

13 | Women Composers, Experimentalism, and Technology, 1945–80

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Technology is a tremendous liberator. *It blows up power structures.* Women are naturally drawn to electronic music. You didn't have to be accepted by any of the male-dominated resources – the radio stations, the record companies, the concert hall venues, the funding organisations. You could make something with electronics and . . . present music directly to the audience and that gives you tremendous freedom – but somehow women get forgotten from the history.

Laurie Spiegel (2020) (italics added)¹

Speaking at the start of *Sisters with Transistors* (2020), Lisa Rovner's documentary film on women working in electronic music, the New York-based composer and software engineer Laurie Spiegel (b. 1945) identifies, not, as we might expect, the power of a tape machine to rework, with radical and infinite possibility, the sound palette available to the composer, but rather its promise to change the social and economic structure of music, to break apart gender differentials, and to explode power structures. This, first and foremost, is the emancipatory promise of machines that make music.

Spiegel's musical education encompassed elements of a conventional compositional training followed by an early, and lengthy, immersion in the New York electronic studios created by Morton Subotnick in the late 1960s, and then at the Bell Telephone Laboratories, nearby in New Jersey, where she developed software for computer graphics.² Spiegel is also an artist whose music is situated at the interface with software design in creating the methods for her own compositions. She draws as much from cybernetic systems theory as she does from more formal systems of music. In the 1970s, Spiegel was an early adopter of a series of sound synthesizing systems, from the Bell Labs Digital Synthesizer – also known among the technologists there as the Alles Machine or 'Alice' – to the GROOVE hybrid synthesizer.³ Spiegel has used her own *Music Mouse: An Intelligent Instrument* (1986) compositional program – engineered for Mac, Amiga, and Atari platforms – for a number of her works, and she continued to update the software until approximately 2012. To say that Spiegel's work has gone far is no rhetorical overstatement: *Harmonices*

Mundi, her realization of orbital calculations made by the seventeenth-century astronomer Johannes Kepler, was included on a Golden Record, a copy of which is attached to two spaceships, Voyager 1 and Voyager 2, which are currently travelling through interstellar space.⁴ And yet she speaks of the need for liberation. Why is this?

When Spiegel identifies the capacity of technology to circumnavigate existing power structures and systems of distribution and patronage she is making a generalized statement. However, in linking this liberation to the work of women, she highlights that it is women, because they are women, who need to find new tracks to power, because their work is not served by pre-existing structures. Admittedly all composers, of whatever sex and gender, using electro-acoustic and computer technology as a compositional tool are liberated from the often huge costs of orchestras and of venue hire. However, it is important to stress that though technology itself may be neutral, its applications are not.⁵ In turning to technology-based composition, women may be able to sidestep some obstacles, but they are still operating under the weight of a doubly gendered system: firstly, the structure of social relations and institutions, as a general point; and secondly as artists working with a technology gendered as male. Music historiography contains many instances of the anxiety engendered by the collision between women and technology. Often, these examples evoke a kind of slippage in which the woman concerned becomes a little more cyborg, a little more male, than she otherwise is. One astonishing example is the description of Suzanne Ciani (b. 1946) – who uses Buchla and Moog synthesizers for much of her compositional work – as inhabiting ‘an identity that crossed boundaries, [one] that was hard to categorize, a perfect identity for a woman in a man’s world who wanted to have it all’.⁶ Kyle Gann, though an enthusiastic promoter of Pauline Oliveros, who was one of the primary members of the San Francisco Tape Music Center and a hugely influential figure in electro-acoustic work and the development of social scores based upon listening, nonetheless refers to ‘the avant-garde’s premier female artist’ as a homologue – a ‘female counterpart’ to John Cage. In Gann’s essentializing appraisal, Oliveros has ‘molded her work to the supremely feminine archetype of receptivity, specifically a radical receptivity to sound’.⁷ Similarly, the later nicknaming of the Alles Machine with (what sounds like) a feminine first name (‘Alice’) invites analysis in terms of the uses of anthropomorphism in gender control. Taken together, these examples are linked by ambivalence about the presence of women around technology. They are, to adopt a phrase from the anthropologist Mary Douglas concerning purity and pollution, ‘matter out of place’.⁸

Gender and Technology

The reasons why women are drawn to electronic music remain moot. Spiegel offers a pragmatic explanation, but other composers and critics propose an affinity between female sex and the process of composing for electronic media. Delia Derbyshire (1937–2001), the British composer who sprang to fame for her work at the BBC Radiophonic Workshop, has suggested that women have innate qualities that suit them to both the abstract thinking and the crafty meticulousness that tape splicing, and similar actions, require. As Derbyshire told the researcher Jo Hutton:

Women are good at sound and the reason is that they have the ability to interpret what the producer wants, they can read between the lines and get through to them [the producers] as a person. Women are good at abstract stuff; they have sensitivity and good communication. They have the intricacy – for tape cutting, which is a very delicate job, you know.⁹

Spiegel is right to home in on the need for new routes into music as well as the precarity of women's status in this field. As Sherry Turkle observed, 'the computer has no inherent gender. But computer culture is not equally neutral'.¹⁰ Oliveros provides a telling example of bias in action. 'I had no training in electronics, mathematics or physics', she recalled of those early Tape Center days:

I had to teach myself about the hardware in the analog studio. Though well meaning, the 'boys' were not necessarily helpful. The tech-orientated attitude put me off more often than not – mostly because of lack of vocabulary and knowledge on my part. Men have a way of bonding around technology. There seemed to be an invisible barrier tied to a way of treating women as helpless or hapless beings.¹¹

Oliveros, who would go on to develop a body of electro-acoustic work that demonstrated compositional as well as technical dexterity, nevertheless had to teach herself in a process of painstaking trial and error.¹² She would work in the studio through the night, that way gaining the space to make the creative mistakes so necessary for learning. Some of her early titles reflect these creative wrong turns: *The Day I Disconnected the Erase Head and Forgot to Reconnect It* (1966) or *A Little Noise in the System* (1967–70) are two of them.

