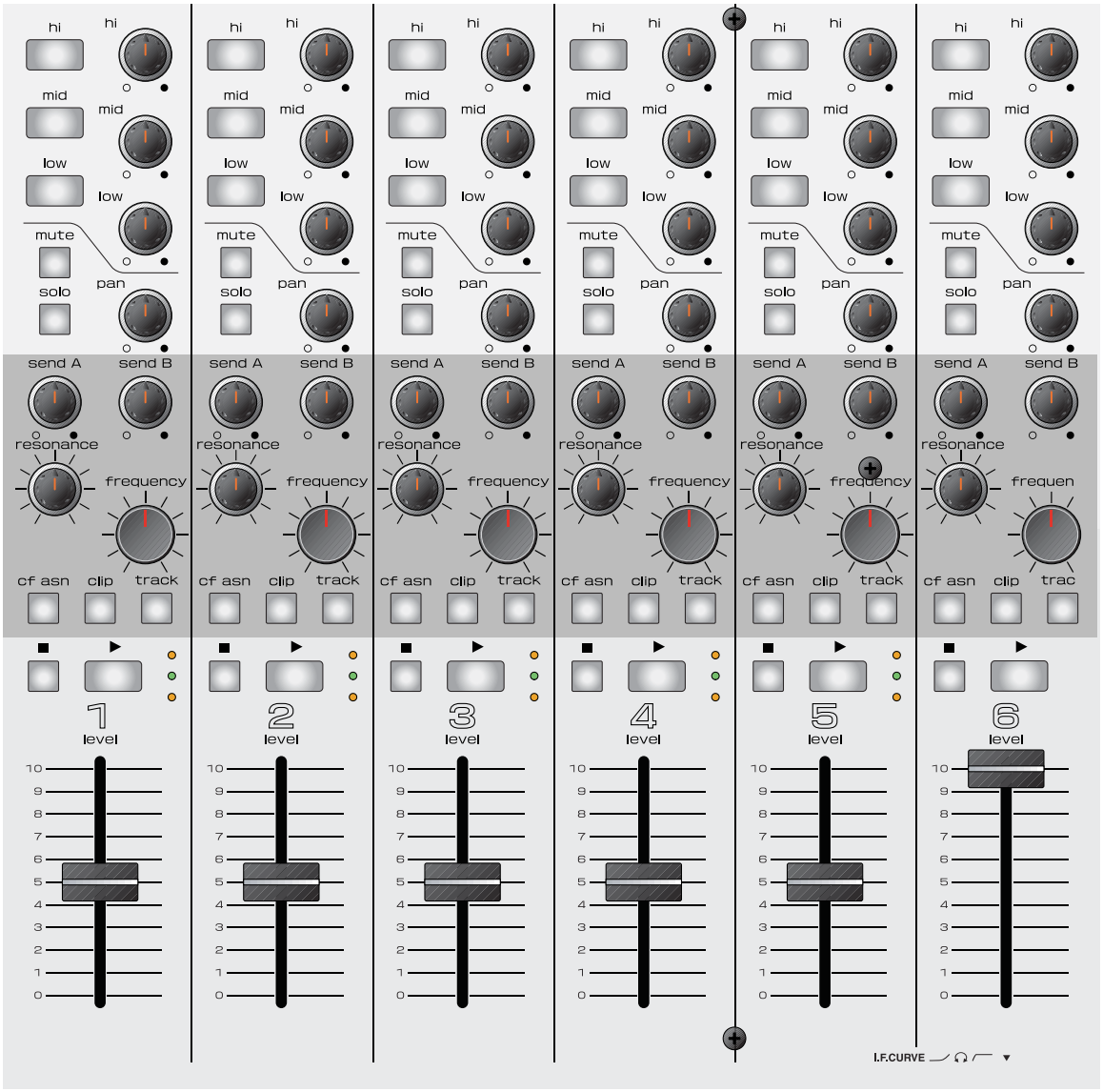

Figure 73. Step Sequencer controls.[277]

[277] *Ibid.*

Control Voltage Step Sequencer

The Control Voltage (or CV) step sequencer is comprised of sixteen steps, set using the first four channels' *hi*, *mid*, *low* or *mute* buttons, the *hi*, *mid*, *low* or *pan* knobs, or any combination of the above: the knobs' values are inverted by activating the corresponding button. For example, if the *mute* button is selected on Channel 1, and the *pan* knob on Channel 1 is turned fully counter-clockwise, the ES-3 module will output a 10V DC signal when the CV Step Sequencer reaches the fourth note. If the user is to turn the *pan* button completely clockwise, the ES-3 module will output a 0V DC signal upon reaching the fourth note within the sequence; values between will be scaled accordingly (¼ turn equals 7.5V DC, ¾ turn equals 2.5V DC). If the user then disengages the *mute* button, the values associated with the *pan* knob would behave "regularly"—i.e. ¼ turn equals 2.5V DC signal, a ¾ turn equals 7.5V DC, etc.

All sequencers in the Fraktur v.4 environment, internal or external, may be stopped or started using the *tempo nudge* button labeled > on the VCM-600. Likewise, all sequencers may be reset to the beginning using the *tempo nudge* button labeled < on the VCM-600. The CV Step Sequencer does not need to be comprised of sixteen steps, but can rather output between four and sixteen steps, distributed over four sub-sequences, accessed per Channel. By selecting one of the three buttons below the *frequency* knob labeled, in left-to-right order, *cf asn*, *clip*, and *track*, a user may limit the length of the subsequence to between 1 and 3 steps: activating the *cf asn* button denotes that the subsequence should be one step long, *clip* denotes two steps, and *track* three. When one of these controls is activated, the others automatically deactivate; however, a user may also opt to deactivate any of these controls without activating another, which will reset the subsequence's length to the default of four steps.

Subsequences may be looped by activating the *play* button, played in reverse by activating the *record* button (whether in loop or continuous play modes), and played in a random order selected upon initial engagement of the *solo* button. In addition, each subsequence has controls over its playback speed. The *loop in* button on the right of the VCM-600 is used to set triplet (active) or duplet (inactive) modes for the subsequence playback speeds. If the playback speed in duplet mode, as it is by default, the *frequency* knob will be split evenly among the ranges of 1/32 speed at the far left, and continuing through 1/16, 1/8, 1/4, and 1/2 speed, up until 45% through the dial, which denotes a playback speed of 1. A playback speed of 1 lies between 45% and 55% of the knob's range, making it easy to find quickly, and the values above this range are split evenly between 2x, 4x, 8x, 16x and 32x speed. If triplet mode is active, these values are replaced by 1/96, 1/48, 1/24, 1/12, 1/6, 1/3, 1x, 3x, 6x, 12x, 24x, 48x, and 96x speed. Each subsequence also has controls over a random offset per step via the *send a* knob, a combined linear up and down "slew time" using the *send b* knob, global offset amount using the *resonance* knob, and global attenuation (values from 50% – 100%) / inversion (from 0% – 50%) using the *level* fader.

In addition to controls over individual subsequences, the CV step sequencer also has a number of global controls over all subsequences, found in the area demarcated *effect* at the top right of the VCM-600. The knob labeled *VR A* may be used to set a global random offset per step. The *VR E* knob, directly below, is used to set the global tempo for all step sequencers, CV and Drum Synthesis alike, and ranges from 90bpm at the extreme left to 180bpm at the extreme right, with a center point of 120bpm, which is the default tempo upon application launch. To the right of these controls, the knobs labeled *VR B* and *VR F* are used to set global values for exponential rise (*VR B*) and fall (*VR F*). The next

two controls are used to set global offset (*VR C*) and attenuation / inversion (*VR G*), and the final two controls are used to set global shift (*VR D*) and swing (*VR H*) amounts.

Global shift values may be used to offset the phase of the Impulse UGen that drives the step sequencer, effectively pushing steps forward or backward up to one-half step, or thirty-second-note value, in increments of ninety-sixth notes. Global swing values may be used to offset the off-beats by up to a sixteenth note forward or backward, in increments of ninety-sixth notes.

The values associated with the *hi*, *mid*, and *low* buttons for each step may be rotated step-wise forward or backwards by pressing down on and turning the *scene* endless rotary encoder left or right—each click to the left represents moving the sequence "backwards" and each click to the right represents moving it "forwards" one step; step values will be wrapped from end to beginning, or beginning to end. Take, for example, a simple "four-on-the-floor" sequence in which an "X" value represents an "on" state, and an "O" value represents an "off" state, as follows: XOOO XOOO XOOO XOOO. Turning the knob to the right one click would create the new sequence OXOO OXOO OXOO OXOO, while turning it to the left one click would create the new sequence OOOX OOOX OOOX OOOX. The values associated with the *hi*, *mid*, and *low* knobs, however, remain consistent with their physical counterparts on the VCM-600 control surface.

The *scene* knob may be used in connection with one other shortcut: automatically filling in step values automatically, thanks to Fredrik Olofsson's Bjorklund class, available using SuperCollider's built-in Quark browser.[278] Given a length of an array, and a number of steps to fill, this algorithm, based on the work E. Bjorklund "in connection with the operation of certain components (such as high voltage power supplies) of spallation neutron source (SNS) accelerators used in nuclear physics,"[279] will find the most even

[278] http://www.fredrikolofsson.com/f0blog/?q=node/434

[279] http://cgm.cs.mcgill.ca/~godfried/publications/banff.pdf

distribution of these values within the given sequence. In order to easily enter values for this algorithm, I have chosen to allow a user to simply press and hold the *scene* button while selecting the button within a sequence equivalent to the number of steps to be distributed. For example, to enter four notes in a sixteen-step sequence (the most even distribution of which is a "four-on-the-floor" rhythm, or XOOO XOOO XOOO XOOO), a user would simply hold down the *scene* button, and press the *mute* button in the first subsequence (equivalent to the fourth step). To create a sixteen-step sequence with six beats as evenly distributed as possible, at least as defined according to the Bjorklund algorithm (XOOX OXOO XOOX OXOO), the user would simply select the sixth step of the sequence—the *mid* button within the second subsequence. A number of the aforementioned features (including the Bjorklund algorithm) are available to the Drum Synthesis step sequencers, with slight differences in implementation, as we shall see below.

Drum Synthesis step sequencers

In addition to the CV step sequencer(s), Fraktur v.4 features six independent step sequencers that are linked in terms of tempo and general functionality. To access a Drum Synthesis step sequencer, the user may press a *low*, *mid*, or *hi* button in the fifth or sixth channel of the second *track_bank*. The drums associated with these channels are as follows:

5	*low*	kick
5	*mid*	sub-bass kick
5	*hi*	rimshot / clave
6	*low*	snare
6	*mid*	hi-hat
6	*hi*	clap

Users may also select a step sequencer by turning a knob or pressing a button on the fifth or sixth channel without first pressing the *low*, *mid*, or *hi* button on these channels. By default, the associated controls will be linked to the bass (Channel 5) or snare (channel

6) drums. However, if a user has selected a different sequence within the specified channel, this will remain the default destination when a knob or button other than the *low*, *mid* or *hi* buttons is enacted. For example, if the *clap* was the most recently-selected drum sequence to be interacted with in Channel 6, and the user chooses to manipulate parameters of the kick drum in Channel 5, by simply grabbing the *level* fader in Channel 6 and changing its value, the *clap* will again become the active drum sequencer. This allows for the user to quickly make changes to other voices while not losing track of other ideas or ongoing processes.

Steps are activated in a way that is similar to the CV Step Sequencer, but with a few key differences. First, the knobs associated with each step act as an accent for each of the steps, with the exception of the hi-hats, for which they function as a variable amount of "open" or "closed"-ness. Also, sequences are not broken into subsequences, but scan through the sixteen *hi* / *mid* / *low* / *mute* buttons in the first four channels at a constant rate. This rate is selected in part by the *VR E* button in the *effect* area at the top right of the VCM-600 controller, the functionality of which parallels that of the frequency knobs found in the CV Step Sequencer, with ranges from 1/32 through 32x speed when duplet mode is active (i.e. the *loop in* button is off) and 1/96 through 96x speed when triplet mode is active (i.e. the *loop in* button is on).

The lengths of these sequences may be altered by selecting the desired last step from the buttons below the frequency knob: *cf asn* means to return to the first note (i.e. *hi* on Channel 1) after passing through the first note in a desired channel (e.g. engaging *cf asn* in Channel 2 will yield a sequence that is five steps long), *clip* will return after the second note, *track* after the third, and *record* after the fourth. By default, the *record* button is lit in the fourth channel for each Drum Synthesis step sequencer, demarcating a sixteen-step

sequence. The lengths of each step sequencer remain separate, allowing for polyrhythms to emerge by simply selecting different lengths for various step sequencers.

Step sequences can be played forwards by engaging the *play* button on a given drum sequencer in Channel 5 or 6 (as is the default), backwards by engaging the *record* button, alternating forwards and backwards by engaging both *play* and *record*, or in random order by disengaging both *record* and *play* buttons. The *cf asn* button on Channels 5 and 6 allows for "Euclidean mode" playback—i.e. a given sequence will take the equivalent time to play back as an even portion of a sixteen-step sequence. For example, if a user has selected a ten-step sequence, its playback speed will be adjusted such that all ten steps are played in the time of an eight-step sequence; likewise, if a three-step sequence is selected, it will take the same amount of time to play these steps as it would normally take to play four. Step sequences longer than eight steps in length but shorter than sixteen steps will take the equivalent time to play as an eight-step sequence, to allow for the emergence of faster / trickier-sounding polyrhythms.

Drum Synthesis

The drum sounds associated with these step sequencers are all synthesized on the fly, and are capable of creating a wide variety of timbres and textures, both traditionally percussive in nature and otherwise. Each of the six drum synthesizers contain the following functionalities: volume (via the *level* fader), *gain* (via the *hi* knob at the top of the channel) release time (via the *mid* knob), accent amount (via the *low* knob), bit reduction (via the *pan* knob), nonlinear distortion (via the *send b* knob), and pitch (via the *frequency* knob). The resulting signals may be muted (or simply not triggered) depending upon the state of the six buttons labeled *SW A* (snare), *SW E* (kick), *SW B* (hi-hat), *SW F* (sub-bass kick), *SW C* (clap), and *SW G* (rimshot / clave). In addition to these parameters, the drum

synthesizers implement a number of features modeled after physical characteristics of actual drums, as well as time-tested features that I have enjoyed on other drum machines.

Additional Kick Drum Parameters

The kick drum is one of the more complex drum synthesizers in the Fraktur v.4 ecology, modeled after the physical properties of a drum and allowing for control over the velocity of the hit (the harder it is struck, the more of the "beater" sound is heard) via the *send a* knob, additional "zappiness" added to the mix (akin to the Hi Q drum sound found on Roland's R8 drum machine) via the *resonance* knob, and can be played in reverse via engaging the *track* button or alternating forward and reverse via the *clip* button.

Additional Sub-bass Kick Parameters

The sub-bass kick is a much simpler sound, consisting of a quick sweep of a resonant filter, which is then passed through a low-pass filter with variable frequency via the *resonance* knob to adjust the amount of initial "click" from this excitation, and then through a compressor / expander to allows for control over the "tail" of the sweep via the *send a* knob.

Additional Rimshot / Clave Parameters

This drum can be used to synthesize both rimshot and clave sounds via the engagement (clave) or disengagement (rimshot) of the *track* button. Alternating between clave and rimshot sounds may be accommodated via the *clip* button.

Additional Snare Drum Parameters

The snare drum consists of a dual-oscillator "drum membrane" sound and a "snare" sound which is fundamentally comprised of filtered white noise. The"velocity" at which this snare is struck determines, via the *resonance* knob, how much filtered white noise is passed through a series of high pass filters and virtual amplification circuits that control the shape and frequency range of the snare sound, ranging from completely dampened snares (only the membrane rings) to an ultra-"snappy" sound, via the *send a* knob. The snare may also be played in reverse via the *track* button or alternating between forwards and reverse via the *clip* button.

Additional Hi-Hat Parameters

Fraktur v.4's implementation of a hi-hat sound is the product of additive synthesis using pulse wave oscillators at unrelated harmonic ratios; these combined frequencies are then passed through a pair of fourth-order (24 db/oct.) high pass filters, the frequency ranges of which may be controlled via the *send a* and *resonance* knob. In place of the typical accent controls found on each step, the *hi*, *mid*, *low*, and *pan* knobs in Channels 1 – 4 are used to set the release time of the hi-hat. Each time a new hi-hat synth is triggered, the previous hi-hats are cut off, effectively "choking" an open hi-hat with a closed (or new open) hi-hat signal. Hi hats may also be played in reverse via the *track* button or alternating between forwards and reverse via the *clip* button.

Additional Clap Parameters

Clap sounds in Fraktur v.4 are synthesized via a pair of white noise generators, each of which passes through a high-pass filter, controlled via the *send a* and *resonance* knobs, then through an additional band-pass filter. The envelopes applied to the volume of the

white noise generators contain a number of peaks and valleys in rapid succession at their onset to give more grit to the clap, but these envelopes may be spread out dramatically, resulting in what sounds like a number of hands clapping rather than a single hand clap, using the *track* button, and alternating between single and multiple hand claps using the *clip* button.

Controls over individual steps

In addition to global controls over the drum synthesizers found in Channels 4 and 5, a user may elect to change the values associated with aforementioned parameters for each individual step via controls found in Channels 1 – 4. The controls are applied to the parameters associated with the most recently selected step in a given channel.

With the exception of the hi-hat synthesizer, parameters linked to *send a* in Channels 1 – 4 correspond to those of *send a* in Channels 5 or 6, controls associated with the *resonance* and *frequency* knobs in Channels 1 – 4 likewise correspond to those found in Channels 5 or 6, and the controls associated with send b in Channels 1 – 4 correspond to those found under the *low* knob in Channels 5 or 6. The hi-hat functionality differs in that the "accent amount" control found in the *low* button on Channel 6 actually determines how much of a "cymbal crash" sound is allowed, according to the value associated with the *send b* knob in Channels 1 – 4.

Each of these per-step parameters may be randomized throughout the entire sequence by pressing the *play* button. The parameter to be randomized is the one that has most recently been interacted with for each drum synthesizer. If no per-step parameters have been interacted with previously, the controls labeled *hi*, *mid*, *low*, and *pan* will be those affected: for all drums with the exception of hi-hats, these controls represent accents, while for the hi-hats, they represent release time. by pressing the *solo* button in

Channels 1 – 4, all parameters within the four steps represented by that channel are reset to their default values.

Steps for drum sequencers may also be shifted forward or backward amongst the entire sixteen step sequence using the *scene* knob as seen in the CV Step Sequencer; all values other than the "on" and "off" states of the buttons associated with each step within a sequence will remain associated with the original step—e.g. given the sequence XOOO OOOO OOOO OOOO with a 75% accent on the first beat and no accent on the second beat, a new sequence of OXOO OOOO OOOO OOOO (obtained by turning the scene knob counterclockwise one click) will no longer have an accent on the X. However, should a user enable the first step to generate the sequence XXOO OOOO OOOO OOOO, the 75% accent will be heard on the first X. Drum sequences may also be filled using the Bjorklund algorithm as in the CV Step Sequencer, but with one primary difference: If the sequence has been set to a length less than 16 steps using the *clip*, *cf asn*, *track*, or *record* buttons on the first four channels, the Bjorklund algorithm will calculate the most even distribution of the desired number of steps given the appropriate length of the sequence.

Drum Pads

In addition to creating rhythmic patterns via Fraktur v.4's step sequencers, a user can elect to record sequences live from a drum pad controller. The current iteration of Fraktur v.4 utilizes Akai's LPD8 midi controller, which features eight knobs and eight velocity-sensitive drum pads. The pads may be used to send either program change messages or four banks of continuous control messages and midi note on / off values. Fraktur v.4 uses the program change messages to clear sequences in eight banks of sequencers that are recorded from each of the four banks of continuous control and note on / off values. The continuous control and note on / off values are implemented identically, but the resulting

sequences may be "muted" individually using two large switches found outside of the VCM-600 in the custom case created for this system. This allows for "A" and "B" sequences to be programmed silently then brought in at an appropriate moment, or programmed aloud then muted later.

In each of the four banks, the pad labeled *Pad 1* may be used to engage a "roll" feature with a variable rate defined by the knob labeled *K5* on the LPD8. This rate defaults to eighth note values, but may be set between a low value of one note every two bars through sixty-fourth notes at increments of powers of two, with an additional "high" value of one-hundred-ninety-second notes at the far right of the knob. Each sequencer is capable of being put into "triplet" mode using the pad labeled *Pad 5*. In this case, the roll speed defaults to eighth-note triplets, but may vary between values of whole note triplets, half note triplets, quarter note triplets, and eighth note triplets, as well as twelfth notes, twenty-fourth notes, forty-eighth notes, ninety-sixth notes, and one-hundred-and-ninety-second notes. These values are also used to automatically quantize pad data as it is stored in sequences even when the sequencer is not in "roll" mode, though the initial input will "play through" without quantization. If the pad labeled *Pad 5* is held down rather than pressed and released quickly, "note erase" mode is engaged, and a user may press other pads on the controller to remove recorded notes from a sequence at rates equal to the roll speed. For instance, if a user is to fill a sequence with eighth notes, then erase notes from the recorded sequence while the roll speed is set to a quarter note value, only the off-beat eighth notes would remain.

The outputs of the four drum sequencer banks are utilized for different purposes: the first bank is used to control the same types of drum synthesizers found in the step sequencers, arranged as follows:

Pad 2	Kick
Pad 3	Snare
Pad 4	Hi-Hat
Pad 6	Sub-bass Kick
Pad 7	Clap
Pad 8	Rimshot / Clave

When a drum pad is pressed, one of the two buttons above the *Master* fader on the VCM-600 will activate, depending on the mode of the LPD-8. If the LPD-8 is set to send out MIDI note on / off values (as it is by default), the "A" bank of drum pad sequencing will become active, and the button labeled *SW I* will engage automatically; if it is set to send out control messages, the "B" bank of drum pad sequencing will become active, and the button labeled *SW J* will engage automatically, the corresponding *hi*, *mid*, or *low* button in Channel 5 or 6 will engage and the controls in Channels 1 – 6 will be used to vary the corresponding drum synthesizer used by the drum pad sequencer. For instance, when a user plays a hi-hat in the "B" bank of the drum pad sequencer (i.e. the LPD-8 is used to output continuous control messages), the button labeled *SW J* will engage, as will the *mid* button on Channel 6, and controls in Channel 6, as well as those found in Channels 1 – 4 will be used to set parameter values for the hi-hats.

The drum pad sequencer is capable of holding up to eight bars' worth of material, and has a much higher resolution in terms of potential notes per bar, so the sixteen steps are used to set parameter values only of sixteenth notes within a single bar. If the sequence is longer than one bar, the parameter values are repeated for each additional bar. Parameter values are held for the duration of a sixteenth note, despite the number of notes played back from the drum pad sequencer during this time.

Currently, the second bank of pads (activated by pressing the pad labeled *Pad 2* after selecting the *Program* button on the LPD-8) is used to play the Fraktur4_Oscillators found in the first *track_bank* using the pads labeled *Pad 2*, *Pad 3*, *Pad 4*, and *Pad 6*, while the third bank is used to send six different pitches to the single simple "ping" SynthDef whose

controls are accompany the *hi* button in Channel 5 of the first *track_bank*, and the controls in Pad, and the fourth bank is used to play the four Fraktur4_Loopers, first Fraktur4_Accumulator, and the Fraktur4_Granulator found in the first *track_bank*.

The method of playback for the Fraktur4_Oscillators is determined by the state of the *loop_in* button associated with the oscillator's channel. If the *loop_in* button is disengaged, the *level* fader in this channel will determine the volume of the oscillator as a continuous sound source; when the oscillator is "played" by the drum pad sequencer, it will instantly jump to maximum volume and quickly decay to the (minimum) level specified by the *level* fader. Thus, the drum pad sequencer may be used to add "spikes" to a constant tone (assuming that the minimum level set using the *level* fader is audible), play short notes with no constant tone (assuming that the *level* fader is all the way down), or play a constant tone with no spikes at all (assuming that the *level* fader is all the way up). If, however, the *loop_in* button is engaged, the *level* fader will determine the volume of the oscillator post-envelope only.

The playback of the Fraktur4_Loopers, Fraktur4_Accumulator and Fraktur4_Granulator work similarly, with a slight exception: when the *loop_in* button associated with the Fraktur4_Loopers and the Fraktur4_Accumulator is disengaged, the buffer playback engine will start playing from the beginning every time it is re-trigged by the drum pad sequencer. Thus, if the *level* fader of the Fraktur4_Looper or Fraktur4_Accumulator is set at maximum, the drum sequencer can simply be used to "rewind" a buffer to the beginning at times specified by the user. It is also worth mentioning that the buffers of the Fraktur4_Loopers, Fraktur4_Accumulator and Fraktur4_Granulator may all be recorded into while being triggered by the drum pad sequencer—this includes recording from their own outputs using their associated

feedback controls, or a version of their outputs that has been sent through the analog modular for additional processing, yielding potentially interesting results.

The volume at which a given drum, looper, or other synth is triggered is based in part on the velocity at which the drum pad is hit. However, since the LPD8 drum pads do not support aftertouch, the knob labeled *K1* may be used to change these volume levels—during "rolls" or otherwise. If this knob is turned all the way to the right, the drum pad sequencer will send the maximum value, no matter what the velocity was when the pad was initially engaged. Similarly, if this knob is turned all the way to the left, the drum pad sequencer will send the minimum value, no matter what the velocity was when the pad was initially engaged. If the knob is set to its 12:00 position, the initial velocity will be sent; other values are scaled between these ranges.

In addition to "straight" playback of recorded sequences, the sequences can be manipulated in various ways: The knobs marked *K3* and *K7* are used to set values for shift and swing, as seen previously in the step sequencers. The knobs marked *K2* and *K6* are used to set end- and start-points for selection and playback of subsequences. The knob labeled *K4* may be used to "rotate" the sequence forward or backward, keeping the start- and end-points intact, and the knob labeled *K8* may be used to set the playback speed of a given sequence, from 1/128 to 128x speed in increments of powers of two.

