Acknowledgments • xiii

About the companion website • xv

Technology and Creativity in Computer Music • 1

- Combining text and software to explore computer music from the inside
 1
- The pursuit of new perspectives in the analysis of electronic and computer music
 3
- Nine case studies from the history of computer music

1 John Chowning: Stria • 15

• Contexts for Stria • 15

Max Mathews and the beginnings of software for computer music • 15

Jean-Claude Risset and timbral synthesis • 23

John Chowning and the evolution of FM synthesis • 25

• Inside Stria • 35

The golden ratio • 37

Timbre and FM synthesis in Stria • 38

The golden ratio in the context of FM synthesis • 39

Stria's synthesis algorithm • 40

Structure of an event • 42

Timing and duration • 43

Frequency parameters • 43

Attack and decay • 46

Spatialization and reverberation • 47

Envelope functions • 47

The terminal interface • 48

The shape of Stria • 48

• Conclusions • 51

2 Barry Truax: Riverrun • 53

• Contexts for Riverrun • 53

The birth and early development of granular synthesis • 53

• Inside Riverrun • 71

Riverrun: Technique, form, and structure • 71

Granular synthesis in *Riverrun* and the GSX system • 73

viii

Tape techniques • 75

Spatialization in *Riverrun* • 76

Sections and streams • 76

Section 1 • 77

Transition from Section 1 to Section 2 • 78

Section 2 • 78

Section 3 • 80

Section 4 • 80

Section 5 • 81

• Conclusions • 82

3 Philippe Manoury: Pluton • 87

• Contexts for Pluton • 87

First steps in the development of technologies for live computer music • 87

The pioneering contributions of IRCAM • 88
The development of the IRCAM 4X synthesizer • 90
Philippe Manoury: The background to the composition of
Pluton • 97

• Inside Pluton • 105

The global form and materials of Pluton • 106

Constitution of the digital environment for the performance of *Pluton* • 108

The Trevor sampler module • 108

Gumbos: FFT-shaped oscillators • 110

The pitch shifter module • 112

The frequency shifter • 113

The reverberation modules • 114

The quadraphonic spatialization module • 114

Mapping the piano performance to the real-time environment • 115

The score follower: A virtual listener to the pianist's performance • 115

Integrating the performance into the development of electroacoustic processes • 116

Markov sequences: Generating virtual scores from the piano performance • 117

The interactions between the piano and the computer through the musical work • 118

Section II: Toccata • 118
Section II: Antiphony • 119
Section III: Sequences • 121

Section IV: Modulations • 122 Section V: Variations • 123

• Conclusions • 125

4 Hildegard Westerkamp: Beneath the Forest Floor • 127

Contexts for Beneath the Forest Floor
 127

The World Soundscape Project and the evolution of soundscape composition • 127

New directions in the development of the World Soundscape Project • 132

Hildegard Westerkamp and her influences on soundscape composition • 135

Inside Beneath the Forest Floor

Recording as part of the creative process • 144

Field recording locations in British Columbia • 145

The raw materials of Beneath the Forest Floor • 145

Digitally processing the environmental sources • 147

Isolating sounds from their original

environment: Equalizing and gating • 148

Reversing and looping • 149

Extending materials over time with delay and

reverberation • 150

The Doppler effect • 151

Transposing and harmonizing • 151

Assembling the processed sound files into premixes • 153

The environmental materials through the structure of

Beneath the Forest Floor • 154

Section 1: Opening • 154

Section 2: Storm • 156

Section 3: Water • 157 Section 4: Ending • 158

• Conclusions • 159

5 Francis Dhomont: Phonurgie • 161

• Contexts for Phonurgie • 161

Background and early career • 161

Musique concrète and the birth of Groupe de Recherches Musicales (GRM) • 164

New directions for GRM: From analog to digital • 169

The birth of SYTER • 171

Dhomont, Quebec, and GRM • 178

A final homage to *musique concrète* within Dhomont's *Cycle du son* • 179

 Inside Phonurgie
 180 The materials of Phonurgie • 182 The sound sources • 183 Synthesis • 183 Sampling of preexisting works • 184 Indoor object recordings • 184 Instrumental recordings • 184 Field recordings • 185 Processing the sound sources • 185 Basic transformations • 186 Complex transformations • 186 Successive sound transformations • 187 Building reservoirs of sound materials • 187 Improvising with sounds and processes: Séquences-jeu • 188 Exploring empirically software environments and **SYTER** • 190 Editing the materials into the final mix • 192 The structure of Phonurgie • 193 Conclusions
 197 6 Trevor Wishart: Imago • 199 Contexts for Imago
 199 The Composers Desktop Project • 199 The development of Sound Loom as a composing resource • 205 Inside Imago • 216 From a single source to a variety of processed sound files • 217 Successive Sound Loom processes • 218 Assembling the work • 219 The Opening of Image • 220 The Gamelan section • 225 The large-scale structure of Imago • 227 Conclusions
 230 7 Jonathan Harvey: Fourth String Quartet • 233 Contexts for the Fourth String Quartet
 233 First steps exploring the possibilities of electronic and computer music • 233 The IRCAM dimension • 239

Inside the Fourth String Quartet • 250
 Inspiration and structure • 250

Acoustic compositional techniques • 253

```
Melodic cycles • 253
```

Rhythms • 255

Electroacoustic techniques • 257

Loop buffers • 258

Phase vocoders • 259

Granulation • 260

Reverberation and biquad filters • 262

Harmonizers • 263

Spatialization • 263

Performing the electroacoustic part of the Fourth String

Quartet • 267

Summary of the integration of acoustic writing and electronics • 269

Conclusions
 269

8 Cort Lippe: Music for Tuba and Computer • 271

Contexts for Music and Tuba and Computer
 271

Early exploration of the possibilities of computer music • 272

From composing software to real-time synthesis: The road to IRCAM • 274

The IRCAM Musical Workstation and Max • 278

Inside Music for Tuba and Computer
 287

General form and materials • 289

The digital environment for the performance of Music for Tuba and Computer • 290

The sigmund~ object and the oscillators module • 291

The two samplers S and T • 295

The Toto synthesizer • 296

Harmonizer, noiser/phaser, frequency shifters • 297

The FFT processors • 298

Allpass filters and reverberation • 300

Spatialization and stereo output • 301

Global control of the digital environment • 302

Instrumental and electronic interactions through Music for

Tuba and Computer • 303

Section 1 • 303

Section 2 • 304

• Conclusions • 306

9 Natasha Barrett: Hidden Values—The Lock • 307

Contexts for Hidden Values—The Lock • 307
 The early evolution of spatial technologies • 307

xii

```
The development of sound diffusion systems for performance • 308

John Chowning • 309

Surround sound techniques • 311

Ambisonics • 312

The IRCAM Spatializer (Spat) • 316

Vector base amplitude panning (VBAP) • 319

Natasha Barrett and spatial projection • 321

• Inside Hidden Values—The Lock • 329

The musical materials of The Lock • 330

Barrett's software environment for the playback and spatialization of materials • 334
```

Three-dimensional positioning and movements operated by IRCAM's Spatialisateur • 335
Sound source positioning • 335
Playback of prerecorded trajectories • 337
Sound images • 338
Rotations • 339
Image transpositions • 339
Spatial randomization • 340

Spatialization and dramatization in the structure of *The Lock* • 340
Section 1 • 341

Section 2 • 343

Conclusions
 344

Conclusion • 347

Notes • 353

Bibliography • 393

Index • 405