These early works also brought a defining interest in a musicological feminism to her tape compositions. *Bye-Bye Butterfly* (1965) is a two-

channel deconstruction of an aria from Puccini's *Madame Butterfly*. For Oliveros, it was a way of pulling the curtain down on nineteenth-century operatic tropes of female passivity and, in its loops, a way of 'rescuing' the heroine from her fate. Later works, most significantly *To Valerie Solanas and Marilyn Monroe in Recognition of Their Desperation* (1970) and the text score sound exercises collected as the *Sonic Meditations* (1974), are explicitly feminist strategies for tackling the silence of women in musical and public life. Oliveros wrote prolifically; her 1970 article for the *New York Times*, 'And Don't Call Them "Lady Composers"', was an important broadside against the belittlement of women in the musical field.¹³ Read in tandem with the art historian Linda Nochlin's 1971 essay 'Why Have There Been No Great Women Artists?', Oliveros's text is a defining moment for a refocusing on the systemic effects of sexism.¹⁴

Although, from the mid-1970s onwards, Oliveros's work was to turn away from a purely studio-based composition, she remained an enthusiast throughout her life. The Expanded Instrument System – a set-up of tape delays and pedals that she used in tandem with her accordion – allowed her to adjust sonic temporalities to recreate spatializing effects of architectural reverberation. Deep Listening, the practice that she defined 'as listening to all things, all the time', grew out of listening to sound in space: famously, Deep Listening began for her in an improvisation session conducted underground in a huge disused cistern at Fort Worden, Washington State.¹⁵ The practices that Deep Listening represents are many, but they also have clear social and societal applications; for Oliveros, one of them pertained to social justice in terms of recognizing that no sound – for this, read person – should be privileged over another. She is clear that Subotnick and Ramon Sender, the two founders of the Tape Center in 1962, were not acting with any animus against her; it is simply that she did not fit into what she has called the 'boys' world' and that they – men – were bound up in systemic sexism not through choice but by acculturation.¹⁶ These memories of exclusion were, no doubt, behind some of her own feminist activities: in later life, she used her professional networks to encourage more women into learning about studio-based composition. Elizabeth Hinkle-Turner details how Oliveros tried to short-circuit a female reticence to enter the technological field by circulating details of Mills College's electronic music programme to feminist listservs.¹⁷ This situation sits parallel to the gender biases of classical music's performance and historiography, as documented so clearly by Susan McClary, Marcia Citron, and others.¹⁸ This issue is larger than the interface of music with technology; it concerns wider cultural transmission of gender, and related issues of opportunity.

Composition, Technology, and Beyond

This chapter considers the compositional output of an indicative selection of female composers using a variety of technologies within a time frame that, loosely, stretches from post-1945 *musique concrète* to 1980. This period saw work created by such sound sources as early synthesizers, computers, and the studio itself (as witnessed in the work coming from worldwide experimental and radiophonic studios), as well as by composers taking existing acoustic technologies and radically reusing them in ways that owe much to the liberatory strategies coming out of experimental composition, fine art practice, and performance art. It was an era that saw technologically based composition move out of the studios of elite, hierarchical institutions, to smaller studios with more collaborative and rhizomatic patterns of working. In this period, we also see the changing nature of technology, from the large and unwieldy tape machines, oscillators, and mainframes of *musique concrète* and computer music, to the more portable digital units. It is also, significantly, a period in which compositional methods are increasingly informed by practices that originate outside music and musicology: we can look to the influence of fine art, performance, and live art on compositional techniques and performativity, as well as the stimulus provided by feminism and other liberatory social movements.

The years between 1945 and 1980 see experimentalism in composition throwing a trajectory outward from old technologies to new territories. In the latter category we might trace the career of Annea Lockwood (b. 1939), a composer who signalled her break from more conventional electro-acoustic music most radically through her series of *Piano Transplants* (1969–2005). The four *Transplants* – the title is informed by the pioneering heart transplant surgery first performed in 1967 by Christiaan Barnard – are, like the medical procedure that Lockwood references, about the translation of energy; they should be understood as composition based upon decomposition, the transmogrification of one energetic state to another. By burning, drowning, and planting broken pianos, Lockwood repurposed the instrument of her early training in a creative process of (de-)composition that values the aleatoric sonics produced by the action of fire, water, and decay.¹⁹ To hear and witness *Piano Burning*, for example, is to hear the lap of flames, the ping of breaking strings, the sigh of the instrument's metal harp as it heats up and then cools down. Like all time-based art, the piece is durational, but it is also performative in its reflexivity. Lockwood invited