Gesture Recorder

Fraktur v.4 utilizes a customized version of Alberto de Campo and Hannes Hoelzl's CtLoop class (part of the GamePad Quark)[280] to record and play back gestures associated with controls throughout its entire ecology. The current control surface for recording and playing back gestures is a Korg Nanokontrol2 MIDI controller, mapped as follows:

[280] https://github.com/supercollider-quarks/GamePad

Control values associated with Channels 1 – 6 in the first *track_bank* are mapped to the first six channels on the NanoKontrol2, while controls for drums in Channels 5 and 6 of the second *track bank* are associated with the last two channels on the NanoKontrol2. When a user interacts with a control on the VCM-600, the *S* button on that channel is activated, signaling that this channel is currently selected for potential recording. At the same time, a *rewind*, *fast forward*, or *stop* button on the NanoKontrol2 is lit, signaling that a given *low*, *mid*, or *hi* button is connected to the most recently-selected source in that channel, and its gesture is ready to be recorded. If more than one of the *low*, *mid*, or *hi* buttons is selected on the same channel, their gestures associated may be recorded simultaneously. By pressing the *R* button, the gesture is recorded. When the *R* button is pressed again, the *M* button will automatically engage, signaling that the recorded material is now is looping continually. New gestures may overdubbed onto previously recorded material; if the new recording is longer than the previous, the duration of the loop will be extended. If it is shorter, the loop will be truncated to the length of the most recent gesture. The *record* and *play* buttons on the left-hand side of the NanoKontrol2 may also be used as a shortcut to avoid needing to look at the control surface to find the appropriate *R* or *M* buttons.

Gesture playback can be stopped at any time using the *M* or *play* buttons, and the state of the controls will remain "frozen" at their current values. Gestures may also be stopped and cleared using the *set, marker* <, and *marker* > buttons: The *set* button stops and clears all recorded gestures, regardless of channel or bank (*low* / *mid* / *hi*), while the *marker* < button stops and clears all gestures within the currently selected channel, represented by the state of the *S* button on Nanokontrol2 surface, and the *marker* > button stops and clears only the "active" target, represented by the *S* button as well as the *rewind*, *fast forward* or *stop* buttons. It is worth noting that a user may select a different target at

any time by pressing an *S* button on a different channel or *rewind*, *fast forward* or *stop* button.

In addition to straight playback of the gestures, a number of types of manipulation are made available through CtLoop and customizations I have made to this class in my Fraktur4_CtLoop class. The knobs at the top of the NanoKontrol2 surface are used to manipulate playback speed, end- and start-points, the addition of variable random offset values to the data during playback, as well as the rotation, scaling, inversion, and reversing of the data during playback. The faders accompanying each channel may used to attenuate the recorded gestures during playback. The values of the controls used to manipulate playback of the gestures may be reset for an entire channel using the *track* < button or for the active target only using the *track* > button.

As well as data captured directly from the VCM-600's surface, Fraktur v.4's gesture recorder also keeps track of gestures passed on from the Magic Trackpad. This data is typically associated with filter frequency and resonance, but when the *cycle* button on the NanoKontrol2 is pressed, the Magic Trackpad or Fraktur4Win application may be used to pan audio signals throughout a stereo or quadraphonic space from every sound source throughout the Fraktur v.4 ecology; these gestures may also be recorded and played back like any other gesture.

Additional Controls

The custom flight case into which the VCM-600 was built hosts an Arduino Nano, a USB hub, two USB-A ports for stand lights, a single USB-B port for connection from the case to the host computer, twelve switches, two knobs, and four faders with center detents used in Technics 1200 turntables (discussed further in the *Schaulust Projection Apparatus* section of this document).

The two largest switches, found at the furthest right within the case, are used to "mute" playback of the two banks of drum sequencers, as mentioned previously. The other ten switches and two knobs are used to control mute and solo states throughout Fraktur, as detailed below, and the two knobs are used to control the volume of the modular synthesizer and MPC2000XL or other incoming signal on the first two analog inputs when muting / soloing channels using these switches.

Mutes and Solos

Each of the six channels found on the VCM-600 surface are represented by a switch at the top of the flight case in which it is mounted, with alternating red and white caps to easily distinguish between them. Next to these six switches are three more switches (without caps), which represent the *low*, *mid*, and *hi* banks found throughout the Fraktur v.4 ecology. The mute / solo states of the corresponding Fraktur4_Loopers, Fraktur4_Pvocs, Fraktur4_Oscillators, Fraktur4_Accumulators, Fraktur4_Granulator or various drum synthesizers are controlled by using these three switches to select from the *low*, *mid*, and *hi* banks within any channels associated chosen by the six switches with alternating red and white caps. The final switch, to the right of the three non-capped switches, is used to alternate between *mute* and *solo* modes.

For example, given the following settings of the first six switches: XOOOOO, and the following set of the next three switches: XOO, we see that the first Fraktur4_Looper, found in the *low* bank of Channel 1, is the only "active" target. Depending on the state of the final switch, this Fraktur4_Looper will either be muted or soloed. If this switch is pointed downwards, the Fraktur4_Looper will be muted, and all other sound sources will play as usual. However, once this switch is flipped upwards, the Fraktur4_Looper will be the only voice heard, and all other sound sources will be muted. By combining multiple

sources, complex Mute and Solo Groups may be created. XOXOOX / OXX, for instance, will allow for muting and soloing of the Fraktur4_Pvocs and Fraktur4_Oscillators in the first and third Channels as well as the drum synthesizers in the sixth Channel. This can be very effective, especially if the signals derived from these sources are manipulated by the Fraktur4_Accumulators or Fraktur4_Granulator found in the alternate Mute / Solo state.

Figure 74. Mute and Solo switches.

Integration of Analog Modular Synthesis

In addition to the signal generation / manipulation possibilities of the Fraktur v.4 system within the digital domain, a number of unique features exist which allow for seamless integration into analog domain.

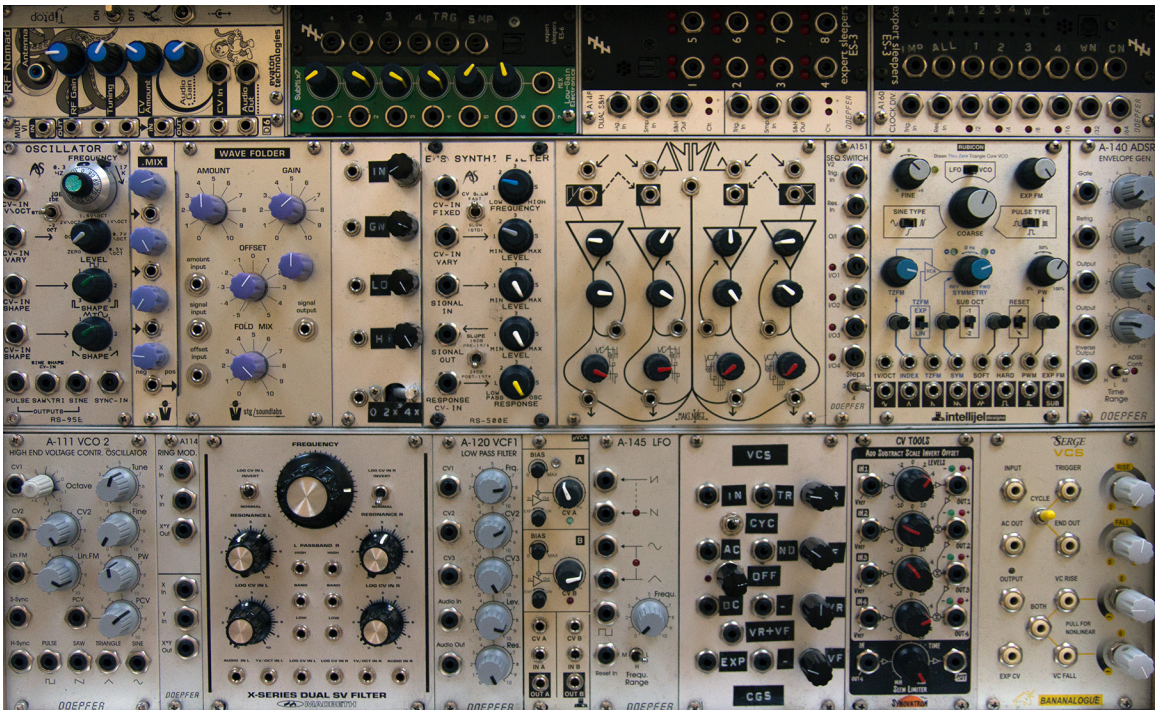

Figure 75. Eurorack modules currently utilized in Fraktur v.4 system (November 2015).

These features are afforded by the use of three Eurorack modules made by Expert Sleepers: two ES-3 Lightpipe/CV Interfaces and one ES-6 CV/Lightpipe Interface. The ES-6 CV/Lightpipe Interface allows for six discrete audio signals to be sent to SuperCollider over a single optical cable. Each Fraktur4_Looper, Fraktur4_Pvoc, and Fraktur4_Accumulator, as well as the Fraktur4_Granulator, has the ability to choose from among these six input sources using the *scene* endless rotary control (without pressing down on this control).

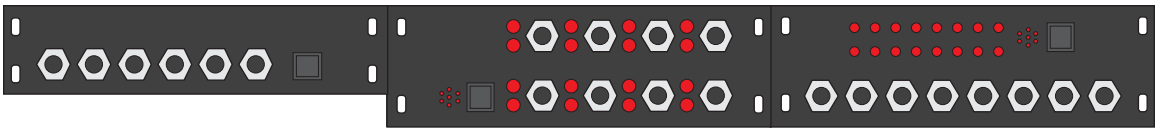

Figure 76. ES-6 CV/Lightpipe Interface (L) and ES-3 Lightpipe / CV Interfaces (C + R).

The first four inputs are mixed together for direct auditioning (the level of which is controlled by the *pan* knob above *return A*, as previously mentioned); the final two inputs are passed on silently for potential sampling, manipulation, and playback, as well as to virtual ring modulation and sample and hold "circuits" in SuperCollider. The resulting signals are passed to the seventh and eighth channels of the Optical A output on a MOTU 828mk3 audio interface, and from there to physical outputs 7 and 8 on the first ES-3 module. The other six physical outputs on this module are used to send signals from the six channels as represented on the VCM-600 control surface, based upon the state of the *SW A*, *SW B* and *SW C* controls associated with these channels.

The second ES-3 module receives a "tick" for every sixteenth note output by an Impulse UGen running at the rate defined by the global tempo established by *VR E* knob, as associated with the CV Step Sequencer, and outputs this from its first outlet. (I have mounted the module backwards and re-labeled the outputs for ease of patching, so this would in fact be the eighth outlet, but for ease of discussion, I shall follow this "reversed" version of outputs as we continue.) The next physical output is comprised of all four subsequences of the CV Step Sequencer, played in order as discussed previously. Following this output the four individual subsequences, then a white noise and colored noise output, which take up much less space than their Eurorack counterparts.

Graphical User Interface

The current version of Fraktur v.4 also utilizes an iOS 8 application called Fraktur4Win running on an iPhone 6, which I built in XCode using the OpenFrameworks C++ toolkit,

for its Graphical User Interface. It is important to me that I do not rely upon a screen in performances for anything other than a quick reference, so this application is very minimal but also very effective. This application sends and receives data from / to SuperCollider via UDP over a wireless network connection using the OpenSoundControl protocol. At home, I use our usual wireless router; in performances, I bring a Airport Express with a secure and hidden network. As I am currently running Fraktur application on a Mac Mini, this also allows me to launch it remotely via a Screen Sharing App on my phone before a performance, which allows me to circumvent the need for an external monitor. Once the Fraktur application has been launched, I can launch the Fraktur4Win application on my phone, and begin the performance.

Figure 77. Fraktur4Win iPhone application (inactive).

The Fraktur4Win interface includes four numbers: the peak and average CPU utilization may be found in the lower left-hand side of the screen. Located in the lower right-hand side of the screen are the selected input from the ES-6 for the currently chosen Fraktur4_Looper, Fraktur4_Pvoc, Fraktur4_accumulator or Fraktur4_Granulator, and the

elapsed time in half-minutes (0, 0.5, 1, 1.5, etc.) since either the application was launched or the *loop out* button was reset, to allow for easy but stress-free timekeeping in performance situations.

In addition to these lines of text, there are five rows of meters. From the bottom up: The first row is comprised of eight meters: two inputs for external sound sources passed in via Optical A Inputs on the MOTU 828mk3 (such as Laura's signal in Mem1 performances), two inputs for Analog Inputs 3 & 4 on the back of the MOTU 828mk3 (such as the MPC2000XL), and four analog outputs used in quadraphonic performances. The next row up is comprised of six meters, which reflect the Optical B Inputs utilized by the ES-6 CV/Lightpipe Interface. The final three rows represent the state of each of the outputs, per bank and channel: the first of the three rows represents the Fraktur4_Loopers, Fraktur4_Accumulator, and Fraktur4_Granulator associated with the *low* button, the second represents the Fraktur4_Loopers, Fraktur4_Accumulator, and Kick, Sub-bass Kick and Rimshot / Clave drum synthesizers associated with the *mid* button, and the top row represents the Fraktur4_Loopers, Fraktur4_Accumulator, and Snare, Hi-Hat and Clap drum synthesizers associated with the *hi* button. In addition to metering, the Fraktur4Win application provides a handful of other helpful reminders and functions. When the application is first launched, the screen is blank except for the words "SYNC DRUMS." This acts as a simple reminder to test the synchronization between Fraktur and external MIDI devices (if in use), and to "re-sync" them if necessary. The "main screen" may be reached by simply clicking anywhere on the screen.

By default, the Fraktur4Win application's background and meters are red. Once the Fraktur4Win application has received a message from the main Fraktur4 application that it is recording, the background and meters turn aqua blue. If the recording is stopped, the background and meters turn red again. The Fraktur4 stand-alone applications I use in

performance settings (and most rehearsals) are set to automatically record the audio stream; however, I have found that in many circumstances, I will launch the application during soundcheck, and leave everything running during the time between soundcheck and my performance, but do not want to fill my hard drive up with empty soundfiles of these moments, so I simply stop recording after (or in many cases, during) soundcheck. The change in background / meter color is a simple (and unavoidable) visual reminder when beginning a performance, replacing the need to check if the *loop on / off* button on the VCM-600 is lit.

The final function that the Fraktur4Win application currently hosts is the ability to send multitouch X / Y coordinates over OSC to the Fraktur4 application to control the filter cutoff and resonance or quadraphonic panning parameters of the current looper / accumulator / granulator / oscillator / drum synthesis engine. When this function is engaged, a set of white, single-pixel-wide crosshairs corresponding to the most recently-actvated multitouch point is overlaid above the rest of the Fraktur4Win interface.

Schaulust Projection Apparatus

Schaulust is a new paracinematic performance platform I have created for my dissertation performance involving the use of robotically-controlled mirrors and lights designed specifically for use in real-time improvisations. The word "Schaulust" translates as "the pleasure of seeing."[281] These performances are meant to embrace precisely the base visual pleasure derived from stroboscopic light, in the tradition of works such as Peter Kubelka's *Arnulf Rainer*, Tony Conrad's *The Flicker* and Paul Sharits' *Shutter Interface*, as well as the work undertaken in Laszlo Moholy-Nagy's *Licht-Raum Modulator*, Valie Export's early works such as *Abstract Film no. 1* and *Ars Lucis*[282] Ken Jacobs' *Nervous Magic Lantern* performances.

The project itself began as an investigation into the relationship between glass and active spectatorship dating back to my Master's studies at the Rhode Island School of Design, during which time I spent countless hours in the hot and cold shops, kiln and moldmaking rooms. This work culminated in my MFA thesis project, *Effective Dose*, "a contemplative environment in which users may directly experience the traffic of cellular networks via custom-designed instruments that mine the frequencies utilized by these networks for local activity and create tangible, physiological responses through non-representational data visualization and sonification in real time."[283]

The piece utilized the open source software radio initiative GNU Radio in conjunction with Ettus Research LLC's United Software Radio Peripheral, or USRP, to harvest data from the 850 and 1900 Mhz bands utilized by North American GSM transmissions. These transmissions were then analyzed using custom software built in Max/MSP/Jitter; results from these analyses triggered reactions in a generative system

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[281] Jacques Lacan, *The Four Fundamental Concepts of Psycho-Analysis*, 178.

[282] Roswitha Mueller, *Valie Export: Fragments of the Imagination*, 4 – 7.

[283] Mark Cetilia, "Effective Dose: Creating Physiological Responses to Invisible Networks," 3.

disbursed four Mackie HR824 studio monitors, one Mackie HRS-120 subwoofer and three hyperdirectional speakers manufactured by American Technology Corporation: one HSS T-120, and two HSS H-450s, creating a "unique and constantly changing environment for those who enter the room."[284]

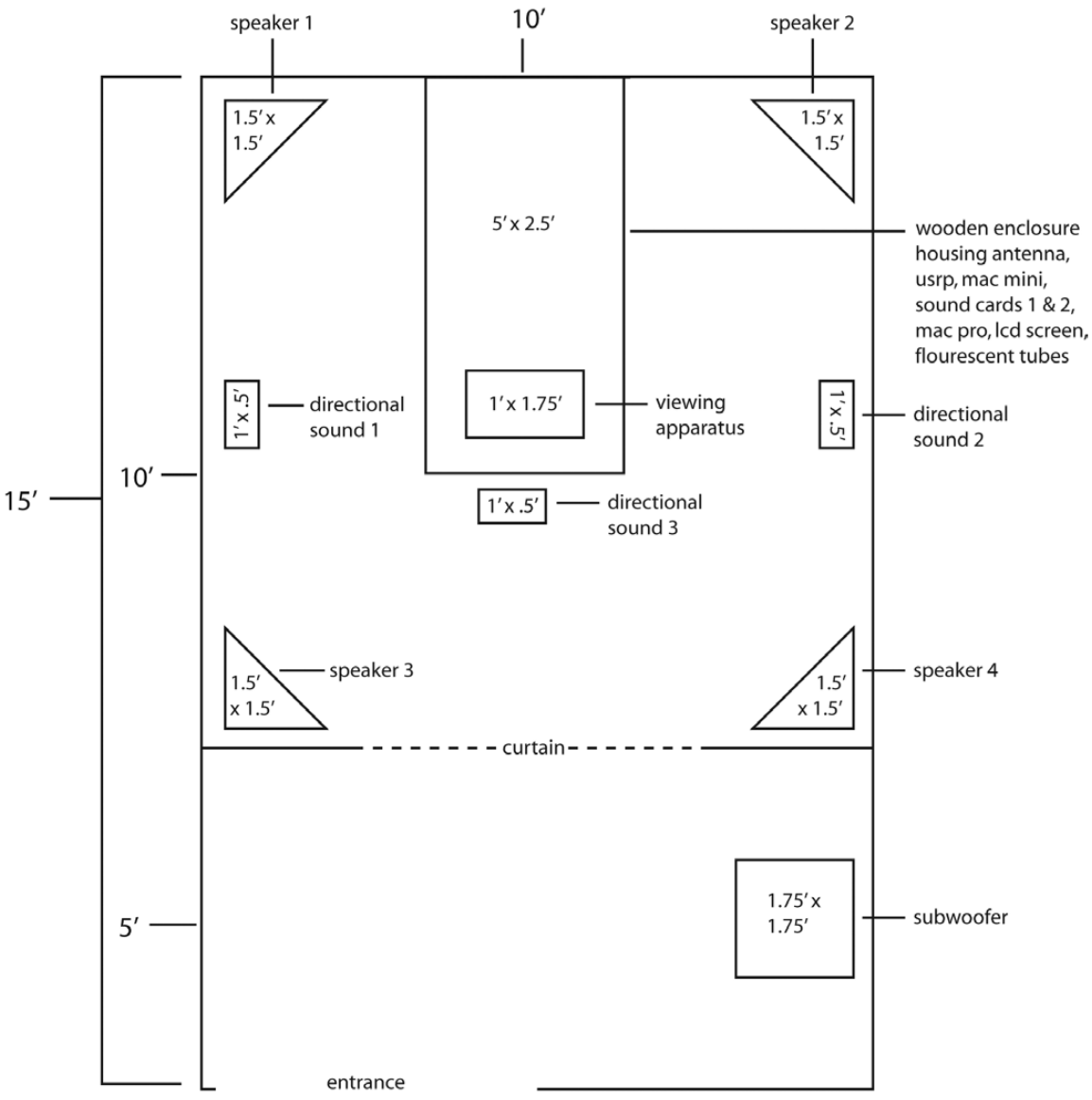

Figure 78. Floor plan for *Effective Dose* (2008).

[284] *Ibid*, 40.

In addition to sound, this installation featured a unique viewing apparatus:

> The visual component of the work is comprised of three prismatic lenses mounted on an observation table. Underneath the prism lies an LCD screen whose backlight has been removed. The backlight has been replaced with fluorescent tubes mounted in a wooden box that is attached to the underside the table. The image projected through the prisms is a solid field of flickering color that varies between slightly different shades of black. The resulting effect is the creation of a combined optical / physiological experience, with distortion created by the prismatic lenses, traces of motion as the screen tries to approximate these subtle differences in shades of black, and shifting colors resulting from the retinal after-images induced by flickering light. The intensity and speed of the flicker are impacted by the data carried by the cellular networks in the local area, thus creating physiological responses to these networks without didactically "visualizing" the data.[285]

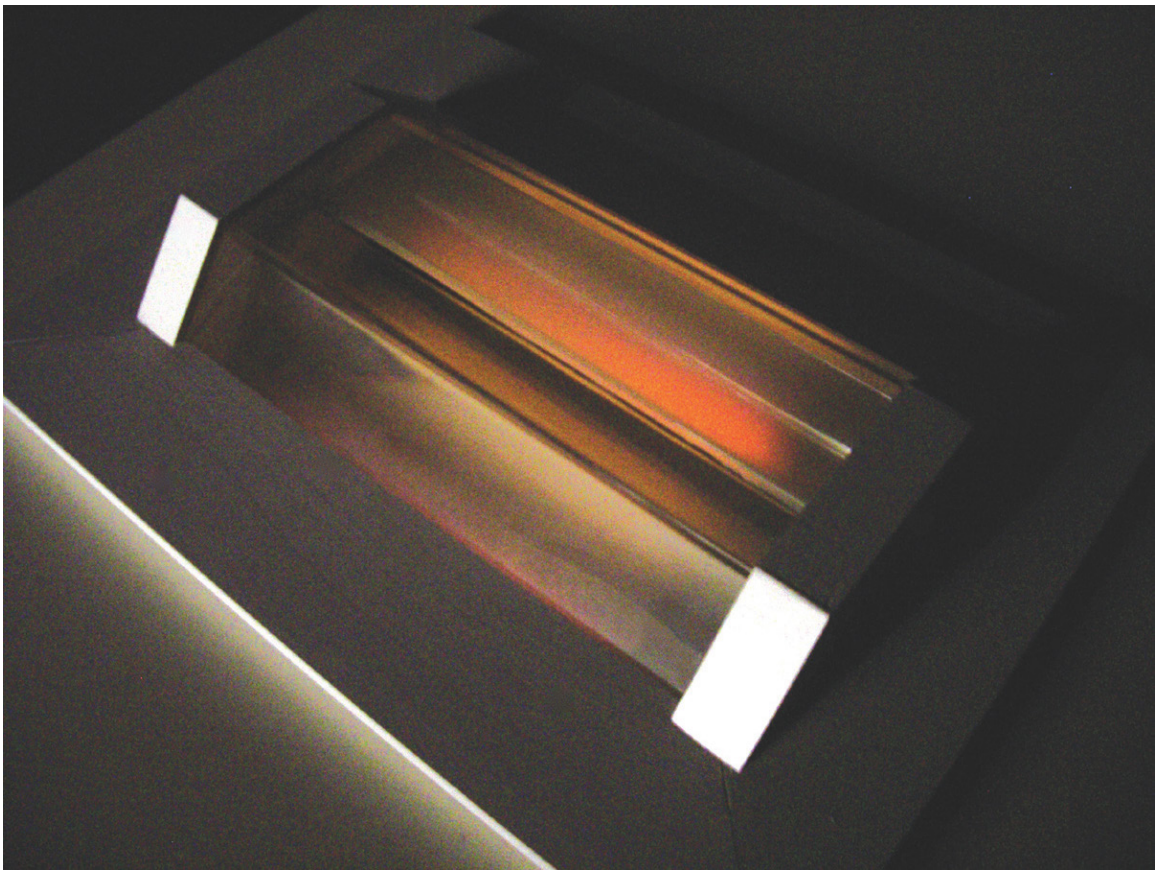

Figure 79. Viewing apparatus from *Effective Dose* (2008).[286]

[285] *Ibid*, 39.

[286] *Ibid*.

The utilization of this viewing apparatus, in conjunction with the fully immersive soundscape utilizing traditional surround sound and directional sound projection technologies, allowed me to create a highly focused environment in which slight shifts in perspective on the part of the active viewer would allow for discovery of new details inherent in the work.

The work I undertook in this piece led both very directly to the *Schaulust* projection apparatus (as I repurposed the large glass optical-quality prismatic lenses I had cast for *Effective Dose* in to make this new work possible), as well as through more circuitous routes. Upon my acceptance to Brown, I found myself once again drawn towards working with glass, and began working on custom hardware that I called the *Logical Extension*, to be used in conjunction with a Digital Single-Lens Reflex (DSLR) camera.