her early listeners to consider new worlds of sound – indeed, she continues to do so, whether through the flowing currents of sound of the Danube or the Housatonic rivers in her *Sound Map* installations, or the imperceptible sounds of the natural world – bat squeaks, pulsars, underwater geysers that are sonified into frequencies compatible with human hearing.²⁰ She widens the performative frame that John Cage first provided in *4'33"* (1952) to something huge yet simultaneously intimate. For the *Transplants*, Lockwood's compositional tools were necessarily dramatic. Since then, her methods have been varied: she uses conventional instrumentation as well as sonic data sourced from the natural world to create a body of work that plays with the tension between what can be recorded or fixed, and what is transitory.²¹ Flowing water – especially in the polyrhythms of great bodies of water – has always inspired Lockwood. Her *River Archive* works are as much about process as the geographic sounding of place and the vertiginous aeons of time. These compositions, in essence, recognize that their material (and materiality) is bigger and longer-lived than any of their listeners.

The years since 1945 are rich in the production of female-authored experimental music of many types. Thom Holmes, in his comprehensive survey of electronic and experimental music technology, rightly notes both that 'women have always played a key role in the development of electronic music' and that their work has not received the attention that it deserves.²² Among the names Holmes cites are Daphne Oram and Derbyshire at the BBC Radiophonic Workshop in London; in Colombia, Jacqueline Nova; Teresa Rampazzi in Italy; and in the United States, Lily Greenham, Oliveros, Lockwood, Maggi Payne, Yoko Ono, Wendy Carlos, and Alice Shields. This is by no means an exhaustive list. We could add so many more: in Denmark, Else Marie Pade; in the United States, Ruth Anderson and Maryanne Amacher, Bebe Barron, Pamela Z, Suzanne Ciani, Joan La Barbara, and Meredith Monk; in Brazil, Jocy de Oliveira; in France, Éliane Radigue and Beatriz Ferreyra; and in Germany, Christina Kubisch. Laurie Anderson, a multimedia artist from a predominantly fine art background, whose *United States I-IV* project began at the end of our period (its first part was staged at the Kitchen, in New York, in 1979), has long used the technology of music to make larger points about gender, authority, and, above all, political activity and warfare.²³ Taken as a group, these artists represent a wide palette of approaches. They have all been required to create their work outside old hierarchies (indeed, where hierarchies have impinged, the composers have left,

as Oram and Derbyshire did the BBC Radiophonic Workshop in 1958 and 1973 respectively); many have embraced a multi-disciplinarity that blurs the lines between fine art, music and sound arts, and all have, by necessity, created new facilitating networks open to decentred collaboration and experimentation. The literary theorist Eve Sedgwick asks us what effect a homosocial society – here, the patriarchal networks that privilege male composers, doubly so within technological music – has upon the women that stand outside it.²⁴ The answer lies in these new networks, a manner of working, and of creating the conditions necessary for work, that Lisa Tillmann-Healy calls ‘friendship as method’.²⁵

Female composers working in experimental music (whether with technology or not) are a group that is marginalized within an already marginalized area of post-1945 composition. When Éliane Radigue (b. 1932) speaks of not daring, as a young woman, to imagine herself as a composer, she is referring not only to the first, tentative steps of her compositional life but also to the interlinked actions of the patriarchal and economic milieu within which she existed:

I always thought that [becoming a composer] was somehow forbidden. At the time [her husband, the artist] Arman’s career was taking off, so I let him forge ahead. I had our three children to raise and my priorities were clear. I never referred to my works back then as compositions, either – I called them *propositions sonores*. Unfortunately, few of them survive.²⁶

Her awakening to the extended properties of sound occurred around 1951, a period when she was taking harp classes at the local conservatoire in Nice and studying ragas, serialism, and other musical forms. The harmonic possibilities suggested by the sounds of engine drones from a nearby airfield captured her imagination, but it was only after hearing a broadcast of the *Étude aux chemins de fer* (1948), an early *concrète* work by Pierre Schaeffer, that Radigue realized how music might be extended into a different register of sonics.²⁷ The *Étude* was, Radigue says, her road to Damascus, her ‘eureka moment’.²⁸ The chance introduction to Schaeffer led to her being invited, in 1955, to work – as an unpaid *stagiaire* (intern) – at his Studio d’Essai in Paris, and it was here that she made her first tape compositions. These *propositions sonores*, as she titled them (only one now exists), were sketches of how she might be a composer: the reticence to become one was rooted in how a young mother could survive as one. She had sound reasons for wondering so. In terms of opportunities, commissions, and income – the gender-sensitive infrastructure that

Spiegel refers to – it has been, historically speaking, harder for women to enter the field of work. Radigue, by the late 1960s, divorced and the mother of three children, was able to work as an unpaid assistant to Pierre Henry on his *L'apocalypse de Jean* because he had tape machines and other equipment installed in her Paris flat, thereby enabling her to combine her technical work with that of motherhood.²⁹ When we see a successful composer, we discern behind them the existence of barely visible networks and support structures; when we see a successful female composer, we need to search – actively – for different networks and structures, often ones working horizontally, rather than vertically, through friends and word-of-mouth, rather than the vertical hierarchies of organizations. To these conditions of work, we must add factors that go beyond sex alone: composers of colour (men and women) and so many other groups subject to intersectional aggressions are woefully underrepresented in new music.

This was recognized by the composer Oliveros and Fluxus artist Alison Knowles (b. 1933) in their short, but pointed, set of five images issued as the *Postcard Theater* (c. 1974). The postcards had titles such as *Beethoven Was a Lesbian*, *Mozart Was a Black Irish Washerwoman* and *Brahms was a Two-Penny Harlot*: the images showed, respectively, Oliveros reading a book while a papier-mâché bust of Beethoven glowers over her shoulder; Oliveros riding an elephant at a zoo; and details of pictures of both postcard artists as unlovely infants. This feminist consciousness-raising exercise poked fun at a very white male (and heterosexual) musical establishment.³⁰ The Irish composer Jennifer Walshe (b. 1974) makes a similar point in her *Historical Documents of the Irish Avant-Garde* project (2015), a collection of compositions and documentation that imagines the work and practices of a wide range of Irish experimental musicians and sound artists. That none of the artists in the *Historical Documents* ever existed beyond Walshe's *magna opera* is the crux. The project offers a bundle of simultaneous realities: it is a series of musical imaginings; it is a revisionist history, created in a humour that honours the spirit of the Irish author Brian O'Nolan (who wrote as both Flann O'Brien and Myles na gCopaleen), in which Dada and drone music spring first from Irish roots; it is a documentary spoof (as opposed to a spoof documentary), a series of fictions and sleight of hands that imagine a parallel history for Ireland, one that listens – to revisit the words of the historian Lucien Febvre – to its voices from below.³¹ Or it would listen had those voices – lost not only to history but lost, too, to the possibility of history – ever been able to imagine the possibility of creativity.

Communicating and Securing New Territories

Prior to 1945, compositional training was the preserve of conservatories and of private study, with individual teachers taking on virtuoso students. Certainly, this system continued after this date –for example, in the case of Nadia Boulanger (1887–1979), to whose Paris flat came a formidable list of budding composers, among them Aaron Copland, Virgil Thomson, Ruth Anderson, Philip Glass, and, for a short period, Beatriz Ferreyra. This select, individuated manner of transmission could continue (and still does) while the instruments producing the sounds remained unchanged. But with the advent of electronic music, an alternative approach to pedagogy was required. Writing in 1955, Herbert Eimert, one of the founders of the Cologne-based Studio für elektronische Musik des Westdeutschen Rundfunks (Studio for Electronic Music of West German Radio), acknowledged that new sounds required new methods of teaching. So critical was this need, he stated it firmly on the first page of the first issue of *Die Reihe*, the hugely influential contemporary music journal that he edited with Karlheinz Stockhausen:

Despite the fact that electronic music is the outcome of decades of technical development, it is only in the most recent times that it has reached a stage at which it may be considered as part of the legitimate musical sphere. The manner of its birth must in many respects be distinguished from all other beginnings we have understood to be natural developments. Here there has been no extension of traditional procedure. By the radical nature of its technical apparatus, electronic music is compelled to deal with sound phenomena unknown to musicians of earlier times. The disruption by the electronic means, of the sound world as we have known it leads to musical possibilities, the ultimate consequences of which can hardly yet be appreciated.³²

Because of the expense of studio equipment, the early radiophonic and electronic music studios in the years immediately after 1945 were usually attached to state radio stations, universities, technology companies, or, in the case of the Institut de Recherche et Coordination Acoustique/Musique (IRCAM) in Paris, galleries.³³ They were, thus, elitist institutions with all the issues of access attendant on that restricted status.³⁴ Certainly, teaching occurred in these settings and others. The biennial Darmstadt summer courses, which began in 1946, for many years represented the high church of serialism and *reinelektronische Musik*, and as such wielded a persuasive influence over post-war composition. Pierre Boulez, who, in 1977, decried a ‘conservative historicity’ which ‘impoverishes musical invention’, saw the

IRCAM project as an antidote.³⁵ One way that IRCAM's influence is seen now is by its capacity to help composers realize technological aspects of their music with the provision of programmers and other technologists. However, as technology gradually became less costly, it has also become more accessible. Adapting a phrase used by Francesco Giomi in his history of Italian electronic music, Laura Zattra traces the development of a series of 'second-generation' studios in Italy from the mid-1960s, thereby illuminating new working practices that revolve around friendship and informality.