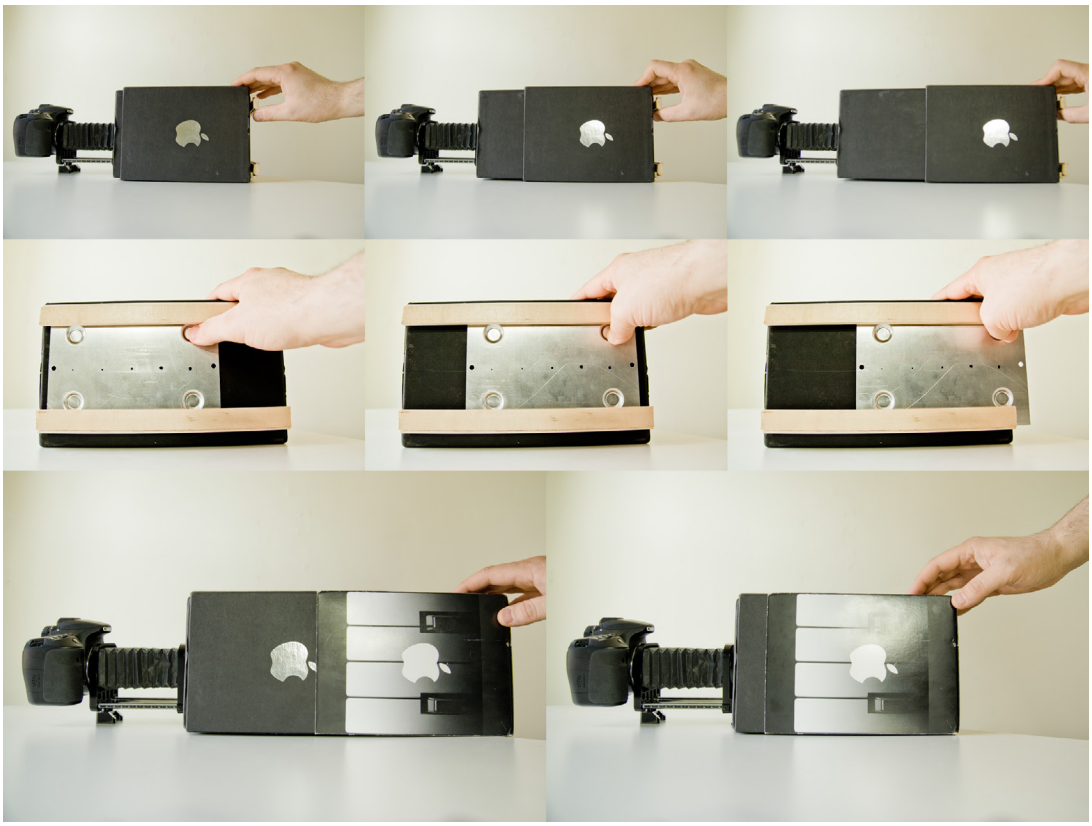

Figure 80. The *Logical Extension*'s focal length, aperture, and positive maniscus lens.

The *Logical Extension* was, naturally enough, made from a box that my copy of Apple's Logic 8 software and manuals arrived in, which I converted into a pinhole camera—but not just any pinhole camera. This system featured an adjustable aperture (in the form of a sliding metal plate with holes of different sizes), adjustable focal length (obtained by adjusting how far the lid of the box slid into the base), and support for multiple lenses, including a positive maniscus lens affixed to the outer shell of the box, as well as "external" lenses in the form of cast-glass blocks with various inclusions, and was capable of being utilized in conjunction with a DSLR via a commercially-available bellows attachment.

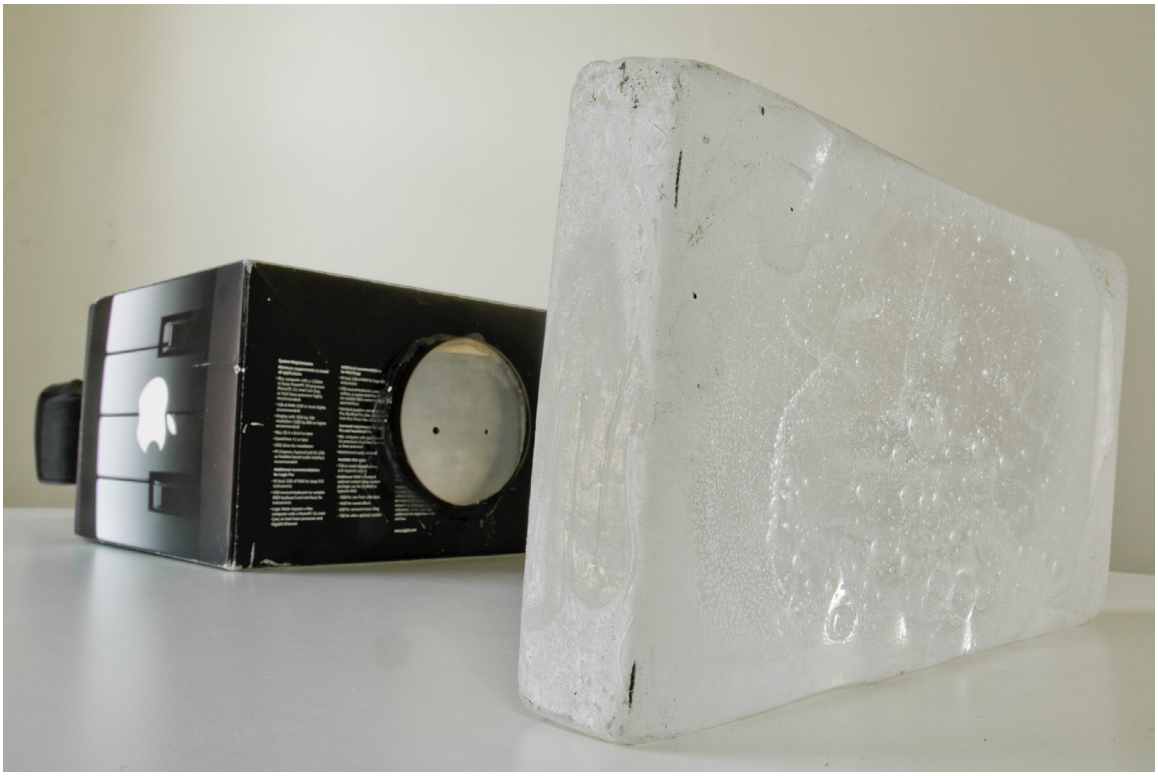

Figure 81. The *Logical Extension* positioned to shoot through an "external lens."

These experiments led to the development of my Brown Master's thesis project, an audiovisual performance entitled *Pulse Shape 22*, an improvisational audiovisual performance featuring shortwave radio transmissions as the sole source material for

realtime audio processing alongside macrovideography of a cast glass block that had been embedded with baking soda, thus creating a number of smaller lenses at different focal planes within the glass block. The use of a bellows extension for my DSLR allowed navigation through the myriad focal planes, and the video footage captured was limited strictly to shooting directly into the brightest light source available: the sun, which was not only captured but also projected through cast glass lenses designed specifically for this piece.

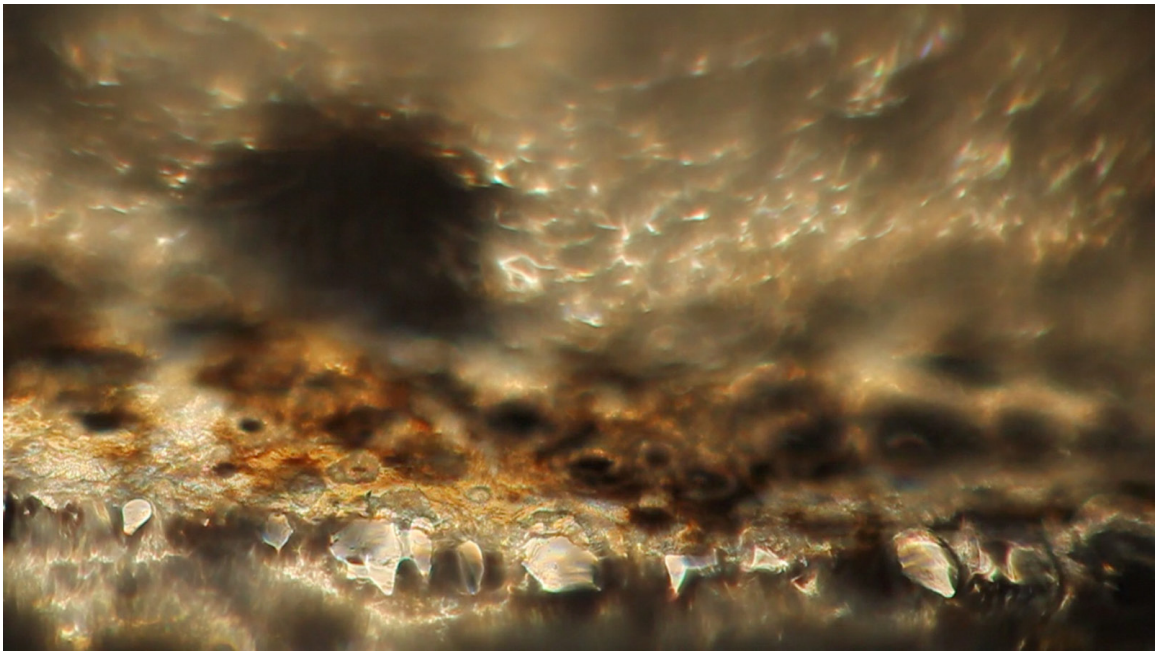

Figure 82. Still from an early portion of *Pulse Shape 22* (2012).

Pulse Shape 22 utilizes Gnu Radio software in conjunction with Ettus Research LLC's Universal Software Radio Peripheral for realtime data acquisition and demodulation, as well as custom software built in SuperCollider and C++ for live signal processing and video manipulation. The structure of the piece is derived from metrics on energy accumulation over a period of 2.2 nanoseconds resulting from the targeting of sixty lasers on a single tetrahedral hohlraum in weapons testing experiments as carried out at the Los Alamos Inertial Confinement Fusion unit's Omega laser facility. *Pulse Shape*

22 is an exploration of architectural space through the use of site- and time-specific information found in regions of the electromagnetic spectrum outside of the reaches of the human sensory apparatus, and is an attempt to alter the audience's perceptions of their surroundings and create a moment of rupture from hidden worlds found in our local environment.

This structure for *Pulse Shape 22* is based on energy accumulation in tetrahedral hohlraum experiments (cf. Figure 42). A hohlraum is the closest physical reproduction of an "ideal radiator" that "absorbs all incident radiation and reflects none" used in nuclear weapons and reactors. [287] In these experiments, the hohlraum is targeted by a number of lasers and, rather than simply absorbing all radiation without reflection, the result is instead an even distribution of energy in all directions that is used to trigger an implosion that starts the nuclear reaction.[288]

The structure of the piece is based on the amount of energy accumulated over the 2.2 nanosecond sequence, which is stretched out to the length of the performance and used to determine the intensity of strobing within the video manipulation engine as well as the perceived intensity of sound. Data gathered from tetrahedral hohlraum experiments at the Omega laser facility was mapped to the frequency at which a single frame of video held in a Frame Buffer Object is updated within custom video processing software, and used subjectively as a visual aid for the performer, who is able to follow the amount of the accumulation by watching a "playback head" advance in a sound file viewer user interface object in SuperCollider. Higher values are taken to represent a greater degree of sonic "intensity," produced through increase in spectral density (especially at wavelengths within the range of the human voice) and overall amplitude, as well as the use

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[287] Sybil P. Parker, ed. *McGraw-Hill Dictionary of Physics*, 42.

[288] "Tetrahedral Hohlraum High-Convergence Implosion Experiments on Omega ID4-FY98," 2.

of more chaotic and tumultuous transmissions as raw material for manipulation, and a decrease in the number of bits used to represent a given signal.

In addition to the use of energy accumulation data, *Pulse Shape 22* also uses pointing parameters for the laser beams to drive the spatialization engine throughout the piece. These pointing parameters are used to determine location in quadraphonic sound space for each of twelve possible buffer playback engines within the SuperCollider scripting language, which exchange positions sixty times throughout the duration of a performance. Thus, in a half-hour performance, the position of each buffer playback engine in quadraphonic space shifts every thirty seconds with a cold, mechanical accuracy.

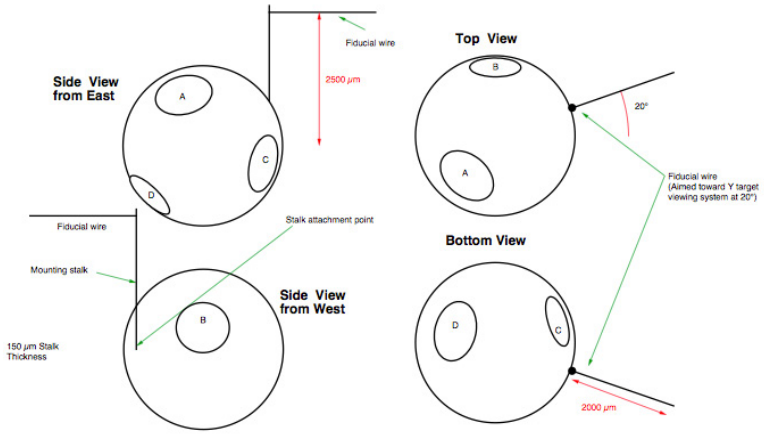

Figure 83. *Tetrahedral Hohlraums for Omega H4-H7 orientation.*[289]

The energy accumulation data was also of pivotal importance for the video for this piece, which is manipulated in real time through custom software written in C++ using the open-source OpenFrameworks libraries. The video manipulation engine utilizes only a few key technologies to create imagery of striking complexity. The basic logic of the video engine is as follows: Create three video player objects, of which two are playing at

[289] *Ibid*, 29.

any given time. Load videos into these objects. Every five seconds, load a new video into the third video player object. The specific movie clip is chosen based on the amount of time since the beginning of the performance. When this video is completely loaded, kill off the first video player. At intervals determined based on the data from the tetrahedral hohlraum experiments, pick a random image from one of the two movies currently loaded and draw it into a frame buffer object (FBO). The opacity of the image drawn into the FBO is determined by the volume of an incoming audio signal (mixed down to a single channel from the quadraphonic sound currently playing through the PA system). There are three frame buffer objects: one to hold the current frame, one to hold the previous frame (these two are drawn off-screen onto the graphics card), and one that allows for adding the other two together, which is drawn to the screen. Sixty times a second, the opacity of both the new frame and old frame (these values are inversely proportional) is determined based on the volume of the incoming audio signal.

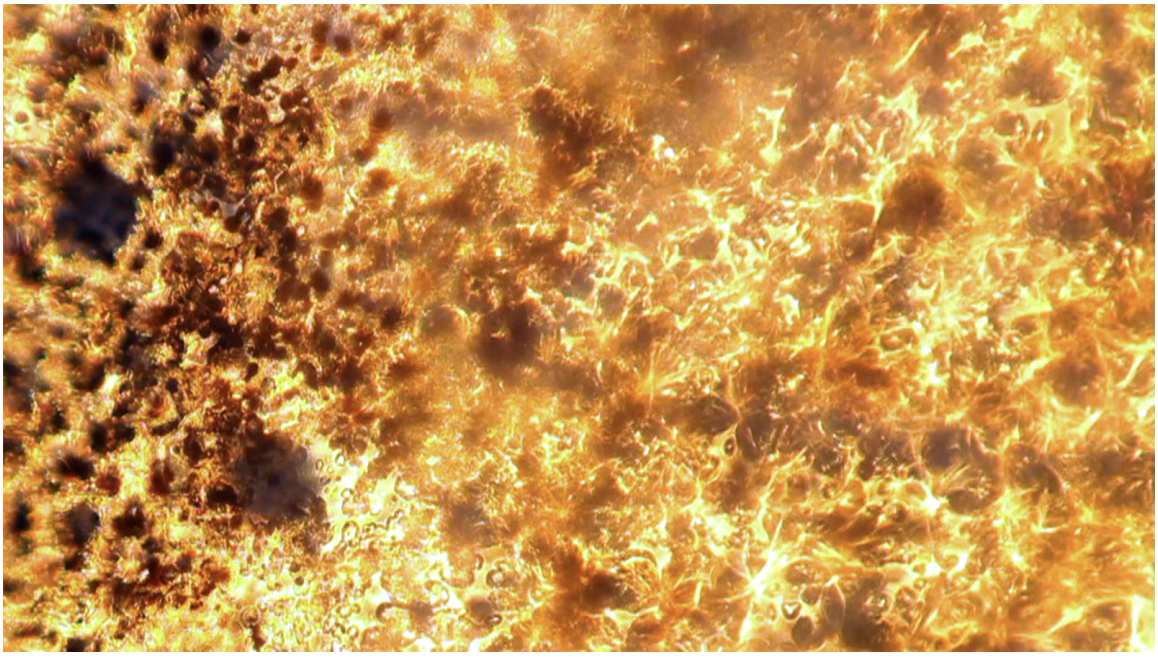

Figure 84. Still from the "peak energy accumulation" section of *Pulse Shape 22* (2012).

It is important to note that, while the foundation of *Pulse Shape 22* is data derived from scientific experiments, this project does seek to reveal patterns in complex data, as in most data visualization / sonification projects. Instead, it is a phenomenological response to the data that aims to situate the listener / viewer inside a *new* experiment. The piece is based on scientific data, but it is transformed and mutated into an artistic work through a personal process that does not seek decoding or quantification.

The visual material used in *Pulse Shape 22* is comprised entirely of images of the sun shot through a custom cast-glass lens designed for this purpose. The sun as the source for visual material was not accidental, but used for its linkages both to nuclear activity and its properties as a generator of electromagnetic energy received our bodies themselves.

> Plants are already dialled into higher regions of the electromagnetic spectrum through photosynthesis. They are patched through a transductive mechanism called a light-harvesting complex that takes sunlight and feeds it into a system of proteins and pigments that feeds the plant. We harvest plants and they harvest light. We feed on them feeding on light. The term "light-harvesting complex" cropped up in the 1930s when biophysicists were historically closer to agrarian culture than in the Cold War years of the 1950s, when the same mechanism began to be called a "light-harvesting antenna." …For the artist James Turrell, plants were not the only ones. "As human beings, we drink light in the form of vitamin D through the skin, so we are literally light eaters."[290]

Pulse Shape 22 is also an investigation into the physicality of light as medium that is closely tied to the history of the "flicker effect" as demonstrated in Brion Gysin and Ian Sommerville's *Dreammachine* as well as in films by Tony Conrad, Peter Kubelka, Paul Sharits, and others, as discussed in the section of this document entitled *Structure / Materialist Film*. However, despite the physical nature of the piece accessed through the use of flicker, and the "expansion" of the screen beyond its borders through projection through a large water lens, I still found that this piece was lacking in dimensionality due to its reliance upon a projection screen as a single, flat focal plane, and that the work was

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[290] Douglas Kahn, "Electrical Atmospheres" in *Invisible Fields: Geographies of Radio Waves*, 26.

more physical and immersive sonically than visually, due to my abilities to incorporate architectural space through the use of sound. These realizations led to a series of experiments with stepper motors and mirrors, working with light sources of striking intensity whose flicker speed could be accessed directly, without needing to rely on film or video projectors with a fixed refresh rate.

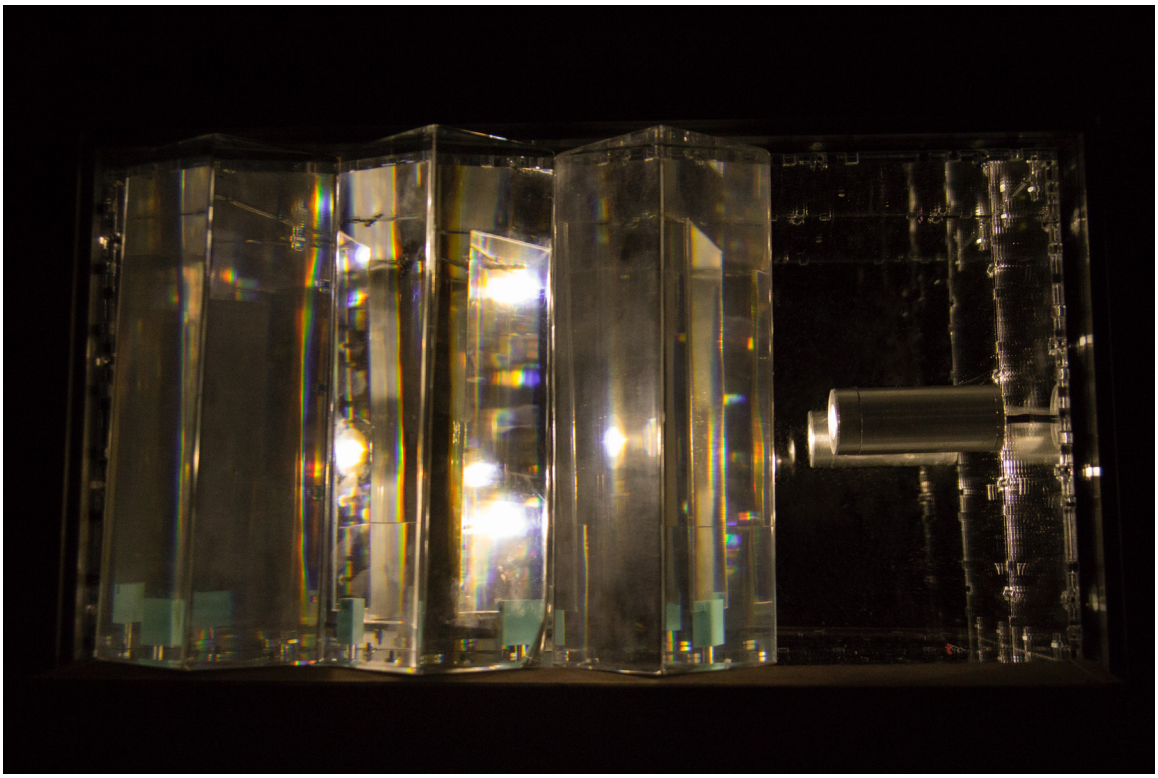


Figure 85. Close-up of *Schaulust* projection apparatus (2015).

The results of these experiments were the *Schaulust* projection apparatus. This apparatus is comprised of three mirrors, each affixed to a stepper motor via a 3D-printed joint, three large optical-quality cast-glass prismatic lenses, a high-powered LED, driver and housing, as well as an Arduino microcontroller, which is used to control the stepper motors and LED. It is situated in a road-ready enclosure, which houses a laser-cut mirrored acrylic shell containing the motors, mirrors, lighting system, and associated wiring.

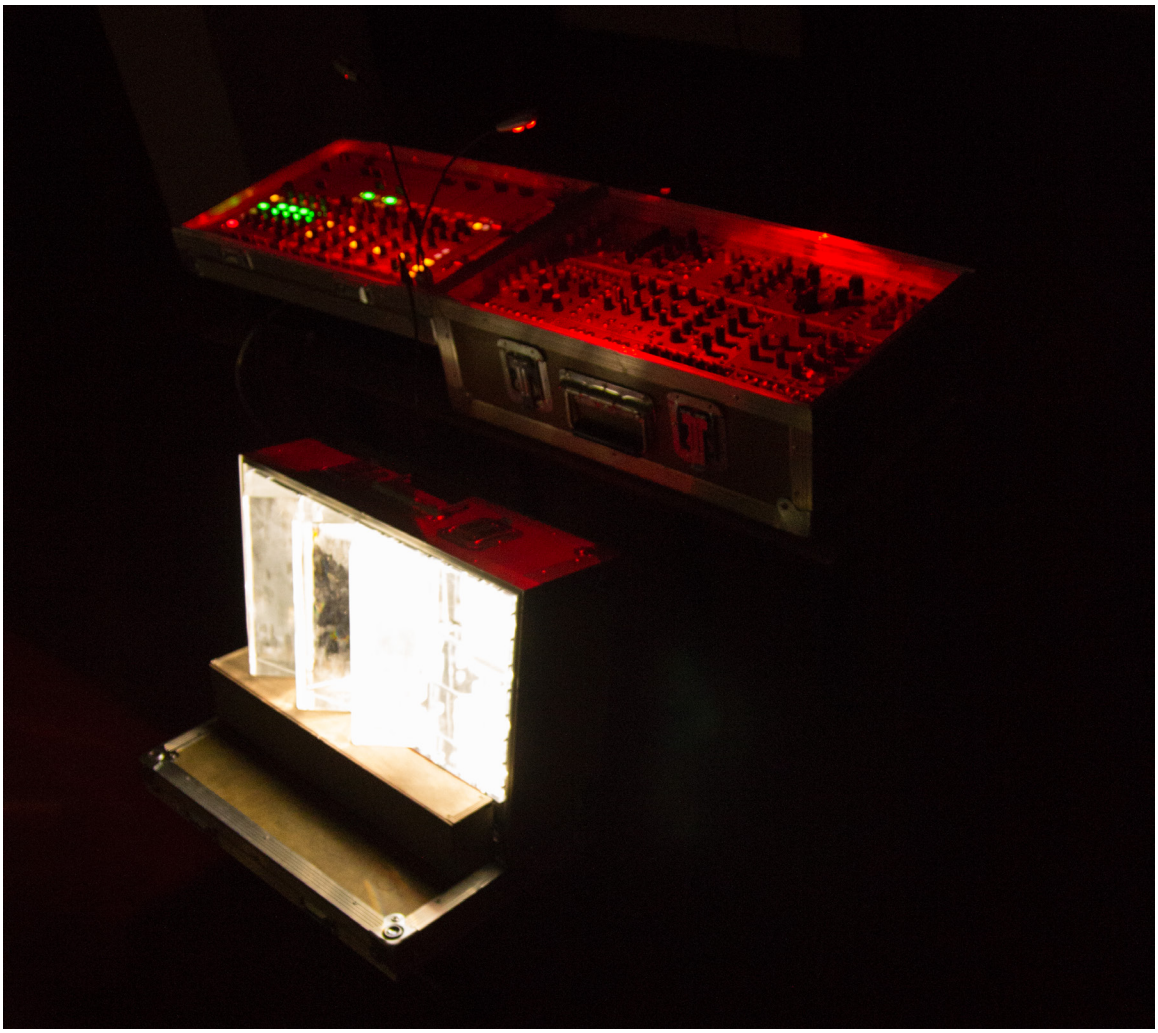
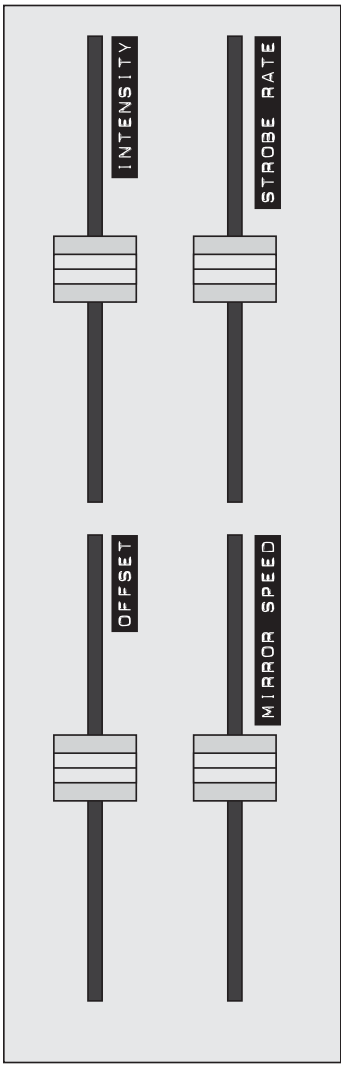


Figure 86. Overview of *Schaulust* performance system (2015).