There was, by necessity, much in-situ learning. Pierre Schaeffer's Studio d'Essai and its successor studios were the training ground not only for Radigue but also Beatriz Ferreyra (b. 1937).³⁶ The BBC Radiophonic Workshop, the closest the UK has come to the radio-centred experimental studios of Europe, was founded in 1958 by the composer Daphne Oram (1925–2003) and studio manager Desmond Briscoe, initially to provide 'special sound' – somewhere between a sound effect and music – for radio programmes. The workshop, which closed in 1998, has featured heavily in the historiography of electronic music, with much of the focus being on Oram and Derbyshire to the exclusion of others, including Jenyth Worsley (who was at the workshop between 1961 and 1962), Maddalena Fagandini (who joined in 1962), Elizabeth Parker (who joined in 1977), and Glynis Jones (who joined in 1973).³⁷ The workshop had no mission to be a pure research unit, nor to provide an educational institution for the training of musicians in new techniques. Oram, in fact, did not stay long at her own creation: she left to pursue her own work, which included the invention and utilization of her Oramics machine, an optical sound invention in which sound waves and shapes were painted on 35 mm film which was then scanned and turned into sound. Derbyshire, a Cambridge mathematics and music graduate, joined the workshop in 1962 after being rejected from a job at the studios of Decca Records, where she had been told that they 'did not employ women in the recording studios'.³⁸ Within a year, she had created what subsequently became one of the world's most recognizable and enduring pieces of electronic music, the theme tune to *Doctor Who*, which was an extended, virtuoso realization of a hastily sketched tune by Ron Grainer. The swooshing arpeggios of Derbyshire's *Doctor Who* theme, created with a white noise generator, sine waves and a square-wave oscillator, were first aired on BBC TV on 23 November 1963. Paired with a bassline provided originally by a long string and subsequently transformed by tape technology, the tune's effect was electrifying. Derbyshire's music, never credited to her partly because the workshop took joint

authorship of its works, is one of the most recognizable pieces of electronic music in the world.

Operating under more permissive conditions, the new studios in the United States were not reined in by hierarchical authority. In 1962, Morton Subotnick and Ramon Sender established the San Francisco Tape Music Center, building on the artistic foundations of Sender's original music studio which was housed in one of the attics at the San Francisco Conservatory as well as the excitement that had formed around a number of programmes in the city.³⁹ These included Robert Erickson's Composers' Workshop at the Conservatory, where Sonics, a series of new music concerts was initiated. These events featured works by Subotnick, Oliveros, and Sender, as well as older, established European composers, including Stockhausen, Luciano Berio, and Gottfried Michael Koenig. Additional influences were regular concerts organized by La Monte Young and others at the University of California, Berkeley's department of music as part of its Student Composers' Symposium, and the radio station KPFA 94.1, for which Oliveros, with Terry Riley and Loren Rush, recorded improvisations. Finally, the growing reputation of Mills College, Berkeley, as a focal point for radical composition cannot be overstated. Although the educational establishments provided homes for these programmes, the music's impact was felt beyond the academic audiences due to the layering of multiple artistic networks that cut across institutional boundaries. In this way, the content of these composers' programmes seeped into the city's considerable counterculture.

These were new ways of working, which Subotnick would soon after import to his own electronic studio in downtown New York. In both civic location and attitude, this studio was very different to the uptown Columbia-Princeton Electronic Music Centre, which had been founded in 1959 by composers attached to both universities. Although for its early years, Subotnick's studio had a low-key affiliation with New York University, this 'highly non-institutional studio', with all its informality, was open to divergent currents in music in a way that the older studio was not, and its users remember Subotnick's encouragement of their work.⁴⁰ Maryanne Amacher, and (especially) Radigue and Spiegel, are the women most closely associated with it. Meeting Rhys Chatham there – then in his late teens – provided Radigue with the contact to stage some of her early works at The Kitchen, where Chatham was to run a new music programme. These are examples of horizontal, rhizomatic networks, rather than the top-down formalities of patronage.

While the invention of tape and new studio techniques did much to revolutionize sounds available for composition, these new technologies also required teachers capable of recognizing the potential for these new soundworlds. At the heart of any pedagogy is the need or desire to pass on and share one's own world in order to enable the practice and scholarship of others. For many such musician-teachers, this was an explicitly feminist practice. The flautist and electro-acoustic composer Ruth Anderson (1928–2019), one of the first four women to be allowed onto Princeton's post-graduate composition programme (this was in 1962), also trained at the Columbia-Princeton Electronic Music Center with Vladimir Ussachevsky and Pril Smiley, the latter being one of the centre's four instructors.⁴¹ After compositional studies in Paris with Darius Milhaud and Nadia Boulanger, Anderson returned to the United States. Having joined the faculty of Hunter College, the City University of New York (CUNY), in 1966 she founded an electronic music studio there, serving as its director between 1969 and 1979. It was one of the first such studios in the public university system and the first one set up by a woman. It was, she wrote in a 1973 letter to her partner, Annea Lockwood, not only a studio or academic course but also 'a safe space to be'.⁴² Put in the context of Oliveros's sense of dislocation in the San Francisco studio, the safety Anderson mentions is important. Anderson was a professor of composition and music theory, but her real interest was sound, as her *Points* (1973–4) demonstrates. A little over five minutes in length, *Points* is built around clusters of sine waves, formed into shifting shapes over its duration. For Anderson this was a way of using pure sound to restate fundamental tenets of music – of rhythm, space, amplitude – and, in doing so, to draw our listening attention to the paradox of an immaterial play of fluid sonic material.

Radigue shares Anderson's preoccupation with the nature of sound. Her early works were, as we have seen, made with tape and feedback. In 1970, she discovered synthesizers – first the Buchla, then the analogue ARP 2500 – during a residency at New York University. It was at Subotnick's studio that she met not only Spiegel, but also the major figures in the city's downtown music scene. Radigue's tape experiments had allowed her to experiment with harmonics and synchronization; the synthesizers allowed her to go much further. Between *7th Birth* (1971) and *L'île re-sonante* (2000), Radigue worked exclusively on her own ARP 2500, which she used without its keyboard, in her Paris apartment (The one deviation was 1973's *Arthesis*, for which Radigue used a Moog synthesizer.). This refusal of a keyboard enabled her to float free of anchoring octaves to concentrate, instead, on the electronic shape and frequency of the sounds that she was

working on. Radigue's music from this period – for example, the *Adnos* trilogy (1974–82) – is characterized by slowly moving, richly timbral drones, the harmonics of which she accentuated by carefully shaving off frequencies during her editing process. While she does not see her music as in any way sacred, the slow processes of sonic transition and transformation are linked to her practice of Tibetan Buddhism. Since 2000, Radigue has been working with acoustic instruments, composing in a process of co-creation with chosen musicians in a manner that recalls the oral transmissions of ancient teachings.⁴³ In this chapter, we have considered female composers working *with* technology: Radigue is an example of a composer who has worked *through* technology, to develop an acoustic compositional interface that interrogates the sonic properties of sound in a way that is related to her electronic work. Her most recent works, for the acoustic *Occam Ocean* series, fit into this pattern.

In the summer of 1980, as part of the New Music America festival – based that year at the Walker Art Center in Minneapolis – Ellen Fullman (b. 1957), then a young artist starting out, took her *Metal Skirt Sound Sculpture* onto the streets of the city's red-light district to perform her new work, *Streetwalker* (1980). Fullman, who had recently graduated from the Kansas City Art Institute where she had majored in sculpture, was looking at ways to create soundtracks to her performance art; she made this wearable sculpture during her final year at the institute. The skirt comprised metal panels attached to a waistband, while its hem was threaded with guitar strings; these in turn were attached to the platform shoes that completed the costume. Rudimentary amplification – a contact microphone was attached to the skirt – was supplied by a small Pignose amplifier that Fullman carried over her shoulder, rather like a handbag.⁴⁴ As the guitar strings were alternately pulled and released by the action of walking, raucous glissandi were produced; these were accompanied by the clanking rhythms of the skirt's metal twirling panels. (A grainy video excerpt of *Streetwalker*, available on Vimeo, portrays something of the edgy, clangorous nature of Fullman's performance.)⁴⁵ *Streetwalker* was – and remains – a performance that is as much about female audibility as about female visibility; it is an explicitly feminist riposte to the display and commodification of bodies that characterize any public space where sex is sold and bought.

While *Streetwalker* bears no resemblance to Fullman's subsequent work – the invention and continuous refinement of her Long String Instrument – it nevertheless exemplifies much of what this chapter has considered: the creation and accessibility of new technologies, of female audibility and visibility, and of intersecting artistic practices. Indeed, Fullman herself – an artist who

travelled from fine art to sound sculptures to composition – is a musician/composer who, with the creation of her own instrument, typifies the techne, the craft, of experimental music. The Long String Instrument, the origins of which arose from self-initiated experiments with the sonic properties of horizontal wires rather than a familiarity with the history of long-string harmonics, injects a quantum of sonic and concrete materiality that is often missing in experimental music-making.

Streetwalker was made possible not only by the availability of the technology required (in this case, a simple portable amplification unit) but also by developments in both musical composition and fine art method that had, since 1945, been redrawing the definitions of what constituted composition, music, and performance. As a young artist applying a knowledge of sculptural techniques to sound and wearable sculpture, Fullman was entering into a compositional arena that took inspiration from the innovating synergies created by the clash of formerly monolithic disciplines. She was able to do this because of the work of others. Certainly, Cage was an axial figure, one who linked musicians, composers, visual artists, and, via his '(Experimental) Composition' classes at the New School in New York between 1950 and 1960, the American Fluxus artists. But there were other key players whose existence, perhaps, the young Fullman was unaware of then. These include Charlotte Moorman with the Avant-Garde Festival in New York (1963–80) and her collaborations with the installation artist Nam June Paik; the happenings staged in 1950s Japan by the Gutai group, and in particular, Atsuko Tanaka's own wearable electric sculptures which, in addressing consumerist spectacle, prefigure the raw feminist performativity of Carolee Schneemann's *Meat Joy* (1964). *Streetwalker's* crossover of fine art-based practices of performance into a sonic medium problematizes how a woman might move through architectural, social, and gendered spaces, even as it heralds the multi-disciplinarity that has characterized much subsequent new music. In this way, the young Fullman sounds out the alarm for a very real problem of audibility of women in the arts, music, and technology.

On the Controls, in Control

Earlier in this chapter I noted that technologically generated sound opens up new vistas for composition, of 'sonic possible worlds', to borrow a phrase from the sound artist and theorist Salomé Voegelin.⁴⁶ However, to assume that studio technology comes into the world unencumbered with