Commands regulating the motion of the motors, as well as strobe speed and intensity, are sent from SuperCollider to the Arduino board using SuperCollider's Arduino Quark.[291] The strobe speed is based on the rate defined by the global tempo established by *VR E* knob of the VCM-600 (thus corresponding to the rate at which "ticks" are sent to the ES-3 module via an Impulse UGen). The speed of the CV Step Sequencer is used to determine how quickly the mirror closest to the strobe turns in a clockwise direction (two bars = 360 degrees). For each note played by the step sequencers associated

[291] https://github.com/supercollider-quarks/Arduino

with the kick, sub-bass kick, and rimshot / clave drum synthesizers, the middle mirror turns one step; for this mirror, 16 steps is equivalent to 360 degrees clockwise and 360 degrees counterclockwise. For each note played by the step sequencers associated with the snare, hi-hat, and clap drum synthesizers, the mirror furthest from the strobe turns one step; in this case, 32 steps is equivalent to 360 degrees clockwise, and 360 degrees counterclockwise. The volume of the final mix is used to set the intensity of the strobe, so that when there is silence, the maximum brightness of the strobe is complete darkness, and when the volume is at maximum, the "lit" frame of the strobe is at maximum brightness.



In addition to these automated controls, which define the strategies for general operation of the projection apparatus without need for constant hands-on interaction by the performer, there are four pitch sliders from Technics 1200 turntables (featuring center detents) that may be used to control strobe "intensity" (a multiplier which sets the maximum brightness of the strobe) "offset" (a constant value added to the strobe's brightness value, thus setting the range of its minimum and maximum brightness), "rate" (a multiplier which may be used to change the rate of flicker), and "mirror speed" (another multiplier used to speed up, slow down, or entirely stop the mirrors' rotation). The addition of these controls allows for more dramatic changes in the style of projection during a given performance, as described in the following section of this document.

Figure 87. Technics 1200 pitch sliders used to control *Schaulust* projection apparatus.

Schaulust Dissertation Performance

My dissertation performance was created in response to questions and concerns that arose from a number of Schaulust concerts at underground venues throughout the greater Providence area over the year leading up to the presentation of the dissertation work itself.

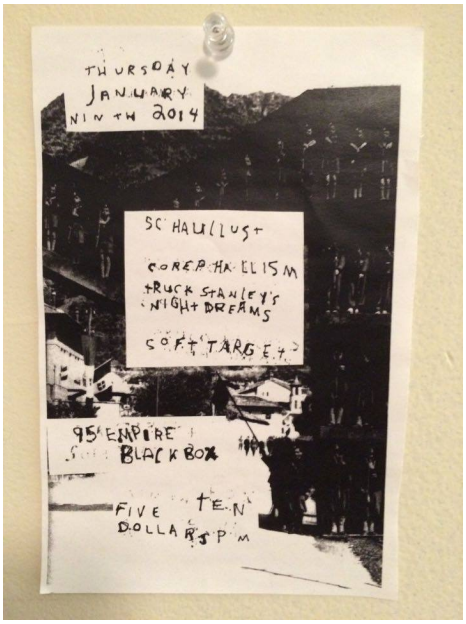


Figure 88. Handbill for first Schaulust performance by Eric Grieshaber..

The first public Schaulust performance was in January 2014 as part of a night jointly organized with Eric Grieshaber at AS220's black box theater at 95 Empire in downtown Providence, alongside performances by Soft Target, Truck Stanley's Night Dreams, and Corephallism. 95 Empire itself presented some challenges that I had not foreseen prior to soundcheck. The space itself is long (roughly 45') and, due to the addition of risers, also fairly narrow, but even importantly: all the walls are black.

This performance utilized something of a "beta" version of the Schaulust projection apparatus, without mirrored plexiglas or the use of prismatic lenses. Given the architectural properties of the space—in particular, the nature of the matte black painted walls—the majority of the projections were simply absorbed into the environment rather

than reflecting back towards the audience. In order to maximize the amount of reflected light, I chose to aim the apparatus towards the corner of the room from a fairly short distance. This helped a bit, but ultimately, only those who positioned themselves at the far end of the room, looking directly into the light were able to experience the full impact of the stroboscopic light.

This performance was not only the premiere performance of the Schaulust projection apparatus, but also of the CV step sequencer, as well as the initial forays into drum sequencing and synthesis of kick and snare drum sounds. Given the fact that neither the drum sequencer nor synthesis engines were fully developed at this time, I decided to augment these technologies with an MPC2000XL, which I used to generate additional rhythmic material, sequenced entirely in real time during the performance.

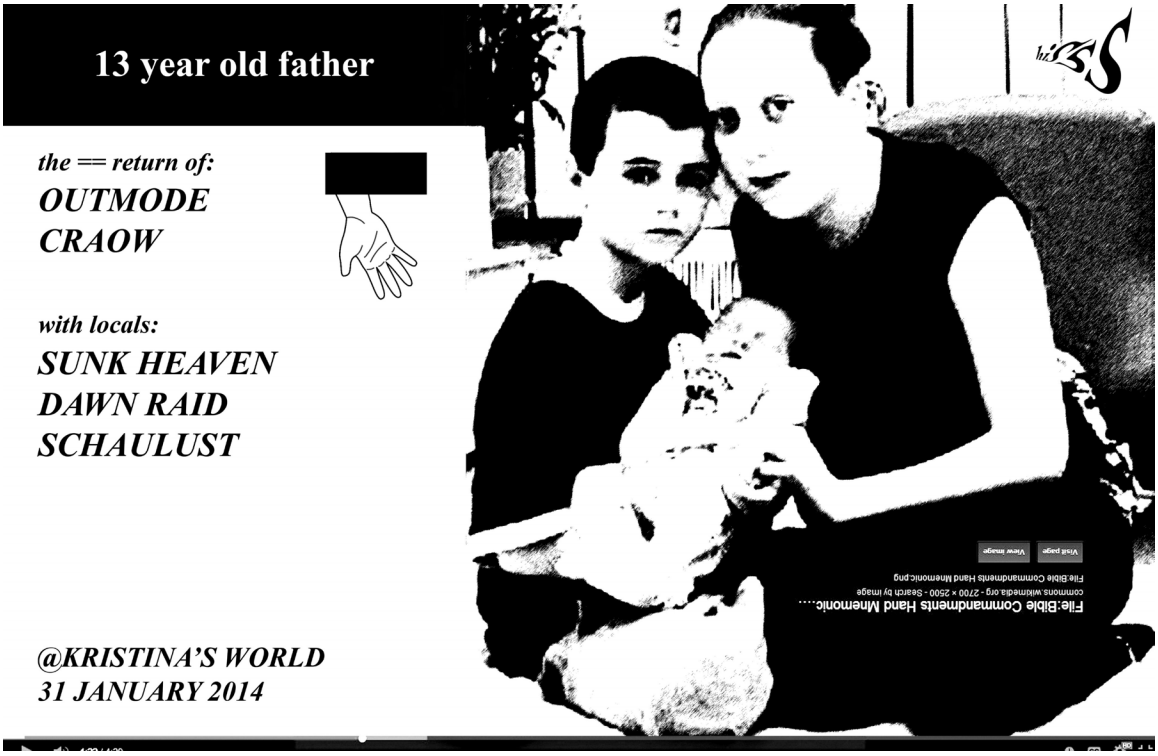


Figure 89. Flyer for Kristina's World performance by Eli V. Manuscript.[292]

[292] https://grossdomesticproduct.wordpress.com/2014/01/31/outmode-craow/

The second Schaulust performance took place at Kristina's World in Olneyville alongside Outmode, Craow, Sunk Heaven, and Dawn Raid, as part of a night curated by Eli "V. Manuscript" Milholland. Kristina's World presented entirely different challenges: the space was small and crowded, with no room for the projection to throw onto a wall. The only choice was to point the projection apparatus directly into the eyes of the people who crowded up to close to the performance area; the light was obscured for the rest of the audience by their knees. Somehow, it was fitting that the audience members up front would receive a full visual onslaught—especially given Kristina's World's reputation for hosting performances of an extreme nature—but ultimately this night reinforced the idea that there are specific parameters that must be met for Schaulust performances to attain the optimal desired effect.

The next performance was at Machines with Magnets in Pawtucket, as part of the Ctrl+Alt+Repeat Ten Year Anniversary celebration alongside Rrose, Blevin Blectum, Shawn Greenlee, and Piero Guimaraes performing Iannis Xenakis' *Psappha*. This evening was not only a wonderful celebration of a decade of Ctrl+Alt+Repeat performances, but also played an essential role in shaping the future of the Schaulust performance platform.

This was the first performance in which I completely eliminated the use of the MPC2000XL. Instead, I utilized six drum sequencers, applied to three identical kick and snare drum synthesis engines, each of which could be controlled and sequenced individually. Thus, the different voices could take on different roles: differently-pitched kick drums could act as low or mid toms, the decay and filter settings for the snare could be adjusted to simulate open or closed hi hats, and so on.

Figure 90. Ctrl+Alt+Repeat Ten Year Anniversary poster by the author.

Due to my prior experience in staging Schaulust performances at other venues, as well as my knowledge of the Machines with Magnets venue itself, I was able to devise a plan that would make both optimal use of the projection system, and take advantage of the architectural qualities of the venue. I realized that the brightness of the projection apparatus could be increased by mirrorizing the internal walls of the apparatus, which I achieved for this performance simply by applying mirror-like stickers to the plexiglas enclosure. In tests leading up to the performance, I also discovered that the qualities of the light could be enhanced through the use of the large cast glass prisms from my RISD thesis project, *Effective Dose*, which were only being used for decorations around our apartment at the time.

Figure 91. Schaulust performance at Ctrl+Alt+Repeat Ten Year Anniversary (2015).

The performance space at Machines with Magnets has high ceilings and a large, white wall on one side of the room, which is typically used as the stage area. By setting up on the opposite side of the room, however, I was able to project the light onto the audience, thus turning their shadows into virtual performers on the walls behind them.

Audience members could choose to stare directly into the strobe, or look at the projections on the walls; this encouraged motion throughout the space and active engagement with the visual material rather than passive spectatorship.

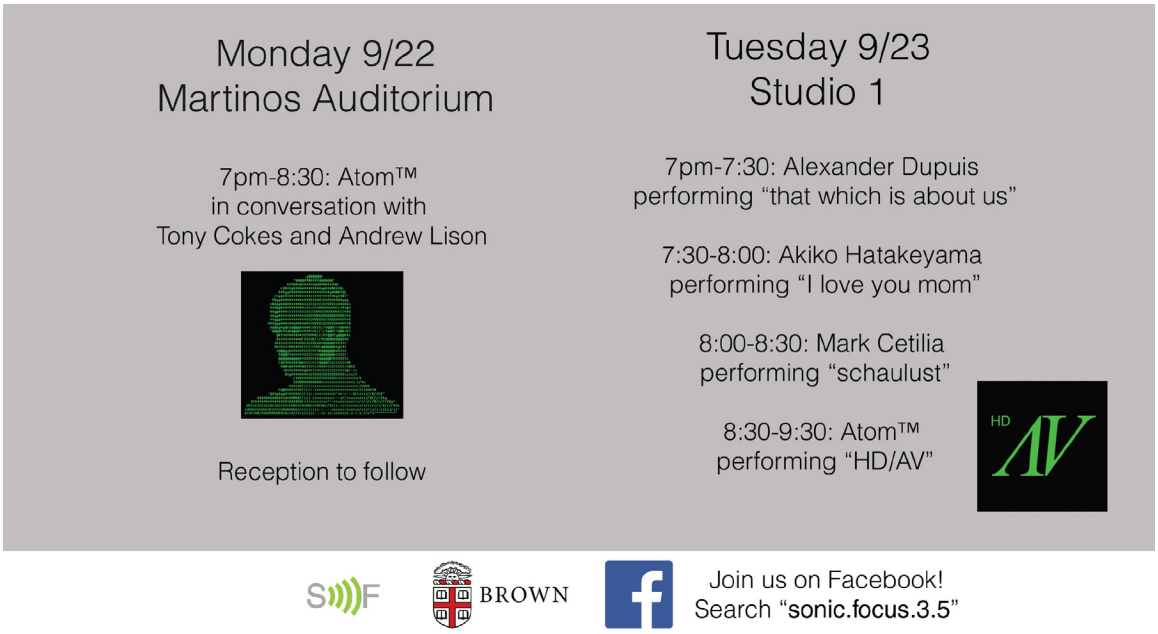


Figure 92. Detail of Sonic Focus 3.5 poster, courtesy of Brown University.[293]

The final Schaulust outing prior to my dissertation performance was in Studio 1 at Brown's Granoff Center for the Arts alongside Atom™, Alexander Dupuis, and Akiko Hatakeyama, as part of the Modern Culture and Media department's Sonic Focus festival. From my past experience, I knew that this space would be problematic for a Schaulust performance, so I replaced the mirror-like stickers applied to the internal walls of the projection apparatus with newly cut mirrorized acrylic, thus amplifying the light even more greatly.

[293] http://www.brown.edu/academics/modern-culture-and-media/sites/brown.edu.academics.modern-culture-and-media/files/uploads/sonic%20focus%203.5%20poster.pdf

However, the space is roughly square with 50' walls on either side—significantly larger than the black box at 95 Empire—and even with this modification, the light was unable to work with the space on an architectural level. Although the walls are not solid black, they are dark enough grey to seriously decrease the intensity of the light, and the ceiling in the room was too high to consider as an alternate projection surface. The only option left available was putting up a screen behind myself and projecting onto it. This was successful in terms of providing a bright projected image, but it did not activate nor engage with the space in a meaningful way as intended. If anything, this resulted in the most traditional, "spectacular"[294] performance yet, aided and abetted by the chairs set out for audience members to passively soak in the performance. However, this performance gave me the opportunity to try out all six drum synthesis engines and the new pad controller driven drum sequencers in a live setting, programming and manipulating rhythmic sequences in ways that are not possible with the MPC2000XL, so it was an important step in becoming comfortable with these new performance tools prior to my dissertation performance.

Given that my dissertation performance was to be a self-contained entity, with no other artists presenting work beforehand, it became clear to me that it would be necessary to set the mood for the evening as the audience arrived. This was achieved by turning off all sources of light, blocking off any light from hallways adjacent to the room, and allowing participants to enter the room and adjust their eyes and ears to the dim light and constantly shifting soundscape they encounter therein.

The dissertation piece itself begins in near darkness, with only two small red lights a generative patch left to run unattended for approximately twenty minutes. In this patch, an Analogue Systems RS-95e oscillator's output is fed into a STG Soundlabs Wave Folder

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[294] For more on this topic, cf. Guy Debord, *Society of the Spectacle*.

module, from the Wave Folder (the output of which is set to be completely silent unless it receives a voltage on its Amount Input jack) to the input of an Analogue Systems RS-500e filter module, and then to a Low-Gain Electronics SubMix7 mixer module, from which it is sent to SuperCollider via an optical connection using an Expert Sleepers ES-6 CV / Lightpipe Interface module.

The output of the RS-500e is also passed to the EXP CV input of a Bananalogue Serge VCS module, whose output is passed to the input of a Make Noise QMMG multi-mode gate module. The QMMG is set such that its output is completely silent unless it receives an voltage on its filter frequency input, and the output of one Low-Pass Gate is streamed to a High-Pass Gate (each with high resonance settings), and from there to the SubMix7 module, as well as the CV2 input of a Doepfer A-111 oscillator module.

The A-111's sine wave output is sent to the input of a Flight of Harmony Plague Bearer filter / waveshaper module. The Plague Bearer is set such that it gives the sine wave a great deal of "grit," and its output is then passed on to a Macbeth Dual SV Filter, whose Bandpass output is set to be silent without receiving a signal on its Log CV In jack, and its output is then patched into both the SubMix7 module, as well as the CV-In Vary (frequency) jack of the RS-95e, thus completing a feedback loop between these three modules.

The DC output of an Elby Panther VCS module, running at very slow speeds, is then patched to the CV-In Vary (frequency) input of the RS-500e filter module. The output of an Intellijel Rubicon, running in LFO mode at a very low frequency, is then patched to the frequency input on the QMMG. The sine wave output of a Doepfer A-145 LFO, running at its lowest possible frequency, is patched to the Log CV In jack of the Macbeth SV Filter module. These three LFOs are not synced to one another in any way, and thus the results of this (fairly simple) generative system are completely unpredictable.

However, the general sound of the patch is an ebbing and flowing, into and out of silence, pure sweeping tones, and chaotic modulations feeding back into noise.

The intent of this section of the piece is to set the stage for the performance, creating a space for contemplation as well as a sense of anticipation. Throughout this time, audience members' eyes are given time to adjust to the darkness: the only source of light in the room is derived from two small red gooseneck lamps mounted in the flight case above the VCM-600. Windows behind the performance area were also left uncovered, allowing a peek into the dimly lit courtyard outside.

Figure 93. Early section of *Schaulust* dissertation performance. Photo by Bettina Knoll.[295]

[295] http://mark.cetilia.org/about/photographs/

As the audience slowly arrives and settles, I wait for an opportune moment to begin the performance, finally entering during a moment of silence from an empty hallway to stage right. Arriving at the control surface, I begin sampling the output of the generative patch with a few different loopers and phase vocoders, slightly shifting their frequencies and stretching them out over time to create difference tones, and passing their outputs to an accumulator and granulator for further manipulation. As these frequencies thicken and fold in on themselves, a thunderous presence becomes evident, looming far in the distance.

A steady pulse rises from the ether, accompanied by sparse flashes of light, the rhythmic matrix gradually coming into focus as the initial soundfield fades into the distance. Clean, sharp stabs of light and sonic energy are driven into the room, and into the participants' eyes and ears. A cascading crescendo of polyrhythms manifest, along with rainbow-tinted beams of light shot throughout the room, revealing faces in the audience and strange architectural details on the ceiling. Different meters emerge, competing for space and attention.

Figure 94. Crowd during *Schaulust* performance. Photo by Laura Cetilia.

Staring directly into the light is unbearable, yet unavoidable—some participants close their eyes and let it soak in, others seem oblivious to the potential for retinal damage, choosing to stare straight ahead. Rhythmic density reaches critical mass, leaving no discernible space between notes and coalescing into a solid blanket of sound. Light has ceased moving through the room, yet the levels of visual intensity continue to build. The searing noise is relentless, all-consuming. The light begins to fade, allowing for glimpses through the darkness, reversing roles of observer and observed. In a breath, all light and sound disappears, leaving in its place nothing but a vacuum.

Conclusion

I learned from prior performances that finding the right space was very important to the success of my dissertation—and to that of future Schaulust performances. In planning my dissertation, I undertook a number of site visits around campus, and decided upon the Kasper Multipurpose room in the basement of the Student Center for a number of reasons. First, it is a public space in the middle of campus, so it could attract audience members that might not typically seek out concerts in traditional settings. Second, this room was attractive logistically, in that it was possible to reserve it for long enough to successfully block off any external light that might be distracting to the performance, such as that coming through the doors between the space and the rest of the building.

Figure 95. Kasper Multipurpose room during dress rehearsal with doors uncovered.

Third, and perhaps most importantly, it is a visually striking space. In spite of being fairly large, it has a low ceilings that the projections could illuminate, and this

ceiling hosts a number of interesting architectural features, all of which are painted white. This allowed me to use the projection to draw attention to these architectural features through the use of projection, rather than simply trying to treat the site as a blank slate.

Figure 96. Kasper Multipurpose room during dress rehearsal; note ceiling and windows.

On one side of the room, the windows face out onto the street side of the building. Fortunately, I was able to draw the (already installed) shades such that any head- or tail-lights from traffic passing above would not interfere with the projected light within the room itself. On the other side of the room, the windows open out onto an empty, but dimly lit courtyard, which I decided to use as a backdrop to my performance. This gave the room a sense of openness and space for contemplation of the specific situation in which the performance was taking place, without diminishing the effect or intensity of the stroboscopic light. The choice of site set a very specific tone for the performance: one that was meditative and contemplative despite the often abrasive light and sound. Audience

members chose to bask in the atmosphere, and interacted with the performance in ways that I could not have anticipated.

Ultimately, I believe that my dissertation performance was successful on a number of levels. First, I was able to acknowledge the architectural elements of the site and its physical location in the world, and integrate them into the piece. Also, I was also able to craft the ideal system for the realization of my dissertation piece through hands-on experience in prior performances, making necessary revisions to the sequencers and synthesis engines, as well as the projection apparatus, along the way. This piece also combined a number of interests: the use of generative / chaotic systems, polyrhythmic or polymetric patterns, structured improvisation, stroboscopic light, and the development of hybrid systems—both analog / digital, and visual / sonic. Most importantly, the work undertaken in putting together this performance and the technology involved for its successful realization have laid a foundation for future performances for years to come.

Future Directions

In moving forward, I have defined a number of objectives. My first task is to combine the functionalities of the gesture recorder / playback engine currently controlled by a Korg Nanokontrol2 fader box and the custom drum sequencer controlled by an Akai LPD-8 drum pad / knob box into a single physical interface using a Pioneer DDJ-SP1. The DDJ-SP1 offers drum pads that take a unique approach towards the implementation of polyphonic aftertouch (the "aftertouch" data they send is actually in the form of separate MIDI controls per pad), knobs that send two MIDI continuous controls in the form of MSB / LSB values, thus increasing the resolution from 128 steps to 16,384 steps, and features an intricately-mapped set of controls.

Figure 97. Pioneer DDJ-SP1 overview.[296]

The DDJ-SP1 was created to use with Serato Scratch software, and as such, its mapping conventions and layout are very specific to the details of this software—a number of the controls (though not all) have multiple "modes" that send different control

[296]http://www.pioneerelectronics.com/PUSA/DJ/Controllers/DDJ-SP1

values that are not necessarily correlated in any way. However, once I have completed the process of mapping and integrating the DDJ-SP1, this control surface will provide a great deal of flexibility and easily allow for the development of further functionality without need for additional hardware.

I also plan to implement other algorithms for generating rhythmic patterns and gestural data, beginning with a port of my 2005 "GAK" (Genetic Algorithm Kit) Max external. This object first selects a random "crossover point" and merges two sequences fed into the algorithm, resulting in a "child" sequence (though this child sequence may also be passed in directly by the user). Once a child sequence has been generated, the algorithm may reverse the sequence, shift it forward or backwards a random number of steps, transpose it a random number of notes up or down, or increment / decrement each step within a the sequence a random number of notes up or down, in any combination selected by the user, or in a random combination selected by the machine.

Figure 98. Help file for my 2005 GAK (Genetic Algorithm Kit) Max external .[297]

[297] mark.cetilia.org/downloads/gak.zip

I have also come to terms with the idea that—in performances of dance music—I do not need to generate all sound signals and rhythmic patterns in real time. Since accepting this idea, I have begun re-incorporating hardware-based sequencers and drum machines such as the MPC2000XL and an Elektron Analog Rytm into my performances, which this has allowed for greater fluidity and a relaxed state of mind during performances.

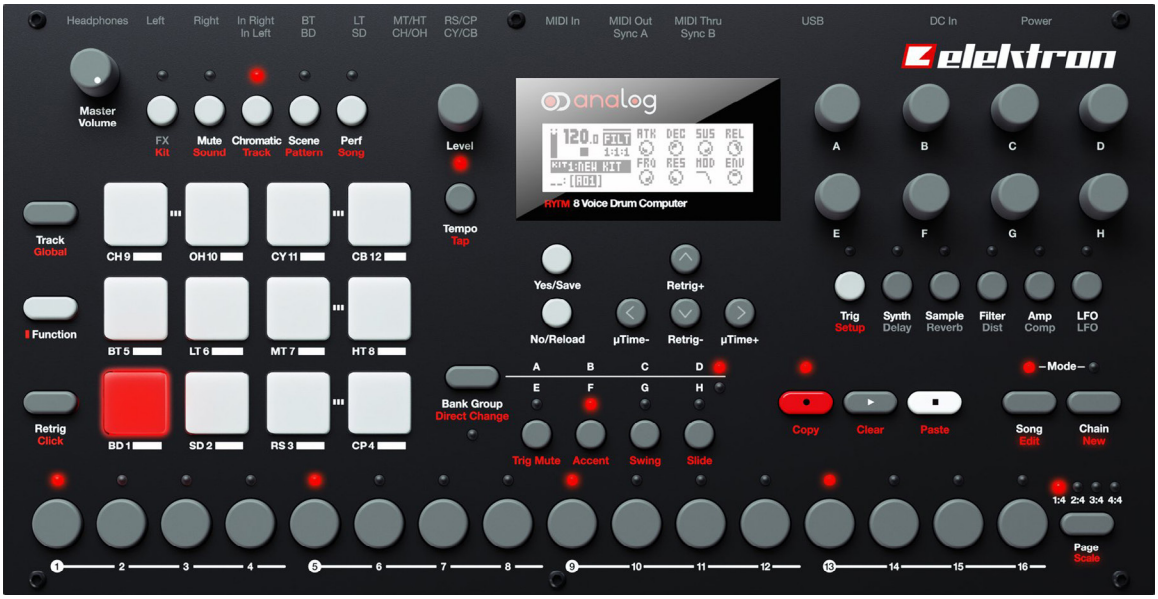

Figure 99. Front panel of Elektron's Analog Rytm.[298]

I no longer find myself limited by the constraints of these machines, as I have created my own versions of them that do the things that they cannot, and can continue expanding upon their abilities as necessary. Rather, I am empowered by the ability to recall past performances, often made in the privacy of my home studio, and re-imagined in a live setting. This allows me to focus my energies in these performances towards the manipulation of the rhythmic content by muting or soloing specific "instruments" and rapidly switching between patterns, live processing of the resulting sounds utilizing the Fraktur hybrid analog / digital performance system, and generation / manipulation of additional sounds in real time, while having a basic structure to work with / deviate from.