a background that reproduces historical and systemic bias would be wrong. Such historical biases exist, and they have, until comparatively recently, been reinforced through a lack of critical thinking by musicians, educators, and technicians. There are honourable exceptions among educators: counted among these are Ruth Anderson at Hunter College, CUNY; Pauline Oliveros at University of California San Diego and elsewhere; Maggi Payne at Mills College; and in the UK, artist-practitioners and academics such as Katherine Norman at Goldsmiths, and, at the Creative Research into Sound Arts Practice (CRiSAP) research centre at the University of the Arts London, Cathy Lane, as well as staff at City University, Brighton University, and at Huddersfield. Nevertheless, it would be remiss to conclude that studio technology has achieved the full liberatory potential that Laurie Spiegel speaks of. That is yet to happen; gender-based biases continue to be a long-term problem, and, in music technology and electronic-based music, the problem is acute. Numerous recent scholars have pinpointed how the gendering of music technology puts off young women from entering the field.⁴⁷ Lucy Green and Frances Morgan have highlighted how women operating in composition and studio-based music respectively have received the dubious accolades of ‘honorary’ men and pioneering exceptions.⁴⁸ That the entry of women into this gendered space has provoked cultural anxiety is indicated by how often the iconography around women in technological music has focused on typically ‘feminine’ signifiers. Besides the feminizing anthropomorphism of the Alles/‘Alice’ machine, we could also mention the familiar images of Radigue where we see the famous photographs of her manicured hands poised on the knobs of her ARP 2500 synthesizer, of her hair,⁴⁹ and of her listening to a conch shell.⁵⁰

In a spirit of detournement, the artist-film-maker Aura Satz has reclaimed images and gestures of several female electronic composers, in a way that stresses their agency and feminist innovation. The drawings presented in Satz’s *She Recalibrates* (2018) series focus on the hands of Radigue, Spiegel, Daphne Oram, and others as they turn dials and adjust controls. The hands here are strong, literally ‘on’ the controls, metaphorically ‘in’ control. Satz reiterates this point in *In Making a Diagonal with Music/Hacer una Diagonal con la Musica* (2019), her short, lyrical film detailing Beatriz Ferreyra’s sonic investigations.⁵¹ We see Ferreyra ‘sound-hunting’ – manipulating the creak of a door, tapping objects to examine their timbres and allure, and vocalizing non-syntactic sounds. Her gestures are agile and graceful as she responds to what she is gathering and composing. Ferreyra here is the controller of her own universe, the creator of sounds and their manipulator. If ever Spiegel’s

words, quoted at the start of this chapter, were in need of their own image, of a composer working and moving through her own work, we see it in the figure of Ferreya.

Further Reading/Listening

- Anderson, Laurie. *Big Science*, LP/CD/DL (New York: Warner Bros, 1982).
- Derbyshire, Delia, and Ron Grainer. Doctor Who: Original Theme Music and Credits (London: BBC TV, 1963), www.youtube.com/watch?v=75V4ClJZME4.
- Eckhardt, Julia, and Éliane Radigue. *Éliane Radigue: Intermediary Spaces/Espaces Intermédiaires* (Brussels: Umland Editions, 2019).
- Molleson, Kate. *Sound within Sound: Opening Our Ears to the 20th Century* (London: Faber & Faber, 2022).
- Oliveros, Pauline. *Software for People: Collected Writings 1963–80*, 2nd ed. (Kingston, NY: Pauline Oliveros Publications, 2015).
- Radigue, Éliane. *Éliane Radigue: Oeuvres Électroniques*, 14 CDs (Paris: Ina-GRM, 2018).
- Tutti, Cosey Fanni. *Re-Sisters: The Lives and Recordings of Delia Derbyshire, Margery Kempe and Cosey Fanni Tutti* (London: Faber & Faber, 2022).

Notes

1. Laurie Spiegel, interviewee, in *Sisters with Transistors: Electronic Music's Unsung Heroines*, dir. Lisa Rovner (Anna Lena Films and Willow Glen Films, 2020).
2. New York electronic studios had links with New York University, and these were formalized when the studio became part of the Tisch School of the Arts at New York University. The French electro-acoustic composer Éliane Radigue is among this studio's alumnae.
3. Hal Alles developed and named what has been described as the first 'digital additive synthesizer' at Bell Labs in the mid-1970s. See Joel Chadabe, *Electric Sound: The Past and Promise of Electronic Music* (Upper Saddle River, NJ: Prentice Hall, 1997), 178. A decade earlier, Max Mathews and Richard Moore created the first iterations of the GROOVE (Real-time Generated Operations on Voltage-controlled Equipment) hybrid analogue/digital system. GROOVE was later updated to include video processing. Spiegel has said of GROOVE that she developed 'a deep personal relationship with that computer': see Laurie Spiegel, 'Graphical GROOVE: Memorial for the VAMPIRE, a Visual Music System', *Organised Sound*, 3/3 (1998), 187–91, at 187.
4. Launched in 1977, Voyager 1 is, at time of writing, more than 14.1 billion miles from Earth. <https://voyager.jpl.nasa.gov/mission/status/> (accessed 24 November 2020).