[298] http://eu.elektron.se/drum-machines/analog-rytm/

One of the more surprising and unexpected outcomes of my dissertation performance was the lack of direct physical engagement with the music, despite the "dancefloor" energy being put forward by the music. I was initially taken aback by this lack of physical engagement, but upon further reflection, I have come to the conclusion to that just because the participants were not moving, it does not mean that they were not engaged. In fact, in a 2014 interview, Jeff Mills said:

> I've been DJing for 30-something years now, and I can see that people are dancing much, much less than they used to… I've seen it gradually decline to the point where people just stand there and move their arms, like in hip hop. Eventually, I have to assume that techno will just be listened to… To be frank, I think we don't dance as much because we don't actually like it… Hearing the sound system pumping, hearing a really good song—we're more into that than looking at others physically move…[299]

Hearing this from Mills certainly eased any concerns I had previously in regards to any necessity for dance (related) music to act as a physical activator. In the same interview, Mills also said: "If you can dance to it, that's great, that's a bonus, but music should say something. It should be made in a manner with seriousness, and that would enlighten someone simply by listening to it."[300] This attitude summarizes my current position on future performances in this vein. In the meantime, I have decided to set aside some time to work on new fixed media pieces utilizing generative video systems in conjunction with a new project I am calling Apathy and Steel. These works continue my interest in optical overstimulation, rhythm and noise, and will be made available in the form of both audio recordings to be released as commercial products, and audiovisual works that may be screened in the context of film festivals, installed in galleries, released on physical media, or used as promotional materials for audio recordings; the material used to create these works also serve as the backbone for concomitant live performances.

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[299] Lauren Martin, "Jeff Mills Delves Deep Into Space, Time, and the Future of Techno," 1.

[300] *Ibid.*

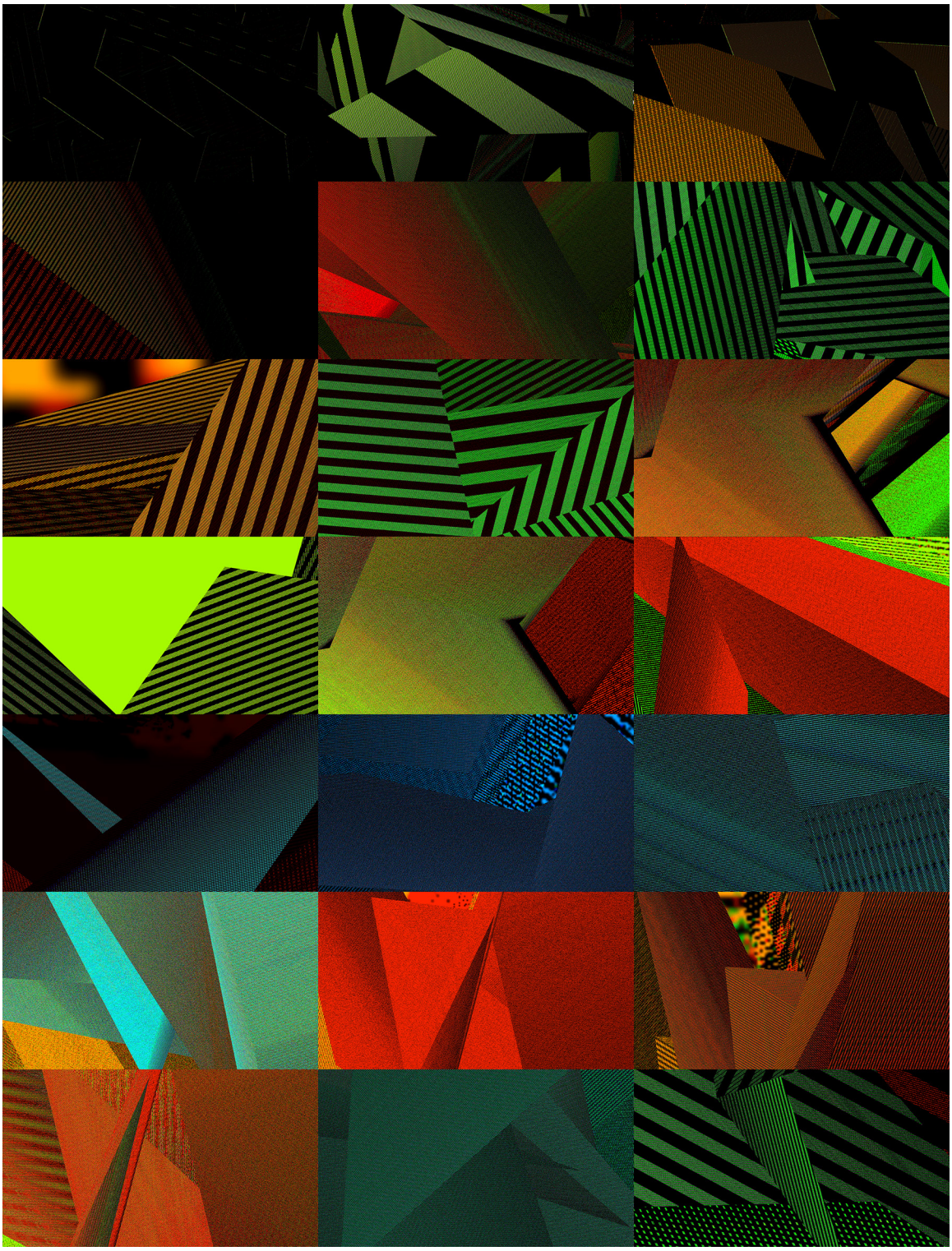


Figure 100. Stills from *Mountains of Cinder* (Apathy and Steel, 2105).

In terms of future Schaulust performances, I foresee integrating the projection apparatus developed for my dissertation project with the generative video system I am currently developing for Apathy and Steel. This integration will be accomplished either by placing a hacked LCD screen between the strobe and the prisms, expanding upon the way that my piece *Effective Dose* initially merged these technologies, or by replacing / augmenting the strobe light with a video projector, possibly in conjunction with the development of a new and more scalable projection system using easily collapsable / transportable materials such as water lenses made out of acrylic sheet, filled on site. As James Stinson of Drexciya once said, "experiments must continue, even until death."[301]

[301] Drexciya. Interview with Liz Copeland. *Music Overnight*, WDET 101.9FM. Detroit, May 2002.

APPENDICES

Appendix A: Bibliography

Ablinger, Peter. *Rauschen*, http://ablinger.mur.at/rauschen.html (accessed October, 2015).

Futurist Manifestos, ed. Apollonio, Umbro. New York, NY: The Viking Press, 1973.

Aristotle. *On Sense and the Sensible*. Adelaide: The University of Adelaide Library, 2007.

Aristotle. *Problems: Books I – XXI*. Cambridge, MA: Harvard University Press, 2000.

Arthur, Paul. *A Line of Sight: American Avant-Garde Film Since 1965*. Minneapolis, MN: University of Minnesota Press, 2005.

Arthur, Paul. "Creating Spectacle from Dross: The Chimeric Cinema of Ken Jacobs" in *Film Comment* Vol. 33 Issue 2, January 1997: 58 – 67.

Arthur, Paul. "Structural Film: Revisions, New Versions, and the Artifact." *Millennium Film Journal* 1, no. 2 (1978): 5 – 13.

Arthur, Paul. "Structural Film: Revisions, New Versions, and the Artifact, Part Two." *Millennium Film Journal* 4 – 5, (1979): 122 – 134.

Attali, Jacques. *Noise: The Political Economy of Music*, trans. Brian Massumi. Minneapolis, MN: University of Minnesota Press, 1985.

Audio Culture: Readings in Modern Music. eds. Warner, Daniel, and Christoph Cox. New York, NY: Continuum International Publishing, 2006.

Bailey, Derek. Improvisation: Its Nature and Practice in Music. Boston, MA: Da Capo, 1992.

Barthes, Roland. *Camera Lucida: Reflections on Photography*. First American Edition. New York, NY: Hill and Wang, 1981.

Bausola, David, Enrike Hurtado, and Thor Magnusson. "Supercollider Tutorial." http://www.ixi-audio.net/content/download/tutorials/supercollider_tutorial.tar (accessed October, 2015).

Bausola, David, Enrike Hurtado and Thor Magnusson, "ixiQuarks - version 7." http://www.ixi-software.net/content/body_software_ixiquarks.html (accessed October, 2015).

Bazin, André. *What Is Cinema?* Berkeley, CA: University of California Press, 1971.

Paul Sharits, ed. Beauvais, Yann. Dijon: Les Presses du Réel, 2008.

Beta, Andy. "Two Artists Light the Way Into the Mind" in *The Wall Street Journal, December 11, 2012*, A26.

Lowering the Boom: Critical Studies in Film Sound, eds.Beck, Jay and Tony Grajeda. Urbana, IL: University of Illinois Press, 2008.

Brewster, Bill and Frank Broughton. *Last Night a DJ Saved My Life: The History of the Disc Jockey*. New York, NY: Grove Press, 2006.

Brougher, Kerry, and Olivia Mattis. *Visual Music : Synaesthesia in Art and Music Since 1900*. First Edition. New York, NY: Thames & Hudson, Hirshhorn Museum Museum of Contemporary Art, 2005.

Brown, Barclay. "The Noise Instruments of Luigi Russolo" in *Perspectives of New Music* Volume 20, No. 1/2, 1982, 31 – 48.

Brøgger, Andreas, and Omar Kholeif. *Vision, Memory and Media.* FACT Series, Liverpool: Liverpool University Press, 2011.

Buchla and Associates, "Series 200e FAQ." https://web.archive.org/web/20130925203959/http://www.buchla.com/series200e_faq.html (accessed October, 2015).

Buchla and Associates, "Buchla Series 300: Digital Control for 200 Series Modules." https://web.archive.org/web/20120425231149/http://buchla.com/historical/b300/ (accessed October, 2015).

Burk, Phil, Larry Polansky, Douglas Repetto, Mary Roberts, and Dan Rockmore. "Music and Computers: A Theoretical and Historical Approach." http://music.columbia.edu/cmc/MusicAndComputers/ (accessed October, 2015).

Butterfield, Jan. *The Art of Light and Space*. New York, NY: Abbeville Modern Art Movements, 1993.

Cage, John. *Empty Words: Writings '73 – '78*. Middletown, CT: Wesleyan University Press, 1981.

Cage, John. *Silence: Lectures and Writings*. Hanover, NH: Wesleyan University Press, 1961.

Cage, John, Robert Shattuck, and Alan Gillmor, "Erik Satie: A Conversation" *Contact*, No. 25 (Autumn 1982), 21 – 26.

Campen, Cretien van. *The Hidden Sense: Synaesthesia in Art and Science*. Cambridge, MA: The MIT Press, 2008.

de Campo, Alberto. "GamePad Quark." https://github.com/supercollider-quarks/GamePad (accessed October, 2015).

Cardew, Cornelius. *Towards an Ethic of Improvisation*, http://www.ubu.com/papers/cardew_ethics.html (accessed October, 2015).

Ceram, C.W. *Archaeology of the Cinema.* First American Edition. New York, NY: Harcourt, Brace & World, 1965.

Cetilia, Mark. "Effective Dose: Creating Physiological Responses to Invisible Networks." Master's thesis, Rhode Island School of Design, 2008.

Chadabe, Joel. *Electric Sound: The Past and Promise of Electronic Music*. Upper Saddle River, NJ: Prentice Hall, 1996.

Chion, Michel, Claudia Gorbman, and Walter Murch. *Audio-Vision : Sound on Screen*. New York, NY: Columbia University Press, 1994.

Chowning, John, "The Synthesis of Complex Audio Spectra by Means of Frequency Modulation" in *Journal of the Audio Engineering Society* Volume 21 Issue 7, 526 – 34.

Cipriani, Alessandro, and Maurizio Giri. *Electronic Music and Sound Design: Theory and Practice with Max/Msp*. Rome: ConTempoNet, 2010.

The Cambridge Companion to Electronic Music, eds. Collins, Nick, and Julio d'Escriván. New York, NY: Cambridge University Press, 2007.

Collins, Nick. *Introduction to Computer Music*. West Sussex: Wiley, 2010.

Collins, Nicolas. *Handmade Electronic Music: The Art of Hardware Hacking*. New York, NY: Routledge, 2006.

Conrad, Tony. "Tony Conrad On The Flicker" in *Film Culture 41,* 1966, 1 – 3.

Music, Cognition, and Computerized Sound: An Introduction to Psychoacoustics, ed. Cook, Perry R. Cambridge, MA: MIT Press, 1999.

Cope, David. *New Directions in Music*. Long Grove, IL: Waveland Press, 2001.

Cornwell, Regina. "Paul Sharits: Illusion and Object." *Artforum* X, No. 1 (1971): 56 – 62.

Cottle, David Michael. "Computer Music With Examples in SuperCollider 3," 2005.

Crary, Jonathan. *Techniques of the Observer: On Vision and Modernity in the 19th Century*. Cambridge, MA: The MIT Press, 1992.

Expanded Cinema: Art, Performance, Film. eds. Curtis, David, A. L. Rees, Duncan White, and Steven Ball. London: Tate Publishing, 2011.

Cycling '74. *Cycling '74 Max:* https://cycling74.com (accessed October, 2015).

Cycling '74, *MSP Tutorials*. http://cycling74.com/docs/max5/tutorials/msp-tut/mspindex.html (accessed October, 2015).

Dargis, Manohla. “Deconstructing Cinema in Order to Reveal it.” The New York Times, 2009.

Davidson, David. “Ken Jacobs and Experimental Cinema (Toronto 2011)” in *Toronto Film Review:* http://torontofilmreview.blogspot.com/2011/12/ken-jacobs-and-experimental-films.html (accessed October, 2015).

De Lauretis, Teresa, and Stephen Heath. *The Cinematic Apparatus*. New York, NY: St. Martin’s Press, 1980.

Debord, Guy. *Society of the Spectacle*. Detroit, MI: Black and Red, 2000.

Demers, Joanna. *Listening through the Noise: The Aesthetics of Experimental Electronic Music.* New York, NY: Oxford University Press, 2010.

Dodge, Charles and Thomas A. Jerse. *Computer Music*: *Synthesis, Composition, and Performance* (Second Edition). New York, NY: Schirmer Books, 1997.

Drexciya. Interview with Liz Copeland. *Music Overnight*, WDET 101.9FM. Detroit, May 2002. https://www.mixcloud.com/backintosh/drexciya-interview-with-liz-copeland-music-overnight-wdet-1019-fm-detroit-052002/ (accessed November, 2015).

Duchamp, Marcel. *Marcel Duchamp: Works, Writings and Interviews*. ed. Moure. Gloria. Barcelona: Ediciones Polígrafa, 2009.

Duchamp, Marcel. *The Essential Writings of Marcel Duchamp: Salt Seller = Marchand Du Sel*. London: Thames and Hudson, 1975.

Duchamp, Marcel. *The Writings of Marcel Duchamp*. eds. Sanouillet, Michel and Elmer Peterson. New York, NY: Oxford University Press, 1973.

Dunne, Anthony, and Fiona Raby. *Design Noir: The Secret Life of Electronic Objects*. Boston, MA: Birkhäuser, 2001.

Eamon, Christopher, Branden W. Joseph, and Jonathan Walley. *Anthony Mccall: The Solid Light Films and Related Works*. 1 ed. Evanston, IL: Northwestern University Press, 2005.

Eco, Umberto. *The Open Work*. Cambridge, MA: Harvard University Press, 1989.

Elderfield, John. *Kurt Schwitters*. London: Thames and Hudson, 1985.

Emmerson, Simon. *Living Electronic Music*, Berlington, VT: Ashgate, 20007.

E-Mu Systems, “E-Mu Systems: Product History.” http://www.creative.com/emu/company/history/timeline/ (accessed October, 2015).

Expert Sleepers, “ES-3 Lightpipe/CV Interface.” http://www.expert-sleepers.co.uk/es3.html (accessed October, 2015).

Export, Valie. "Expanded Cinema as Expanded Reality." *Senses of Cinema* 28, (2003): http://sensesofcinema.com/2003/28/expanded_cinema/ (accessed October, 2015).

Falk, David R., Dieter R. Brill, and David G. Stork. *Seeing the Light: Optics in Nature, Photography, Color, Vision, and Holography*. New York, NY: Wiley, 1986.

Fastl, Hugo and Eberhard Zwicker. *Psychoacoustics: Facts and Models*, New York, NY: Springer, 2007.

Fieldsteel, Eli. "Infinite Hold Reverb in SuperCollider." http://www.youtube.com/watch?v=_2N7lG5uzJI (accessed October, 2015).

Foster, Hal. *The Anti-Aesthetic: Essays on Postmodern Culture.* First Edition. Port Townsend, WA: Bay Press, 1983.

Gamard, Elizabeth Burns. *Kurt Schwitters' Merzbau: The Cathedral of Erotic Misery*. New York, NY: Princeton Architectural Press, 2000.

Geiger, John. *Chapel of Extreme Experience: A Short History of Stroboscopic Light and the Dream Machine*. Brooklyn, NY: Soft Skull Press, 2003.

Structural Film Anthology, ed. Gidal, Peter. London: British Film Institute, 1978.

Alessio Galbiati, "Ken Jacobs: The Demiurgo Of The Moving Image" in *Digimag: The Digicult's Project Journal*, Issue 32 (March, 2008): http://www.digicult.it/digimag/issue-032/ken-jacobs-the-demiurgo-of-the-moving-image/ (accessed October, 2015).

The Grove Dictionary of American Music, ed. Garrett, Charles Hiroshi. Second Edition. New York, NY: Oxford University Press, 2013.

Gidal, Peter. *Materialist Film*. First Edition, Second Impression. New, York, NY: Routledge, 1989.

Structural Film Anthology, ed. Gidal, Peter. London: MIT Press, 1976.

New Media, 1740 – 1915: Media in Transition, eds. Gitelman, Lisa, and Geoffrey B. Pingree. Cambridge, MA: MIT Press, 2003.

Illuminating Video: An Essential Guide to Video Art, eds. Hall, Doug, and Sally Jo Fifer. New York, NY: Aperture / BAVC, 2005.

Hall, William. "Ian Fritz Through Zero (TZ) Oscillator 'Teezer' Construction" in *Bill and Will's Synth*. http://www.dragonflyalley.com/constructionFritzTZVCO.htm#background (accessed October, 2015).

Halle, Randall, and Reinhild Steingröver. *After the Avant-Garde: Contemporary German and Austrian Experimental Film*. ed. Zorn, John, and Martin Scorsese. Rochester, NY: Camden House, 2008.

Halter, Ed. "The Matter of Electronics." *Mediateca Expandida* 2, (2009): 70 – 74.

Halter, Ed. "Powers of Projection." *Artforum* January 2010, 182 – 185.

Hanlon, Lindley and Tony Pipolo. "Interview with Ken and Flo Jacobs" in *Millenium Film Journal: 20th Anniversary Special Edition* Nos. 16/17/18, 26 – 53.

Hanlon, Lindley. "Kenneth Jacobs, Interviewed By Linley Hanlon (Jerry Sims Present) April 9, 1974." *Film Culture* 67 – 69, 1979, 65 – 86.

Hatfield, Shawn. *Drool String Ukelele*: http://www.audibleoddities.com/twerk/?p=6 (accessed October, 2015).

Hayward, Susan. *Cinema Studies: The Key Concepts*. 2nd ed. London ; New York, NY: Routledge, 2000.

Hegarty, Paul. *Noise/Music: A History*. New York, NY: Continuum International Publishing, 2007.

Helmholtz, Hermann von, and Alexander John Ellis. *On the Sensations of Tone as a Physiological Basis for the Theory of Music.* Second English Edition. New York, NY: Dover Publications, 1954.

Hensley, Chad. "The Beauty of Noise: An Interview With Masami Akita of Merzbow." *EsoTerra #8* (1999): http://www.esoterra.org/merzbow.htm (accessed October, 2015).

Hoberman, J. *Jack Smith and His Secret Flix*, New York, NY: American Museum of the Moving Image, 1998.

Hofmann, Hans. *Search for the Real and Other Essays*, Cambridge, MA: The MIT Press, 1967.

Holmes, Thomas B. *Electronic and Experimental Music: Pioneers in Technology and Composition*. New York, NY: Routledge, 2002.

Hughes, Robert. *The Shock of the New: Art and the Century of Change*. New York, NY: Alfred A. Knopf, 1991.

Hutchins, Charles Céleste. "How to Program in Supercollider." http://sc3howto.blogspot.com/ (accessed October, 2015).

Hutchins, Charles Céleste. "Supercollider Tutorial." http://www.berkeleynoise.com/celesteh/podcast/projects/abandoned-tutorial/ (accessed October, 2015).

Huhtamo, Erkki. "Trouble At the Interface, Or the Identity Crisis of Interactive Art." *The Finnish Art Review* (2004): 1 – 9.

Huhtamo, Erkki, and Eizō Gakkai Nihon. *Elements of Screenology: Toward an Archaeology of the Screen*. Japan Society of Image Arts and Sciences, 2004.

Huhtamo, Erkki., and Jussi Parikka. *Media Archaeology: Approaches, Applications, and Implications*. Berkeley, Calif.: University of California Press, 2011.

Iles, Chrissie. *Into the Light: The Projected Image in American Art, 1964 – 1977*. New York, NY: Whitney Museum of American Art: Distributed by H.N. Abrams, 2001.

Ihlein, Lucas. "Pre-Digital New Media Art." *RealTime Arts* 66, (2005): 26.

Jacobs, Ken. "Capitalism: Slavery." New York, NY: Electronic Arts Intermix, 2006.

Jacobs, Ken. *Films That Tell Time: A Ken Jacobs Retrospective*, New York, NY: American Museum of the Moving Image, 1989.

Jacobs, Ken. "Flo Rounds A Corner." New York, NY: Electronic Arts Intermix, 1999.

Jacobs, Ken. "Little Stabs at Happiness," Ubuweb (1960): http://www.ubu.com/film/jacobs_stabs.html (accessed October, 2015).

Jacobs, Ken. "New York Street Trolleys 1900." New York, NY: Electronic Arts Intermix, 1999.

Jacobs, Ken. "Notes on The Nervous System" in *Films That Tell Time: A Ken Jacobs Retrospective.* Astoria, NY: American Museum of the Moving Image, 1989, 29 – 62.

Jacobs, Ken. "Ontic Antics Starring Laurel and Hardy: Bye, Molly / Let There Be Whistle Blowers." New York, NY: Tribeca Film Institute, 2005.

Jacobs, Ken. "Painted Air: The Joys and Sorrows of Evanescent Cinema" in *Millenium Film Journal* Nos. 43/44, 2005, 36 – 61.

Jacobs, Ken. "Roundtable on Experimental Digital Cinema" in *October Summer 2011*, No. 137, 51 – 68.

Jacobs, Ken. "Tom, Tom, The Piper's Son / A Tom Tom Chaser." New York, NY: Tribeca Film Institute, 1969 / 2002.

Jacobs, Ken. United States Patent No. 7,030,902: *Eternalism—A Method for Creating an Appearance of Sustained Three-dimensional Motion-direction of Unlimited Duration, Using a Finite Number of Pictures*, 2006.

Jacobs, Ken, Catherine Jauniaux, and Tom Cora. "New York Ghetto Fishmarket 1903." Tzadik, 2006.

Jacobs, Ken, John Zorn, and Ikue Mori. "Celestial Subway Lines/Salvaging Noise." New York, NY: Tzadik, 2005.

Jacobs, Ken, and Rick Reed. "Capitalism: Child Labor." New York, NY: Electronic Arts Intermix, 2006.

Juno, Andrea, and V. Vale. *Angry Women*. San Francisco, CA: RE/Search Publications, 1991.

Kahn, Douglas. *Noise, Water, Meat: A History of Sound in the Arts*. Cambridge, MA: The MIT Press, 2001.

Kepes, Gyorgi. *Language of Vision*. Chicago, IL: Paul Theobald, 1944.

Kosko, Bart. *Noise*. New York, NY: Viking Penguin, 2006.

Kostelanetz, Richard. *Conversing with Cage*. Second Edition. New York, NY: Routledge, 2003.

Kreisler, Henry. "Conversations with History: Ken Jacobs." *Institute of International Studies, UC Berkeley* (1999): http://globetrotter.berkeley.edu/people/Jacobs/jacobs-con0.html (accessed October, 2015).

Labelle, Brandon. *Background Noise: Perspectives on Sound Art*. New York, NY: Continuum International Publishing, 2006.

Lacan, Jacques. *The Four Fundamental Concepts of Psycho-Analysis*, trans. Alan Sheridan. New York, NY: W. W. Nortan & Company, Inc. 1978.

Le Grice, *Abstract Film and Beyond*. Cambridge, MA: MIT Press, 1977.

Le Grice, *Experimental Cinema in the Digital Age*. London: British Film Institute, 2001.

2004 Cyberarts: International Compendium Prix Ars Electronica: Computer Animation, Visual Effects, Digital Musics, Interactive Art, Net Vision, Digital Communities, U19, Freestyle Computing, the Next Idea. eds. Leopoldseder, Hannes, and Christine Schöpf. Ostfildern-Ruit: Hatje Cantz, 2004.

Levi, Pavle. "Cinema By Other Means." *October* 131, (2010): 51 – 68.

Levi, Pavle. *Cinema By Other Means*. New York, NY: Oxford University Press, USA, 2012.

Levin, Golan. "Painterly Interfaces for Audiovisual Performance." Master's thesis: Massachusetts Institute of Technology, 2000.

Liebman, Stuart. "Apparent Motion and Film Structure: Paul Sharits's Shutter Interface." *Millennium Film Journal* Vol. 1 No. 2, 101 – 109.

Liebman, Stuart. *Paul Sharits*. St. Paul, MN: Film in the Cities, 1981.

Lista, Marcella and Sophie Duplaix. *Sons & Lumières*. Paris: Centre Pompidou, 2004.

Los Alamos National Laboratory, "Tetrahedral Hohlraum High-Convergence Implosion Experiments on Omega ID4-FY98." Rochester, NY, 1998.

Lucier, Alvin. *Bird and Person Dyning*. Cramps Records CRSLP 6111. LP. 33 ⅓ rpm. 1975.

Lucier, Alvin interviewed by Michael Parsons, "Beats that can Push Sugar" in *Resonance Magazine* Vol. 4, No. 1. https://web.archive.org/web/20060208054446/http://www.l-m-c.org.uk/texts/lucier.html (accessed October, 2015).

Lucier, Alvin. "My Affairs with Feedback" in *Resonance Magazine* Vol. 9, No. 2.

Macbeth, Ken. *Macbeth X-Series Dual SV Filter*. http://www.macbethstudiosystems.com/3udualsv.html (accessed October, 2015).

MacDonald, Scott. *A Critical Cinema: Interviews With Independent Filmmakers*. Berkeley: University of California Press, 1988.

Manning, Peter. *Electronic and Computer Music*. New York, NY: Oxford University Press, 2003.

Mannoni, Laurent, and Richard Crangle. *The Great Art of Light and Shadow: Archaeology of the Cinema*. Exeter: University of Exeter Press, 2000.

X-Screen: Film Installations and Actions in the 1960s and 1970s, ed. Michalka, Matthias. Köln: Walther König, 2004.

Marks, Laura U. *Touch: Sensuous Theory and Multisensory Media*. Minneapolis, MN: University of Minnesota Press, 2002.

Martin, Lauren. "Jeff Mills Delves Deep Into Space, Time, and the Future of Techno" in *Thump*, April 22, 2014. https://thump.vice.com/en_us/article/the-man-from-tomorrow-an-interview-with-jeff-mills (accessed November, 2015).

Marvin, Carolyn. *When Old Technologies Were New: Thinking About Electric Communication in the Late Nineteenth Century*. New York, NY: Oxford University Press Incorporated, 1990.

McCartney, James. "Rethinking the Computer Music Language: Super Collider." *Computer Music Journal* 26, no. 4 (2002): 61 – 68.

Mekas, Jonas. *Movie Journal: The Rise of the New American Cinema, 1959 – 1971*. New York, NY: Macmillan, 1972.

Moholy-Nagy, László. *Painting, Photography, Film*. London: Lund Humphries, 1969.

Moore, F. Richard. *Elements of Computer Music*. Englewood Cliffs, NJ: Prentice Hall, 1990.

Morgan, Robert. *Twentieth-Century Music: A History of Musical Style in Modern Europe and America*. New York, NY: W. W. Norton & Company, Ltd. 1991.

Immersed in Technology: Art and Virtual Environments. eds. Moser, Mary Anne, and Douglas MacLeod. Cambridge, MA: MIT Press, 1996.

Mueller, Roswitha. *Valie Export: Fragments of the Imagination*. Bloomington, IN: Indiana University Press, 1994.

Neal, Charles. *Tape Delay: Confessions from the Eighties Underground*. London: SAF Publishing, Ltd., 2001.

NetPierre, "The Eurorack Standard" in *PatchPierre*. http://patchpierre.blogspot.com/2012/02/eurorack-standard.html (accessed October, 2015).

Novak, David. *Japanoise: Music at the Edge of Circulation*. Durham, NC: Duke University Press, 2013.

Olofsson, Fredrik. "Bjorklund." (2010): http://www.fredrikolofsson.com/f0blog/?q=node/434 (accessed October, 2015).

Olofsson, Fredrik. "Writing Algorithms That Sound." (2010): https://web.archive.org/web/20141114161944/http://www.fredrikolofsson.com/software/writingAlgorithmsThatSound.html (accessed October, 2015).

Pagán, Alberte. "An Architecture of Emotion: Peter Kubelka Interviewed," *Alberte Pagán: Últimas Adiçons* (2013): http://albertepagan.eu/a-toupeira/peter-kubelka-interviewed/ (accessed October, 2015).

What is Media Archaeology? ed. Parikka, Jussi. 1st ed. Cambridge: Polity Press, 2012.

McGraw-Hill Dictionary of Physics, ed. Parker, Sybil P. Second Edition. New York, NY: McGraw-Hill, 1997.

Pellman, Samuel. *An Introduction to the Creation of Electroacoustic Music*. Belmont, CA: Wadsworth Pub. Co., 1994.

Perot, Romain. *Manifeste du Mur Bruitiste*, http://www.decimationsociale.com/app/download/5795218093/Manifeste+du+Mur+Bruitiste.pdf (accessed October, 2015).

Pierson, Michele, David E. James, and Paul Arthur. *Optic Antics: The Cinema of Ken Jacobs*. New York, NY: Oxford University Press, 2011.

Pisaro, Michael. "Reviews at Crow with No Mouth." *ihatemusic* (2011): http://ihatemusic.noquam.com/viewtopic.php?f=6&t=5312&start=80#p221735 (accessed October, 2015).

Place, Tim, Trond Lossius, Nils Peters, Théo De La Hogue, Pascal Baltazar, Alexander Refsum Jensenius, Julien Rabin, Dave Watson, Nathan Wolek, Adrian Gierakowski, and Henrique Matias. *Jamoma: A Platform for Interactive Art-Based Research and Performance*: http://jamoma.org (accessed October, 2015).

Polishook, Mark. "Mark Polishook Tutorials" in *SuperCollider Tutorials*. http://doc.sccode.org/Tutorials/Mark_Polishook_tutorial/ (accessed October, 2015).

Prendergast, Mark. *The Ambient Century: From Mahler to Moby—the Evolution of Sound in the Electronic Age*. Cambridge, MA: Bloomsbury USA, 2003.

Puckette, Miller. *The Theory and Technique of Electronic Music*. Hackensack, NJ: World Scientific Publishing Co., 2007.

Quigley, Martin. *Magic Shadows: The Story of the Origin of Motion Pictures*. Washington: Georgetown Univ. Press, 1948.

Recoder, Luis. "The Death of Structural Film: Notes Toward a Filmless Cinema." *Spectator - The University of Southern California Journal of Film and Television* 27, (2007): 26 – 30.

Rees, A. L. *Expanded Cinema: Art, Performance, Film*. London: Tate Gallery Pub., 2011.

Reynolds, Simon. *Energy Flash: A Journey through Rave Music and Dance Culture*. London: Faber and Faber, 2013.

Reynolds, Simon. *Rip It Up and Start Again: Postpunk 1978 – 1984*. New York, NY: Penguin Group, 2005.

What Sound does a Color Make? ed. Richards, Judith. New York, NY: Independent Curators International, 2005.

Roads, Curtis. *The Computer Music Tutorial*. Cambridge, MA: MIT Press, 1995.

Roads, Curtis. *Microsound*. Cambridge, MA: The MIT Press, 2001.

Russolo, Luigi. *The Art of Noises*. New York, NY: Pendragon Press, 1987.

Ross, Ken. "Excerpts from a Conversation with Alphons Schilling" (1977): http://www.vasulka.org/archive/Artists6/Schilling,Alphons/ElectronicSpaces,etc.pdf (accessed October, 2015).

Rossell, Deac. *Living Pictures: The Origins of the Movies (SUNY Series in Cultural Studies in Cinema/Video)*. Albany, NY: State University of New York Press, 1998.

Narrative, Apparatus, Ideology: A Film Theory Reader, ed. Rosen, Philip. New York, NY: Columbia University Press, 1986.

Between Stillness and Motion: Film, Photography, Algorithms (Amsterdam University Press - Film Culture in Transition), ed. Røssaak, Eivind. Amsterdam: Amsterdam Univerity Press, 2011.

Røssaak, Eivind. *The Still / Moving Image: Cinema and the Arts*, Saarbrücken: LAP LAMBERT Academic Publishing GmbH & Co. KG, 2010.

Sattinger, Chris. *Arduino Quark*: https://github.com/supercollider-quarks/Arduino (accessed October, 2015).

Schnell, Norbert and Marc Battier, "Introducing Composed Instruments, Technical and Musicological Implications" in *Proceedings of the 2002 Conference on New Instruments for Musical Expression (NIME-02), Dublin Ireland, May 24 – 26, 2002*.

Sergeant, Jack. "Sonic Doom" in Fortean Times, 12/01: http://www.freerepublic.com/focus/news/696235/posts (accessed October, 2015).

Shannon, Claude E., and Warren Weaver. *The Mathematical Theory of Communication*. Urbana, IL: The University of Illinois Press, 1963.

Shaw, Jeffrey, and Peter. Weibel. *Future Cinema: The Cinematic Imaginary After Film*. Cambridge, MA ; London: MIT Press, 2003.

Sicko, Dan. Techno Rebels: The Renegades of Funk. Second Edition. Detroit, MI: Wayne State University, 2010.

Film Culture Reader, ed. Sitney, P. Adams. New York, NY: Praeger Publishers, 1970.

The Avant-Garde Film: A Reader of Theory and Criticism, ed. Sitney, P. Adams. New York, NY: Anthology Film Archives, 1978.

Sitney, P. Adams. *Visionary Film: The American Avant-Garde, 1943 – 2000* (Third Edition). New York, NY: Oxford University Press, 2002.

Sobieszek, Robert A., and William S. Burroughs. *Ports of Entry: William S. Burroughs and the Arts*. Los Angeles, CA: Los Angeles County Museum of Art: Distributed in the USA by Thames and Hudson, 1996.

Sontag, Susan. *Against Interpretation, and Other Essays*. 1st Picador USA ed. New York, NY: Picador USA, 2001.

Stoichita, Victor Ieronim. *A Short History of the Shadow*. London: Reaktion Books, 1997.

Spielmann, Yvonne. *Video: The Reflexive Medium*. Cambridge, MA: The MIT Press, 2008.

Studio for Electro-Instrumental Music, *LiSa X*: http://steim.org/2012/01/lisa-x-v1-25/ (accessed October, 2015).

Theories and Documents of Contemporary Art: A Sourcebook of Artists' Writings, eds. Stiles, Kristine, and Peter Selz. Berkeley, CA: University of California Press, Ltd, 1996.

Strange, Allen. *Electronic Music: Systems, Techniques, and Controls* (First Edition). Dubuque, IA: William C. Brown Pub, 1972.

Strange, Allen. *Electronic Music: Systems, Techniques, and Controls* (Second Edition). Dubuque, IA: William C. Brown Pub, 1983.

Steina and Woody Vasulka: Machine Media, ed. Sturken, Marita. San Francisco, CA: San Francisco Museum of Art, 1996.

SuperCollider 3 documentation contributors, "Client vs Server" in *SuperCollider Guides*. http://doc.sccode.org/Guides/ClientVsServer.html (accessed October, 2015).

SuperCollider 3 documentation contributors, *SuperCollider Classes*. http://doc.sccode.org/Overviews/Classes.html (accessed October, 2015).

SuperCollider 3 documentation contributors, "SuperCollider 3 Server Tutorial" in *SuperCollider Tutorials*. http://doc.sccode.org/Tutorials/Tutorial.html (accessed October, 2015).

SuperCollider 3 documentation contributors, "SuperCollider IDE" in *SuperCollider Guides*. http://doc.sccode.org/Guides/SCIde.html (accessed October, 2015).

SuperCollider 3 documentation contributors, "Syntax Shortcuts" in *SuperCollider Reference*. http://doc.sccode.org/Reference/Syntax-Shortcuts.html (accessed October, 2015).

Tafler, David. "When Analog Cinema Becomes Digital Memory" in *Wide Angle* Volume 21, Number 1, January 1999, 18 – 204.

Thorburn, David, and Henry Jenkins. *Rethinking Media Change: The Aesthetics of Transition (Media in Transition)*. Cambridge, MA: MIT Press, 2004.

"Time After Time — In and Around the Nervous Magic Lantern and Nervous System of Ken Jacobs." *ARGOS Center for Art and Media* (2004): http://www.argosarts.org/program.jsp?eventid=638ddef964ce434c936881d9e90e7557 (accessed October, 2015).

Tomas, David. *Beyond the Image Machine: A History of Visual Technologies*. New York, NY: Continuum International Publishing, 2004.

Toop, David. *Ocean of Sound*. London: Serpent's Tail, 2001.

Toussaint, Godfried. *The Euclidean Algorithm Generates Traditional Musical Rhythms*: http://cgm.cs.mcgill.ca/~godfried/publications/banff.pdf (accessed October, 2015).

Toussaint, Godfried. *The Geometry of Music: What Makes a "Good" Rhythm Good?* Boca Raton, FL: CRC Press, 2013.

RE/Search #6/7: Industrial Culture Handbook, ed. Vale, V. San Francisco, CA: RE/Search Publications, 1983.

RE/Search #4/5: William S. Burroughs, Brion Gysin and Throbbing Gristle, eds. Vale, V., and Andrea Juno. San Francisco, CA: RE/Search Publications, 1982.

Buffalo Heads: Media Study, Media Practice, Media Pioneers, 1973 – 1990, eds. Vasulka, Woody, and Peter Weibel. Cambridge, MA: The MIT Press, 2008.

Varèse, Louise. *Varèse: A Looking-Glass Diary Volume I: 1883 – 1928*. New York, NY: W. W. Norton & Company, Inc., 1972.

Vertov, Dziga. *Kino-Eye: The Writings of Dziga Vertov*. Berkeley, CA: University of California Press, 1984.

Vestax Multitrack Remix Controller VCM-600. Tokyo: Vestax Corporation, 2008.

Invisible Fields: Geographies of Radio Waves, eds. de Vicente, José Luis, Honor Harger and Josep Perelló. Barcelona: Arts Santa Mònica, 2012.

Walley, Jonathan. "The Material of Film and the Idea of Cinema: Contrasting Practices in Sixties and Seventies Avant-Garde Film." *October* 103, (2003): 15 – 30.

Walter, William Grey. *The Living Brain*. New York, NY: W. W. Norton, 1963.

Weidenaar, Reynold. *Magic Music From the Telharmonium*. Metuchen, NJ: Scarecrow Press, 1995.

Music in the Western World: A History in Documents, eds. Weiss, Piero, and Richard Taruskin. New York, NY: Schirmer Books, 1984.

Weschler, Lawrence. *Seeing is Forgetting the Name of the Thing One Sees: A Life of Contemporary Artist Robert Irwin*. Berkeley, CA: University of California Press, 1982.

Whitehouse. Liner notes to *Birthdeath Experience*. Come Organization WDC 881004. LP. 33 ⅓ rpm. 1980.

Whitehouse. Liner notes to *The Second Coming*. Come Organization WDC 881006. LP. 33 ⅓ rpm. 1981.

Williams, Russell . "Anti-Musicality: An Interview with Romain Perrot of VOMIR" in *The Quietus*, http://thequietus.com/articles/16050-romain-perrot-vomir-interview-harsh-noise-wall (accessed October, 2015).

Wilson, Brian. *Fight, Flight, or Chill: Subcultures, Youth, and Rave into the Twenty-First Century*. Montréal, QC: McGill-Queen's University Press, 2006.

Wilson, Scott. "Spatial Swarm Granulation." http://eprints.bham.ac.uk/237/1/cr1690.pdf (accessed October, 2015).

Wilson, Scott, Nick Collins, and David Cottle. *The SuperCollider Book*. Cambridge, MA: MIT Press, 2011.

Wiseman, Ari, and Judith Zilczer. *Visual Music: Synaesthesia in Art and Music Since 1900*. eds. Brougher, Kerry and Jeremy Strick. London: Thames & Hudson, 2005.

Xenakis, Iannis, and Olivier Messiaen. *Arts-Sciences, Alloys : The Thesis Defense of Iannis Xenakis*. New York, NY: Pendragon Press, 1985.

Youngblood, Gene. *Expanded Cinema*. New York, NY: Dutton, 1970.

Zielinski, Siegfried. *Audiovisions: Cinema and Television as Entr'actes in History*. Amsterdam: Amsterdam University Press, 1999.

Zielinski, Siegfried. *Deep Time of the Media: Toward an Archaeology of Hearing and Seeing by Technical Means*. Cambridge, MA: MIT Press, 2006.

Appendix B: Additional Documentation

Additional video documentation is available via the Brown Digital Repository. Actionable, interoperable, persistent links to these files have also been made available using Digital Object Identifiers (or DOIs) for the sake of longevity. For more information on the Digital Object Identifier System, please visit: http://www.doi.org

***Schaulust* dissertation performance:**
https://repository.library.brown.edu/studio/item/bdr:589102/
DOI: 10.7301/Z0RB72J0

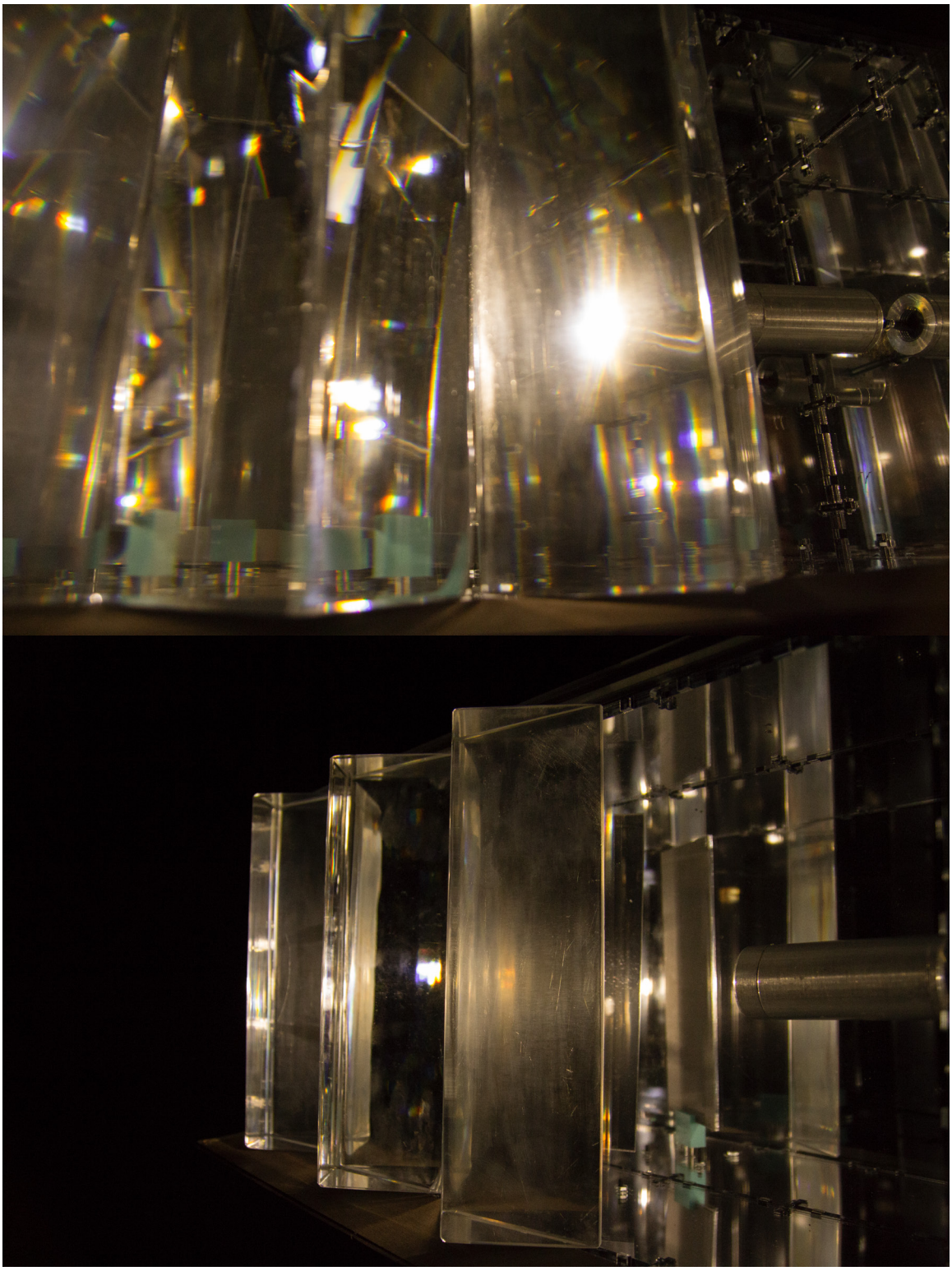
Schaulust performance at Sonic Focus 3.5 (Excerpt):
https://repository.library.brown.edu/studio/item/bdr:589104/
DOI: 10.7301/Z0MK69T8

Schaulust performance at the Ctrl+Alt+Repeat Ten Year Anniversary (Excerpt):
https://repository.library.brown.edu/studio/item/bdr:589100/
DOI: 10.7301/Z0W37T8B

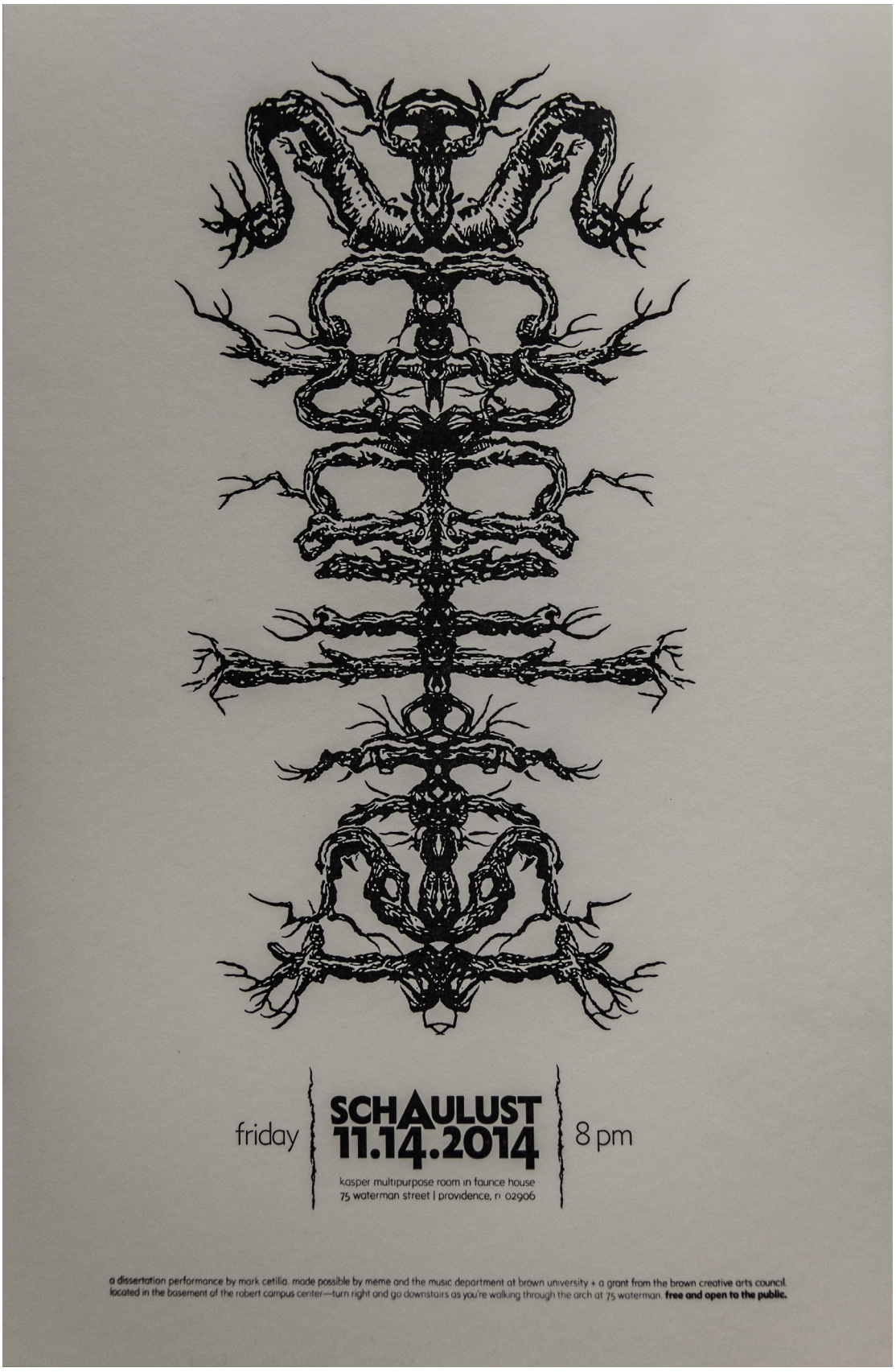
Apathy and Steel: *Mountains of Cinder*:
https://repository.library.brown.edu/studio/item/bdr:589095/
DOI: 10.7301/Z04M92G1

***Pulse Shape 22*:**
https://repository.library.brown.edu/studio/item/bdr:589098/
DOI: 10.7301/Z00V89R9

Additional photographic documentation may be found on the following pages. Photos of dissertation performance by Laura Cetilia; close-ups of *Schaulust* performance system by Mark Cetilia.



Appendix C: Schaulust Dissertation Performance Poster



Appendix D: Fraktur 4 Code

```
Fraktur4_Looper_Player {

	var <> bufnum,
		<> start,
		<> end,
		<> rate,
		<> reverse,
		<> trigRate,
		<> view,
		<> dynamic,
		<> length,
		<> fixed_length,
		<> master_speed,
		<> fine,
		<> gate,
		<> rate_midi,
		<> volume_midi_pre,
		bufRd, phasor, panning_phasor, trig, out,
		numFrames, sampleRate, rateScale,
		startFrame, endFrame;

	*new {

		arg bufnum = 0,
			start = 0,
			end = 1,
			rate = 1,
			reverse = 0,
			trigRate = 12,
			view = 0,
			dynamic = 0,
			length = 0,
			fixed_length = 8.0,
			master_speed = 1,
			fine = 1,
			gate = 1,
			rate_midi = 1,
			volume_midi_pre = 0;

		^super.newCopyArgs(
			bufnum, start, end, rate, reverse, trigRate, view,
			dynamic, length, fixed_length, master_speed,
			fine, gate, rate_midi, volume_midi_pre
		).init;

	}
```

```
    init {

        var lenTest;

        //---------------------------------------//
        // convenience variables

        numFrames = Select.kr(dynamic, [
            (fixed_length * master_speed) * BufSampleRate.kr(bufnum),
            length * BufSampleRate.kr(bufnum)
        ]);


        sampleRate = BufSampleRate.kr(bufnum);
        rateScale = BufRateScale.kr(bufnum);

        startFrame = start * numFrames;         // start frame, based on fraction of loop
        endFrame = (1 - end) * numFrames;    // end frame based, on fraction of loop

        //---------------------------------------//
        // play buffer

        phasor = Phasor.ar(
                trig: gate * (1 - volume_midi_pre),
                rate: (Ramp.ar(K2A.ar(rate * fine)) * rate_midi * rateScale) * (1 - (reverse * 2)),
                start: startFrame,
                end: numFrames - endFrame);

        // sin wave for spatialization:
        panning_phasor = ((phasor / ((numFrames - endFrame) - startFrame)) * 2pi).sin;

        bufRd = BufRd.ar(1, bufnum, phasor, interpolation: 4);

        //---------------------------------------//
        // output phase position + sound

        // trig = SendReply.kr(Impulse.kr(trigRate * view), '/phase', phasor, 1337);
        out = bufRd;

        ^[out, panning_phasor];

    }

}
```

```
Fraktur4_Looper_Recorder {

	var <> bufnum,
		<> cello_input,
		<> cello_volume,
		<> mpc_input,
		<> mpc_volume,
		<> guest_input,
		<> guest_volume,
		<> doepfer_input,
		<> doepfer_channel,
		<> doepfer_volume,
		<> drums1_input,
		<> drums2_input,
		<> drums1_volume,
		<> drums2_volume,
		<> record,
		<> feedback,
		<> channel_feedback,
		<> loop,
		<> append,
		<> dynamic,
		<> length,
		<> fixed_length,
		<> master_speed,
		<> local_in,
		<> loop_disable,
		<> prev_frame,
		phasor, trig, recorder,
		feedback_input, external_input,
		numFrames, sampleRate, rateScale,
		buffer_size;

	*new {
		arg bufnum = 0,
			cello_input = 0,
			cello_volume = 0,
			mpc_input = 0,
			mpc_volume = 0,
			guest_input = 0,
			guest_volume = 1,
			doepfer_input = 0,
			doepfer_channel = 0,
			doepfer_volume = 1,

			drums1_input = 0,
			drums2_input = 0,

			drums1_volume = 0,
			drums2_volume = 0,
```

```
            record = 0,
            feedback = 0,
            channel_feedback = 0.5,

            loop = 0,
            append = 0,
            dynamic = 1,

            length = 1,
            fixed_length = 8.0,
            master_speed = 1,

            local_in,

            loop_disable = 1,
            prev_frame = 0;

        ^super.newCopyArgs(
            bufnum, cello_input, cello_volume, mpc_input, mpc_volume,
            guest_input, guest_volume, doepfer_input, doepfer_channel, doepfer_volume,
            drums1_input, drums2_input,
            drums1_volume, drums2_volume,
            record, feedback, channel_feedback,
            loop, append, dynamic, length, fixed_length, master_speed,
            local_in,
            loop_disable, prev_frame
        ).init;
    }
```

```
init {
    //-------------------------------------//
    // helper vars

    sampleRate = BufSampleRate.kr(bufnum);
    rateScale = BufRateScale.kr(bufnum);

    buffer_size = (fixed_length * master_speed) * BufSampleRate.kr(bufnum);

    numFrames = Select.kr(dynamic, [

        // if (dynamic == 0):
        Select.kr(loop, [

            // if not looping, add a couple extra seconds, just to be safe:
            buffer_size + (2 * sampleRate),

            // if looping, just record loop length:
            buffer_size
        ]),

        // if (dynamic == 1):
        Select.kr(loop, [

            // if not looping, record as much as you like:
            BufFrames.kr(bufnum),

            // if looping, just record loop length:
            (length * BufSampleRate.kr(bufnum))
        ])
    ]);

    trig = Select.kr(record, [          // switch (record)
        0,                              // case 0: output 0
        Select.kr(append, [             // case 1: am i appending?
            1,                          // if not, restart from 0
            0                           // otherwise continue as normal
        ])
    ]);

    //-------------------------------------//
    // record / overdub

    phasor = Phasor.ar(
        trig: trig,
        rate: rateScale * record,
        start: 0,
        end: numFrames,
        resetPos: 0
    );
```

```
        feedback_input = LeakDC.ar(BufRd.ar(1, bufnum, phasor, interpolation: 4) * feedback);

        external_input = Mix.ar([
            (Mix.ar(In.ar(cello_input, 2)) * cello_volume.lag),
            (Mix.ar(In.ar(mpc_input, 2)) * mpc_volume.lag),
            (Mix.ar(In.ar(guest_input, 2)) * guest_volume.lag),

            Mix.ar(doepfer_volume.lag *
                        [
                                In.ar(doepfer_input, 7)
                        ].flatten *

                        Select.ar(doepfer_channel, [
                                K2A.ar([1,0.dup(6)].flatten.shift(0)),
                                K2A.ar([1,0.dup(6)].flatten.shift(1)),
                                K2A.ar([1,0.dup(6)].flatten.shift(2)),
                                K2A.ar([1,0.dup(6)].flatten.shift(3)),
                                K2A.ar([1,0.dup(6)].flatten.shift(4)),
                                K2A.ar([1,0.dup(6)].flatten.shift(5)),
                                K2A.ar([1,0.dup(6)].flatten.shift(6))
                    ])
            ),

            Mix.ar(In.ar(drums1_input, 4)) * drums1_volume,
            Mix.ar(In.ar(drums2_input, 4)) * drums2_volume,

            LeakDC.ar(local_in[0]) * channel_feedback
        ]);

        recorder = BufWr.ar(((feedback_input + external_input) * record).softclip,
                                        bufnum, phasor, loop);

        //---------------------------------------//
        // output phasor

        ^phasor;
    }
}
```

```
Fraktur4_Channel_Effects {

	var <> channel,
		<> samprate,
		<> wordsize,

		<> reverb_revTime,
		<> reverb_feedback,
		<> reverb_softclip,
		<> reverb_hfDamping,
		<> reverb_inFilter,
		<> reverb_leakCoeff,
		<> reverb_combScale,
		<> reverb_mix,
		<> reverb_inVolume,
		<> reverb_outVolume,

		<> volume,

		<> filter_freq,
		<> filter_q,
		<> filter_low,
		<> filter_band,
		<> filter_high,
		<> gain,
		<> a100,
		<> local_in,

		<> gate,
		<> t_trig,
		<> volume_midi,
		<> volume_midi_pre;

	*new {
		arg channel,
			samprate = 1,
			wordsize = 24,

			reverb_revTime = 3,
			reverb_feedback = 0,
			reverb_softclip = 0,
			reverb_hfDamping = 1,
			reverb_inFilter = 0,
			reverb_leakCoeff = 0.995,
			reverb_combScale = 1,
			reverb_mix = 0,
			reverb_inVolume = 1,
			reverb_outVolume = 1,
```

```
        volume = 0,

        filter_freq = 20000,
        filter_q = 0,
        filter_low = 1,
        filter_band = 0,
        filter_high = 0,
        gain = 0,
        a100 = 0,
        local_in,

        gate = 0,
        t_trig = 0,
        volume_midi = 0,
        volume_midi_pre = 0;

    ^super.newCopyArgs(
        channel,
        samprate,
        wordsize,

        reverb_revTime,
        reverb_feedback,
        reverb_softclip,
        reverb_hfDamping,
        reverb_inFilter,
        reverb_leakCoeff,
        reverb_combScale,
        reverb_mix,
        reverb_inVolume,
        reverb_outVolume,

        volume,

        filter_freq,
        filter_q,
        filter_low,
        filter_band,
        filter_high,
        gain,
        a100,
        local_in,

        gate,
        t_trig,
        volume_midi,
        volume_midi_pre
    ).init;
}
```

```
init {
    var  shifted,
        decimated, fullsize,
        filtered,
        low, high, band,
        reverbed,
        out,
        env;

    env = EnvGen.kr(Env.perc(0.001, 0.5, 1, -4), gate) * volume_midi;

    fullsize = 1 + (Schmidt.ar(wordsize, 0.99212598425197, 0.99212598425197) * 8);

    decimated = Decimator.ar(channel,
                    rate: Lag.ar(K2A.ar((samprate * SampleRate.ir))),
                    bits: Lag.ar(K2A.ar((wordsize * 15) + fullsize)));

    low = filter_low * (1 - filter_high);
    high = filter_high * (1 - filter_low);
    band = 1 - ((filter_low - filter_high).abs);

    filtered = SVF.ar(decimated * (1 + gain),
                    Lag.ar(K2A.ar(filter_freq)),
                    Lag.ar(K2A.ar(filter_q)),
                    low.lag(4,4),
                    band.lag(4,4),
                    high.lag(4,4),
                    0,
                    0
    );

    reverbed = [

        Fraktur4_Reverb(filtered,
            revTime: reverb_revTime,
            feedback: reverb_feedback,
            softclip: reverb_softclip,
            hfDamping: reverb_hfDamping,
            inFilter: reverb_inFilter,
            leakCoeff: reverb_leakCoeff,
            combScale: reverb_combScale,
            mix: reverb_mix,
            inVolume:     ((volume * env) * volume_midi_pre) +
                          ((volume + env).clip(0, 1) * (1 - volume_midi_pre)),
            outVolume: reverb_outVolume,
            local_in: local_in
        ),
```

```
                Fraktur4_Reverb(filtered,
                    revTime: reverb_revTime,
                    feedback: reverb_feedback,
                    softclip: reverb_softclip,
                    hfDamping: reverb_hfDamping,
                    inFilter: reverb_inFilter,
                    leakCoeff: reverb_leakCoeff,
                    combScale: reverb_combScale,
                    mix: reverb_mix,
                    inVolume: a100.clip(0, 1),
                    outVolume: reverb_outVolume,
                    local_in: local_in
                )
            ];

            ^ reverbed;
        }
}
```

```
// Fraktur4_Reverb based on AdCVerb ixiQuark:
// http://www.ixi-software.net/content/body_software_ixiquarks.html

// Feedback modeled after Eli Fieldsteel's "Infinite Hold Reverb":
// http://www.youtube.com/watch?v=_2N7lG5uzJI

Fraktur4_Reverb {
	var <> in,
		<> revTime,
		<> feedback,
		<> softclip,

		<> hfDamping,
		<> inFilter,
		<> leakCoeff,
		<> combScale,

		<> mix,
		<> inVolume,
		<> outVolume,
		<> local_in;

	*new {
		arg in,
			revTime = 3,
			feedback = 0,
			softclip = 0,

			hfDamping = 1,
			inFilter = 0,
			leakCoeff = 0.995,
			combScale = 1,

			mix = 0.5,
			inVolume = 1,
			outVolume = 1,
			local_in;

		^super.newCopyArgs(
			in,
			revTime,
			feedback,
			softclip,

			hfDamping,
			inFilter,
			leakCoeff,
			combScale,
```

```
            mix,
            inVolume,
            outVolume,
            local_in
        ).init;
}

init {
        var  predelay = 0,
            apScale = 1,

            maxDelayTime = 0.2,
            maxAllpassTime = 0.06,

            numCombs = 8,
            timeOneSample = SampleDur.ir,
            combTimes = ({ rrand(100, 400).nthPrime } ! numCombs).sort / 40000,

            combsOut,
            local, out,
            wet, dry;

        // establish signal input
        dry = in * (1 - mix) * inVolume.lag;

        in = DelayN.ar(
                    OnePole.ar(
                            LeakDC.ar(
                                    (in.asArray.sum * combTimes.size.reciprocal),
                                    leakCoeff
                            ),
                        inFilter
                ),
                maxDelayTime,
                predelay
        ) * inVolume;

        local = local_in[1] + in;

         // round delay times to int samples & add up to 1/2 sample to them:
        // linear interp between samples loses high freq energy, with max at 0.5

        combsOut = CombL.ar(in, maxDelayTime,
            (combTimes * combScale) .round(timeOneSample)
            + (timeOneSample * 0.5 * hfDamping),
            revTime
         ).sum;
```

```
            // apply reverb
            numCombs.do{
                arg time;
                out = AllpassN.ar(combsOut + local, maxAllpassTime, time * apScale, 3);
            };

            wet = out * outVolume * mix;

            ^[
                // non-feedback signal out to speakers
                (wet + dry),

                // feedback loop + softclipping
                (
                    (out * (1 - softclip)) +
                    (out.softclip * (softclip))
                ) * feedback
            ];
        }
}
```

```
// Fraktur4Win app:
// of_v0.8.4_ios_release
// ofApp.h

#pragma once

#include "ofMain.h"
#include "ofxiOS.h"
#include "ofxiOSExtras.h"

#include "ofxOsc.h"

#define IN_PORT […]
#define REMOTE […]
#define OUT_PORT […]
#define NUM_MSG_STRINGS 2

#define WIDTH 320
#define HEIGHT 568

#define SPACING 10
#define BORDER 20
#define SHIFT_UP -35

class ofApp : public ofxiOSApp {
	public:
		void setup();
		void update();
		void draw();
		void exit();

		float section_width;
		float section_height;

		float touch_x;
		float touch_y;

		int crosshairs_x;
		int crosshairs_y;

		bool show_crosshairs;

		void touchDown(ofTouchEventArgs & touch);
		void touchMoved(ofTouchEventArgs & touch);
		void touchUp(ofTouchEventArgs & touch);
		void touchDoubleTap(ofTouchEventArgs & touch);
		void touchCancelled(ofTouchEventArgs & touch);

		void lostFocus();
		void gotFocus();
```

```
        void gotMemoryWarning();
        void deviceOrientationChanged(int newOrientation);

        ofImage bg;
        ofTrueTypeFont ultramagnetic;
        ofTrueTypeFont myriad;

        ofxOscReceiver receiver;
        ofxOscSender sender;


        float msg_float;
        int msg_int;
        string msg_string;
        string avgCPU;
        string peakCPU;
        string input;
        string time;

        int rec;
        int rec_inited;
        int reminders_acknowledged;

        int current_msg_string;
        string msg_strings[NUM_MSG_STRINGS];

        void draw_left();
        void draw_center();
        void draw_right();
        void draw_text();
        void draw_crosshairs();
        void draw_reminders();
};
```

```
// Fraktur4Win app:
// of_v0.8.4_ios_release
// ofApp.mm

#include "ofApp.h"

float meters[] = {
	0,0,0,0,0,0,0,0,0,0,
	0,0,0,0,
	0,0,0,0,0,0,
	0,0,0,0,0,0,
	0,0,0,0,0,0
};

float meters_left[] = {
	0,0,0,0,0,0,0,0,0,0
};

float meters_center[] = {
	0,0,0,0,0,0,
	0,0,0,0,0,0,
	0,0,0,0,0,0
};

float meters_right[] = {
	0,0,0,0
};

//--------------------------------------------------------------
void ofApp::setup(){
	[[UIApplication sharedApplication] setIdleTimerDisabled:YES];

	bg.loadImage("images/bg.png");
	bg.loadImage("images/bg_red.png");
	ofBackground(255, 0, 0, 0.6);

	receiver.setup(IN_PORT);
	sender.setup(REMOTE, OUT_PORT);

	ofTrueTypeFont::setGlobalDpi(72);
	ultramagnetic.loadFont("fonts/Ultramagnetic_Light.ttf", 37, true, true);
	ultramagnetic.setLineHeight(37);
	ultramagnetic.setLetterSpacing(1);

	myriad.loadFont("fonts/Myriad.ttf", 6, true, true);
	myriad.setLetterSpacing(1);

	msg_strings[0] = "0 / 0";
	msg_strings[1] = "1 / 0.0";
```

```
        section_width = (HEIGHT - (SPACING * 4)) / 3;
        section_height = (WIDTH - (SPACING * 2));

        ofxOscMessage rec_msg;
        rec_msg.setAddress("/get_rec");
        sender.sendMessage(rec_msg);
}

//--------------------------------------------------------------
void ofApp::update(){
        if (reminders_acknowledged == 1){
                ofBackground(255, 0, 0);

                if (ofGetFrameNum() % 120 == 0){
                        ofxOscMessage m;
                        m.setAddress("/stay_active");
                        m.addIntArg(0);
                        sender.sendMessage(m);
                }

                while (receiver.hasWaitingMessages()){
                        ofxOscMessage m;
                        receiver.getNextMessage(&m);

                        if (m.getArgType(0) == OFXOSC_TYPE_INT32){
                                msg_int = m.getArgAsInt32(0);
                        }

                        else if (m.getArgType(0) == OFXOSC_TYPE_FLOAT){
                                msg_float = m.getArgAsFloat(0);
                        }

                        else if (m.getArgType(0) == OFXOSC_TYPE_STRING){
                                msg_string = m.getArgAsString(0);
                        }

                        string address = ofSplitString(m.getAddress(), "/")[1];

                        if (address == "cpu"){
                                string location = ofSplitString(m.getAddress(), "/")[2];

                                if (location == "avg"){
                                        avgCPU = m.getArgAsString(0);
                                }

                                if (location == "peak"){
                                        peakCPU = ofToString(atoi(m.getArgAsString(0).c_str()));
                                }
                        }
```

```
else if (address == "input"){
	input = m.getArgAsString(0);
}

else if (address == "time"){
	time = msg_string;
}

else if (address == "rec"){
	rec = msg_int;

	if (rec == 0){
		bg.loadImage(“images/bg_red.png");
	} else {
		bg.loadImage(“images/bg.png");
	}
}

else if (address == "meters"){
	string value = ofSplitString(m.getAddress(), "/")[2];
	meters[atoi(value.c_str())] = msg_float;
}

for (int i = 0; i < 11; i++){
	switch (i) {
		case 0:
			meters_left[1] = meters[i];
			break;

		case 1:
			meters_left[2] = meters[i];
			break;

		case 2:
			meters_left[0] = meters[i];
			break;

		default:
			meters_left[i] = meters[i];
			break;
	}
}

for (int i = 15; i < 33; i++){
	meters_center[i - 15] = meters[i];
}

for (int i = 11; i < 15; i++){
	meters_right[i - 11] = meters[i];
}
```

```
                msg_strings[0] = avgCPU + " / " + peakCPU;
                msg_strings[1] = input + " / " + time;
            }
        }
}

//--------------------------------------------------------------
void ofApp::draw(){
        ofSetColor(255,255,255);
        bg.draw(0,0);

        ofPushView();
        {
            ofRotate(90);
            ofTranslate(0, -WIDTH);

            if (reminders_acknowledged == 1){
               draw_left();
               draw_center();
               draw_right();
               draw_text();

            } else {
               draw_reminders();
            }
        }
        ofPopView();

        ofSetColor(255,255,255);
        draw_crosshairs();
}

//--------------------------------------------------------------
void ofApp::exit(){
}

//--------------------------------------------------------------
void ofApp::touchDown(ofTouchEventArgs & touch){
        ofxOscMessage touch_msg;
        ofxOscMessage x_msg;
        ofxOscMessage y_msg;

        if (reminders_acknowledged == 1){
            touch_msg.setAddress("/touch");
            touch_msg.addIntArg(1);

            touch_x = ofClamp((touch.x - 10) / 300, 0, 1);
            touch_y = ofClamp(touch.y / 560, 0, 1);
```

```
            crosshairs_x = touch.x;
            crosshairs_y = touch.y;

            x_msg.setAddress("/y");
            y_msg.setAddress("/x");
            x_msg.addFloatArg(touch_x);
            y_msg.addFloatArg(touch_y);

            sender.sendMessage(touch_msg);
            sender.sendMessage(x_msg);
            sender.sendMessage(y_msg);

            show_crosshairs = true;
        }
}

//--------------------------------------------------------------
void ofApp::touchMoved(ofTouchEventArgs & touch){
        if (reminders_acknowledged == 1){
            ofxOscMessage x_msg;
            ofxOscMessage y_msg;

            touch_x = 1 - ofClamp((touch.x - 10) / 300, 0, 1);
            touch_y = ofClamp(touch.y / 560, 0, 1);

            crosshairs_x = touch.x;
            crosshairs_y = touch.y;

            x_msg.setAddress("/y");
            y_msg.setAddress("/x");
            x_msg.addFloatArg(touch_x);
            y_msg.addFloatArg(touch_y);
            sender.sendMessage(x_msg);
            sender.sendMessage(y_msg);
        }
}

//--------------------------------------------------------------
void ofApp::touchUp(ofTouchEventArgs & touch){
        if (reminders_acknowledged == 0){
            reminders_acknowledged = 1;
        } else {
            ofxOscMessage untouch_msg;
            untouch_msg.setAddress("/untouch");
            untouch_msg.addIntArg(1);
            sender.sendMessage(untouch_msg);
            show_crosshairs = false;
        }
}
```

```
//--------------------------------------------------------------
void ofApp::touchDoubleTap(ofTouchEventArgs & touch){
}

//--------------------------------------------------------------
void ofApp::touchCancelled(ofTouchEventArgs & touch){
}

//--------------------------------------------------------------
void ofApp::lostFocus(){
}

//--------------------------------------------------------------
void ofApp::gotFocus(){
}

//--------------------------------------------------------------
void ofApp::gotMemoryWarning(){
}

//--------------------------------------------------------------
void ofApp::deviceOrientationChanged(int newOrientation){
}

//--------------------------------------------------------------
void ofApp::draw_left(){
	float width, x_offset, y_offset, height, space;
	width = (section_width - ((SPACING * 2) + (SPACING * 0.5 * 9))) / 11;
	height = section_height - 50;
	x_offset = SPACING;
	y_offset = SPACING;

	for (int i = 0; i < 11; i++){
		if (i > 8){
		   space = (SPACING * (i + 3) * 0.5);
		} else if (i > 2){
		   space = (SPACING * (i + 2) * 0.5);
		} else if (i > 0){
		   space = (SPACING * (i + 1) * 0.5);
		} else {
		   space = (SPACING * i * 0.5);
		}

		// meter bg
		ofSetColor(0,0,0,80);
		ofRect(x_offset + (i * width) + space, y_offset, width, height);

		// meter value
		if (rec == 0){
		   ofSetHexColor(0xed1c24);
```

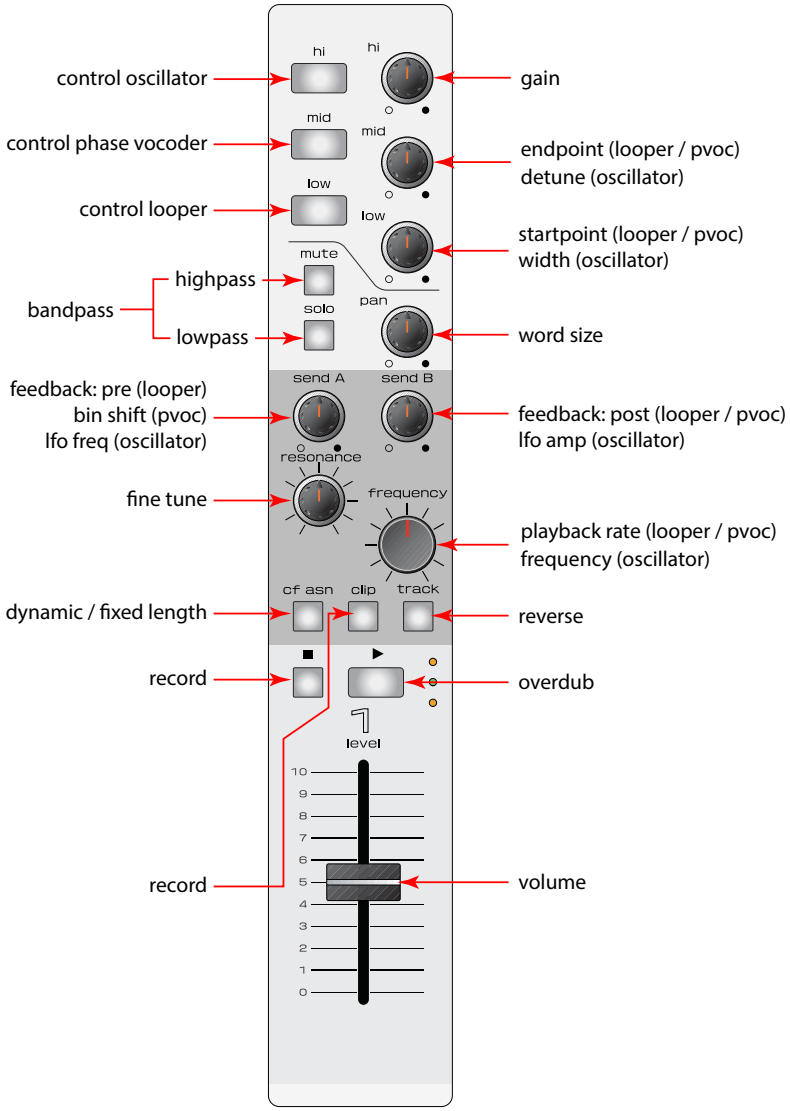
```
            } else {
               ofSetHexColor(0x047391);
            }

            ofRect(
                  x_offset + (i * width) + space,
                  y_offset + height,
                  width,
                  -(height * meters_left[i])
            );
      }
}

//--------------------------------------------------------------
void ofApp::draw_center(){
      float width, x_offset, y_offset, height;

      width = (section_width - (SPACING * 5)) / 6;
      height = (section_height - ((SPACING * 2) + 50)) / 3;

      x_offset = (SPACING * 2) + section_width;
      y_offset = SPACING;

      for (int i = 0; i < 3; i++){
            for (int j = 0; j < 6; j++){
                  // meter bg
                  ofSetColor(0,0,0,80);

                  ofRect(
                        x_offset + (j * (width + SPACING)),
                        y_offset + (i * (height + SPACING)),
                        width,
                        height
                  );

                  // meter value
                  if (rec == 0){
                        ofSetHexColor(0xed1c24);
                  } else {
                        ofSetHexColor(0x047391);
                  }

                  ofRect(
                        x_offset + (j * (width + SPACING)),
                        y_offset + (i * (height + SPACING)) + height,
                        width,-(height * meters_center[((2 - i) * 6) + j])
                  );
            }
      }
}
```

```
//--------------------------------------------------------------
void ofApp::draw_right(){
	float width, x_offset, y_offset, height;

	width = (section_width - (SPACING * 3)) / 4;
	height = section_height - 50;

	x_offset = (SPACING * 3) + (section_width * 2);
	y_offset = SPACING;

	for (int i = 0; i < 4; i++){
		// meter bg
		ofSetColor(0,0,0,80);

		ofRect(
			x_offset + (i * (width + SPACING)),
			y_offset,
			width,
			height
		);

		// meter value
		if (rec == 0){
		   ofSetHexColor(0xed1c24);
		} else {
		   ofSetHexColor(0x047391);
		}

		ofRect(
			x_offset + (i * (width + SPACING)),
			y_offset + height,
			width,
			-(height * meters_right[i])
		);
	}
}

//--------------------------------------------------------------
void ofApp::draw_reminders(){
	ofSetColor(255,255,255);

	string msg1 = "SYNC DRUMS";
	ofRectangle bounds1 = ultramagnetic.getStringBoundingBox(msg1, 0, 0);

	ultramagnetic.drawString(
		msg1,
		(HEIGHT - bounds1.width) * 0.52,
		(WIDTH + bounds1.height) * 0.45
	);
```

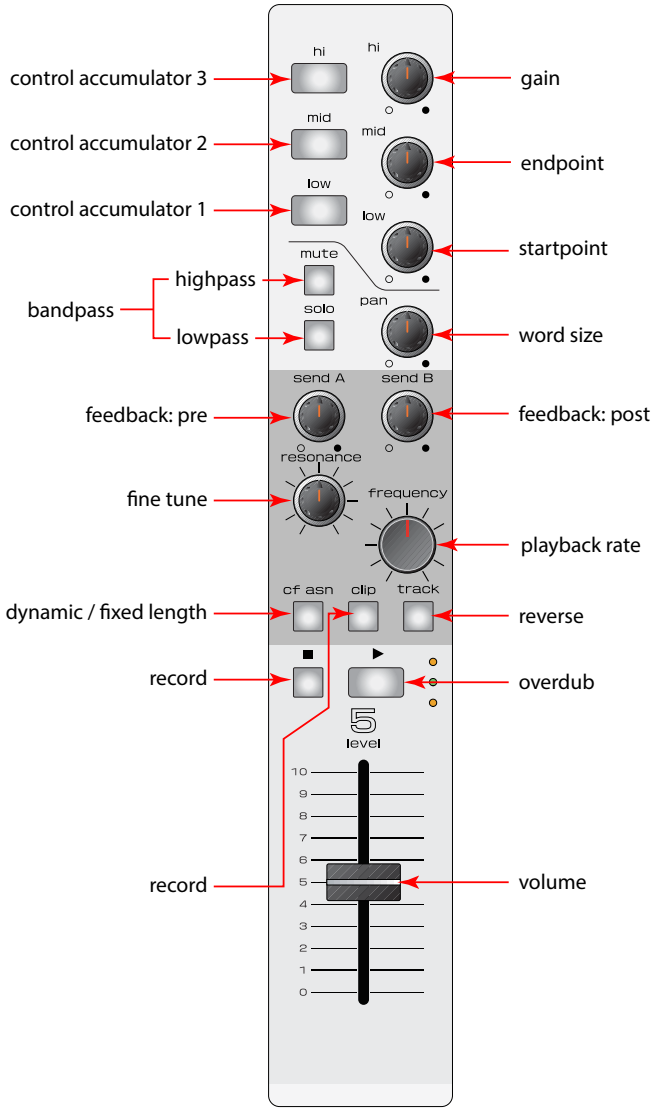
```
        string msg2 = "v.4 | mark.cetilia.org | 2015";
        ofRectangle bounds2 = myriad.getStringBoundingBox(msg2, 0, 0);

        myriad.drawString(
                msg2,
                (HEIGHT / 2) - 13,
                WIDTH - (SPACING - 5)
        );
}

//--------------------------------------------------------------
void ofApp::draw_text(){
        ofSetColor(255,255,255);

        string msg0 = msg_strings[0];
        ofRectangle bounds0 = ultramagnetic.getStringBoundingBox(msg0, 0, 0);
        ultramagnetic.drawString(msg0, SPACING, WIDTH - (SPACING * 1.5));

        string msg1 = msg_strings[1];
        ofRectangle bounds1 = ultramagnetic.getStringBoundingBox(msg1, 0, 0);

        ultramagnetic.drawString(
                msg1,
                (HEIGHT - (bounds1.width + (SPACING * 1.5))),
                WIDTH - (SPACING * 1.5)
        );

        string msg2 = "v.4 | mark.cetilia.org | 2015";
        ofRectangle bounds2 = myriad.getStringBoundingBox(msg2, 0, 0);

        myriad.drawString(
                msg2,
                (HEIGHT / 2) - 13,
                WIDTH - (SPACING - 5)
        );
}

//--------------------------------------------------------------
void ofApp::draw_crosshairs(){
        if (show_crosshairs == true){
                ofLine(0, crosshairs_y, 640, crosshairs_y);
                ofLine(crosshairs_x, 0, crosshairs_x, 1136);
        }
}
```

Appendix E: Fraktur v.4 VCM-600 Controller Mapping Overview

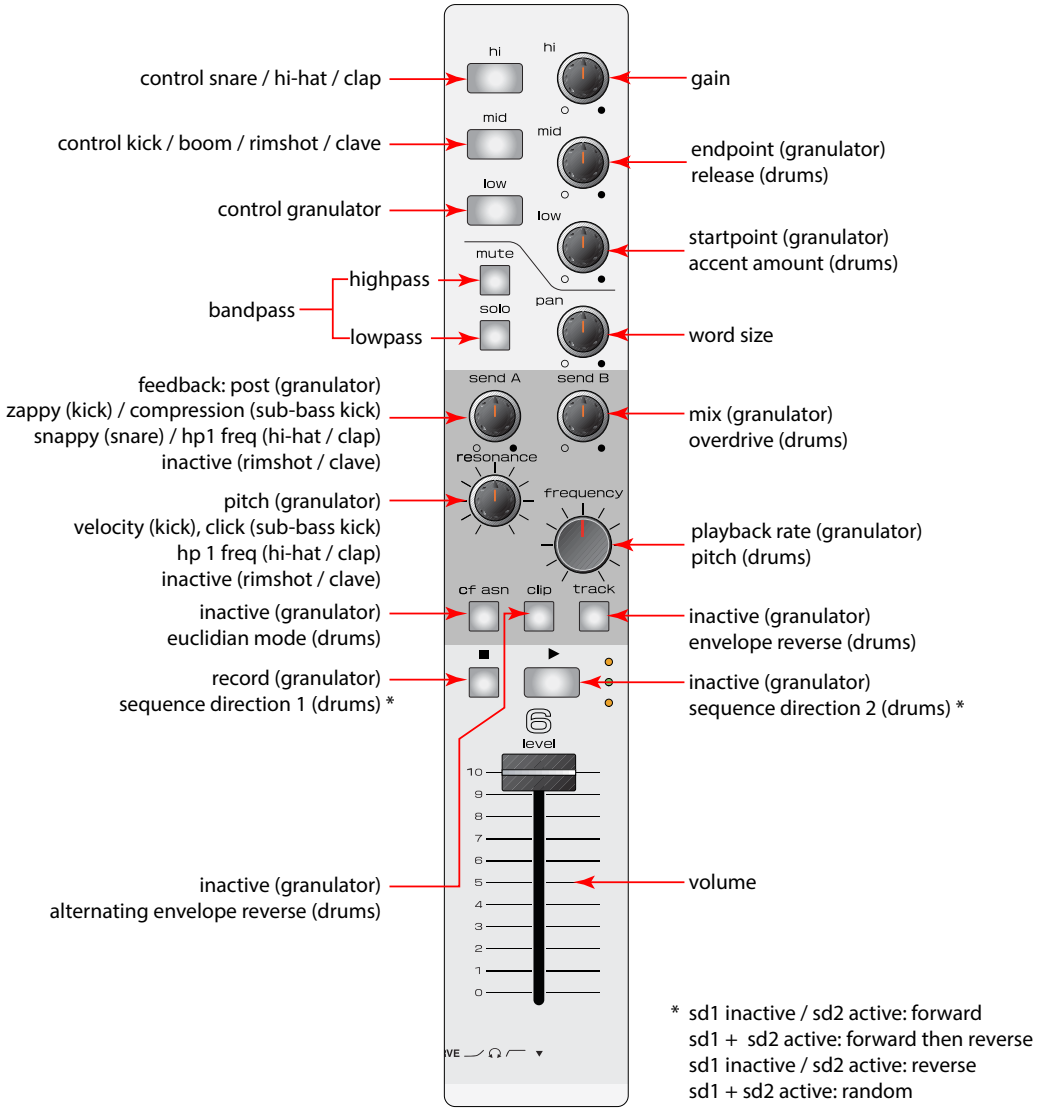
bank 1 / channels 1–4: looper / phase vocoder / oscillator



bank 1 / channel 5: accumulators

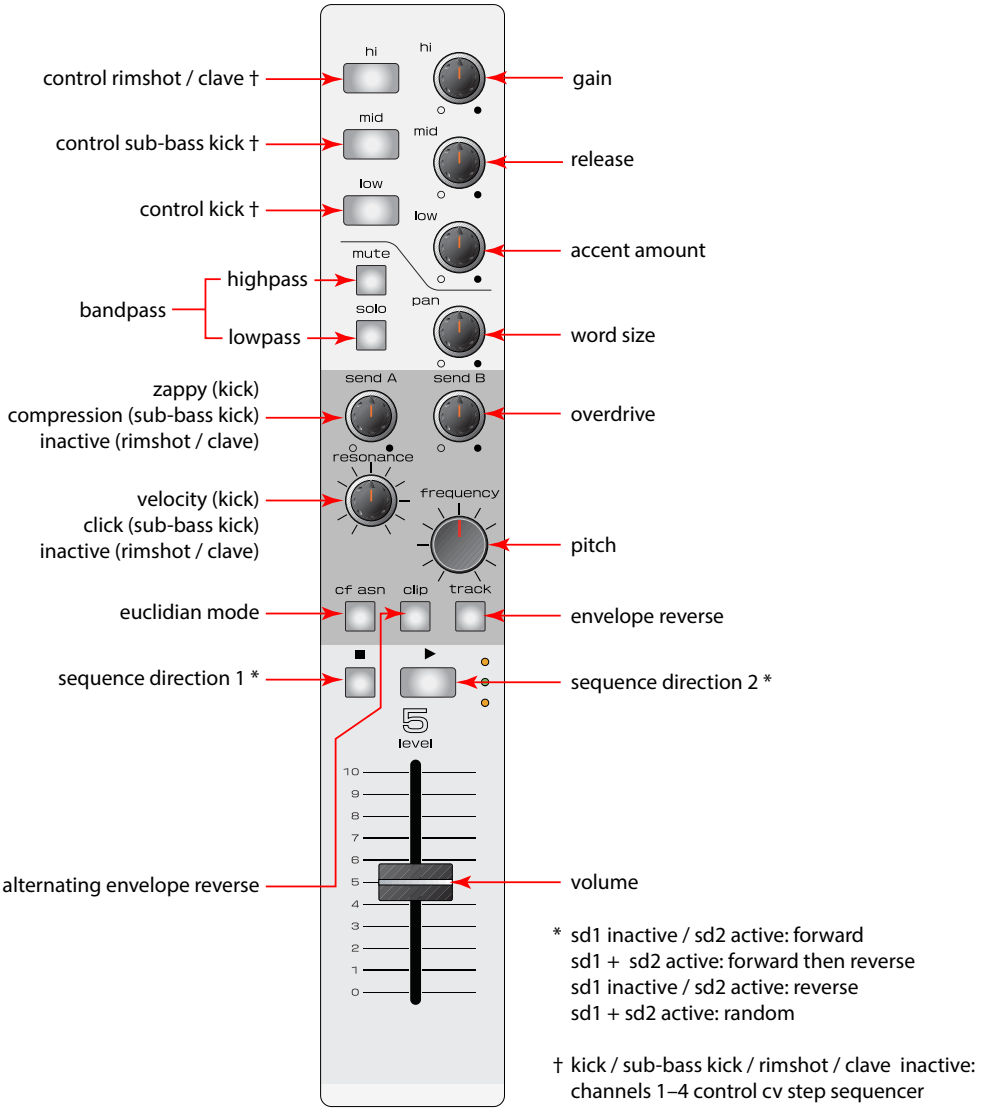


bank 1 / channel 6: granulator / drums



* sd1 inactive / sd2 active: forward
sd1 + sd2 active: forward then reverse
sd1 inactive / sd2 active: reverse
sd1 + sd2 active: random

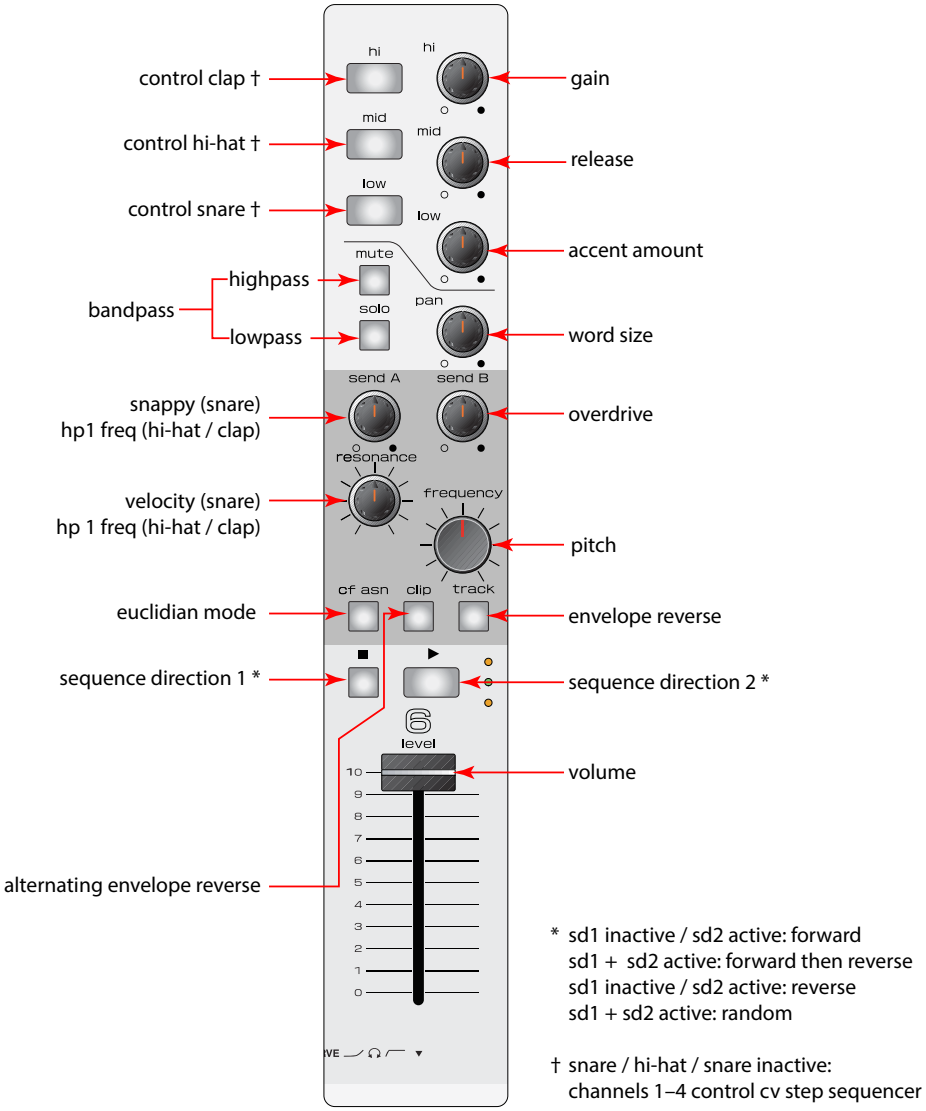
bank 2 / channel 5: kick / sub-bass kick / rimshot / clave



* sd1 inactive / sd2 active: forward
sd1 + sd2 active: forward then reverse
sd1 inactive / sd2 active: reverse
sd1 + sd2 active: random

† kick / sub-bass kick / rimshot / clave inactive:
channels 1–4 control cv step sequencer

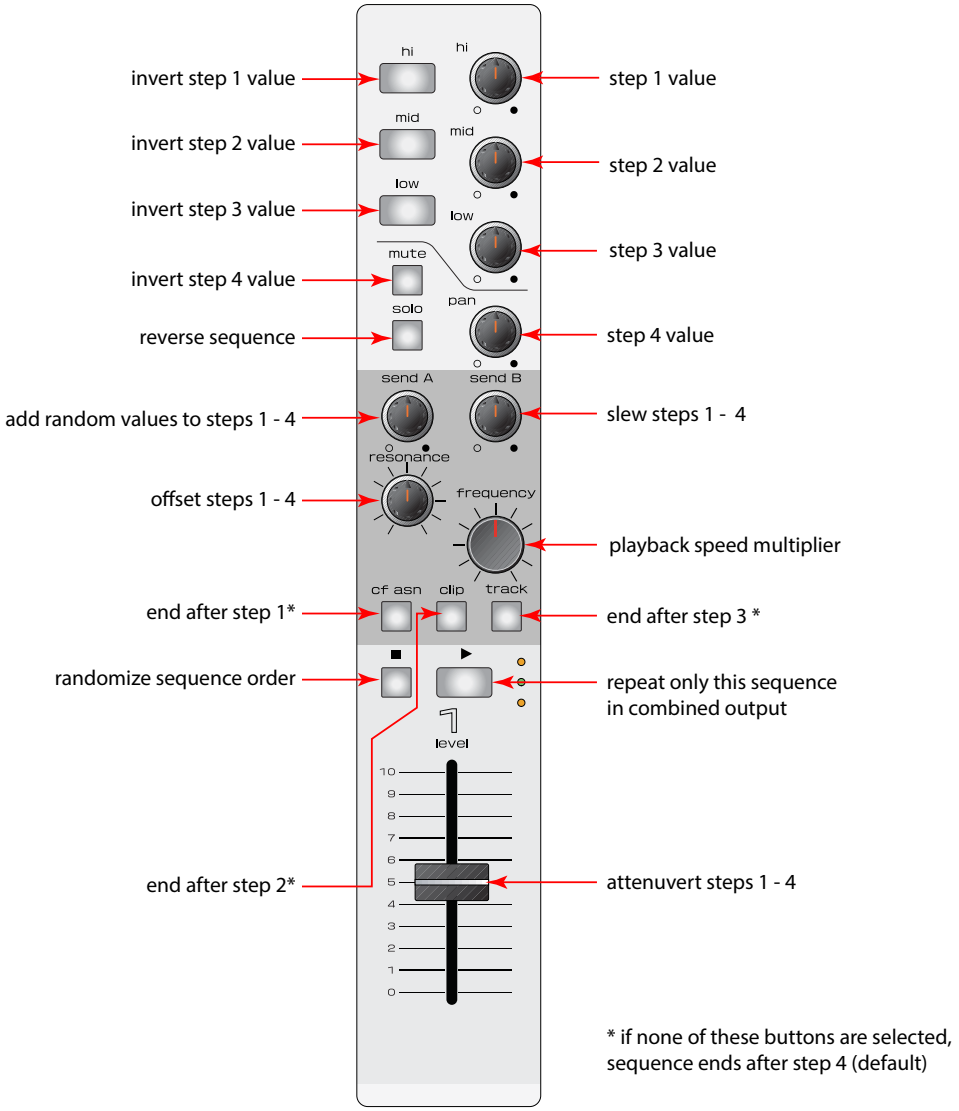
bank 2 / channel 6: snare / hi-hat / clap



* sd1 inactive / sd2 active: forward
sd1 + sd2 active: forward then reverse
sd1 inactive / sd2 active: reverse
sd1 + sd2 active: random

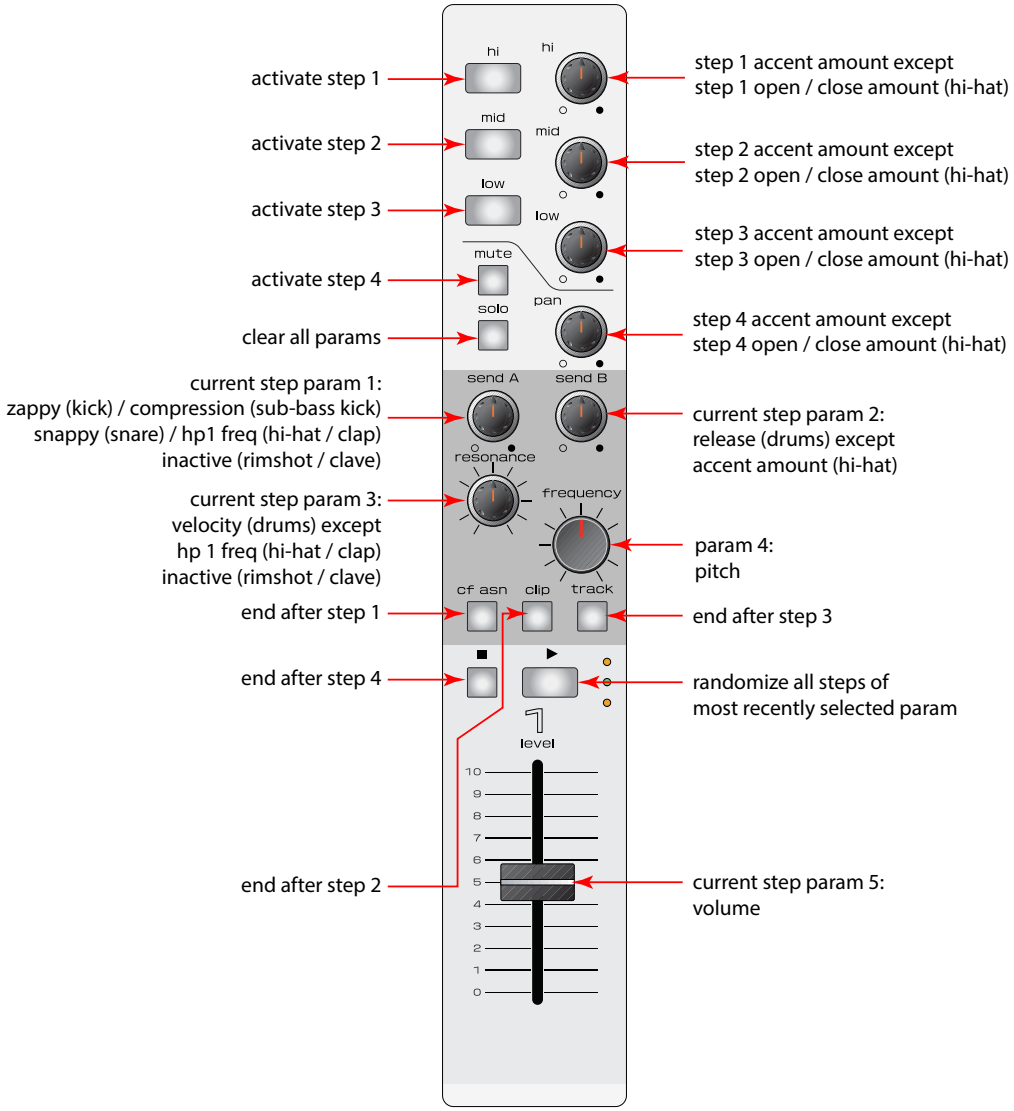
† snare / hi-hat / snare inactive:
channels 1–4 control cv step sequencer

bank 2 / channels 1–4 (cv step sequencer mode)

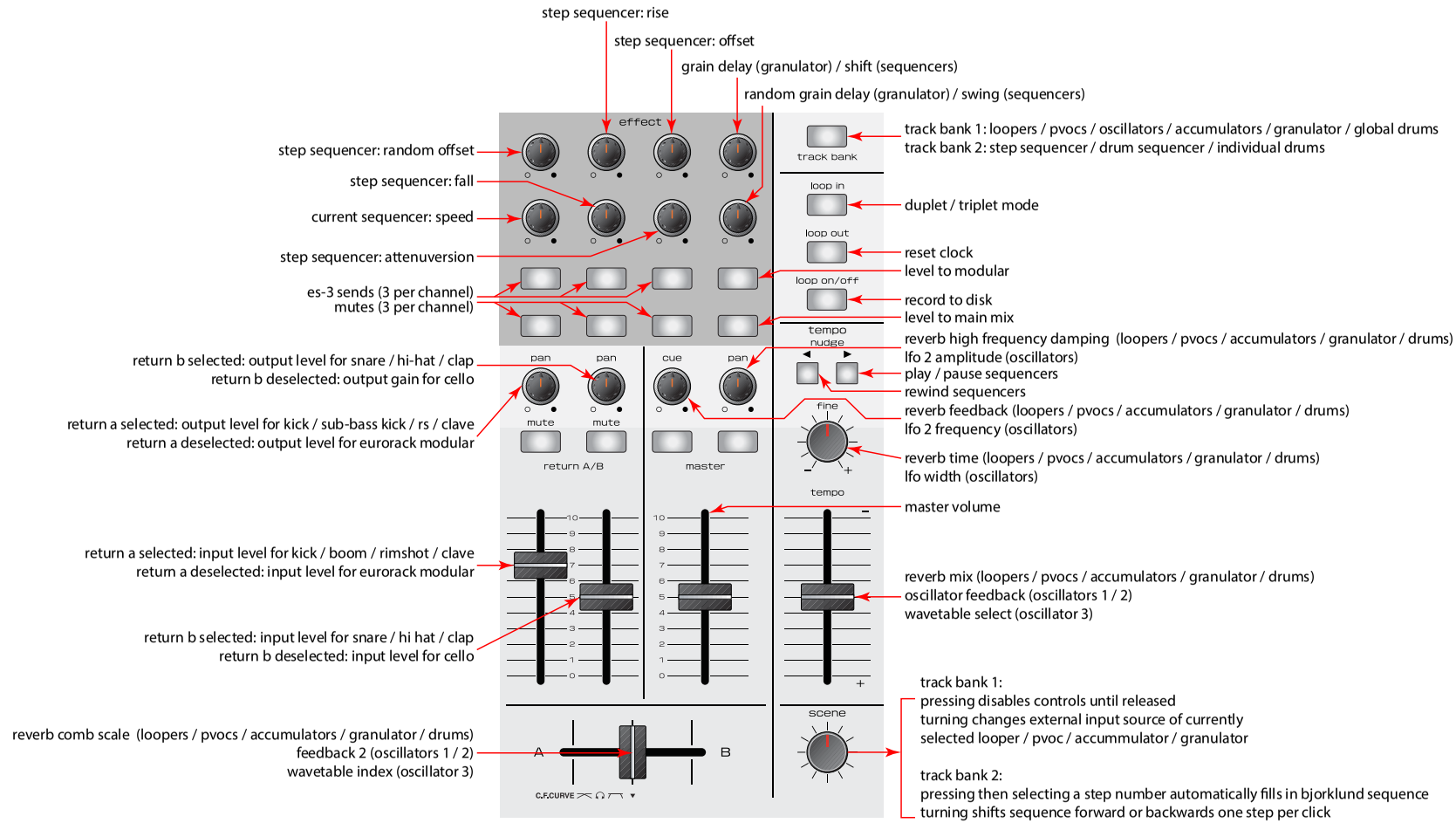


* if none of these buttons are selected, sequence ends after step 4 (default)

bank 2 / channels 1–4 (drum sequencer mode)



master channel controls



Appendix F: Fraktur v.4 Block Diagram