5. Sherry Turkle, 'Computational Reticence: Why Women Fear the Intimate Machine', in *Technology and Women's Voices*, ed. C. Kramarae (New York: Pergamon Press, 1986), 41–61, at 41.
6. Trevor Pinch and Frank Trocco, *Analog Days: The Invention and Impact of the Moog Synthesizer* (Cambridge, MA: Harvard University Press, 2002), 170.
7. Kyle Gann, *American Music in the Twentieth Century* (New York: Schirmer Books, 1997), 161.
8. Mary Douglas, *Purity and Danger: An Analysis of Concepts of Pollution and Taboo* [1966] (Abingdon: Routledge Classics, 2002), 36.
9. Jo Hutton, 'Radiophonic Ladies' (2002). Online article available via <http://delia-derbyshire.net> (select tab 'Articles and Interviews').
10. Turkle, 'Computational Reticence', 41.
11. *The San Francisco Tape Music Center: 1960s Counterculture and the Avant-Garde*, ed. D. W. Bernstein (Berkeley, CA: University of California Press, 2008), 88.
12. Many of these early works are compiled on Pauline Oliveros, *Reverberations: Tape and Electronic Music, 1961–1970*, re-issue box set (Important Records, IMPREC352, 2012), 12 CDs.
13. Pauline Oliveros, *Software for People: Collected Writings 1963–80*, 2nd ed. (Kingston, NY: Pauline Oliveros Publications, 2015), 47–51.
14. Linda Nochlin, *Women Artists: The Linda Nochlin Reader*, ed. M. Reilly (London: Thames & Hudson, 2015), 44–68.
15. Pauline Oliveros, 'Quantum Listening: From Practice to Theory (to Practise Practice)', in *Culture and Humanity in the New Millennium: The Future of Human Values*, ed. S. Chan and S. T. Kwok (Hong Kong: Chinese University Press, 2002), 27–44, at 27. For further details of Deep Listening improvisation, see Pauline Oliveros, 'Improvising with Spaces', *Journal of the Acoustical Society of America*, 119 (July 2007), 68–72.
16. Louise Marshall, 'Deep Listening: The Strategic Compositional Practice of Female Experimental Composers Post 1945', PhD diss. (University of the Arts London, 2018), 127.
17. Elizabeth Hinkle-Turner, *Women Composers and Music Technology in the United States: Crossing the Line* (Farnham: Ashgate, 2006), 247.
18. Susan McClary, *Feminine Endings: Music, Gender, and Sexuality* (Minneapolis: University of Minnesota Press, 1991); Susan McClary, 'Women and Music on the Verge of the New Millennium', *Signs*, 25/4 (2000), 1283–6, and Citron, GMC.
19. Marshall, 'Deep Listening', 44.
20. Lockwood, *A Sound Map of the Hudson River* (1982), *A Sound Map of the Danube* (2008), and *A Sound Map of the Housatonic River* (2012).
21. Tara Rodgers, *Pink Noises: Women on Electronic Music and Sound* (Durham, NC: Duke University Press, 2010), 8.

22. Thom Holmes, *Electronic and Experimental Music: Technology, Music, and Culture*, 5th ed. (New York: Routledge, 2006), xv.
23. Laurie Anderson, *United States I–IV Live*. Warner Bros Records (4 CDs, 1984); Laurie Anderson, *United States* (New York: Harper & Row, 1984); and RoseLee Goldberg, *Laurie Anderson* (London: Thames & Hudson, 2000).
24. Eve Kosofsky Sedgwick, *Between Men: English Literature and Male Homosocial Desire* (New York: Columbia University Press, 1985), 1–14.
25. Lisa M. Tillmann-Healy, ‘Friendship as Method’, *Qualitative Inquiry*, 9/5 (2003), 729–49. See also Lisa M. Tillmann-Healy, *In Solidarity: Friendship, Family, and Activism Beyond Gay and Straight* (New York: Routledge, 2015).
26. Cited from Dan Warburton, ‘Into the Labyrinth’, *The Wire*, 260 (October 2005), 29. Only one – a graphic score titled *Asymptote Versatile* (1960) – seems to have survived.
27. Girard, Bernard, *Entretiens avec Éliane Radigue* (Château-Gontier: Éditions Aedam Musicae, 2013), 33.
28. Julia Eckhardt and Éliane Radigue, *Éliane Radigue: Intermediary Spaces/ Espaces Intermédiaires* (Brussels: Umland Editions, 2019), 64.
29. Marshall, ‘Deep Listening’, 41.
30. Louise Gray, ‘Beethoven Was a Lesbian: Tracing an Alternative History of Music Mapped by Pauline Oliveros and Alison Knowles’, *The Wire* [Online] (December 2016) www.thewire.co.uk/in-writing/essays/pauline-oliveros-louise-gray#.
31. Lucien Febvre, ‘Albert Mathiez: Un Tempérament, Une Éducation’, *Annales d’histoire Économique et Sociale*, 18 (1932), 573–6, at 576.
32. Herbert Eimert, ‘What Is Electronic Music?’ *Die Reihe*, 1: *Electronic Music* (1958), 1–10, 1. Eimert’s article was first published in the German edition of *Die Reihe* in 1955.
33. IRCAM is unusual in that its foundation lies in a 1970 request from President Georges Pompidou that Pierre Boulez create a sound and music research organization. Linked now to the Pompidou Centre, IRCAM opened in 1977.
34. Laura Zattra, ‘Audiogrammi of a Collective Intelligence: The Composer-Researchers of S2FM, SMET, NPS, and Other Mavericks’, in *The Bloomsbury Handbook of Sound Art*, ed. S. Krogh Groth and H. Schulze (New York: Bloomsbury Academic, 2020), 273–94, at 276.
35. Jo Langton Hutton, ‘Beyond the Instrumental: Systems, Objects and Space in the Work of Beatriz Ferreyra, Teresa Rampazzi, Éliane Radigue and Delia Derbyshire’, PhD diss. (University of Surrey, 2020), 39.
36. For the purposes of this chapter, the Groupe Recherches de Musique Concrète (GRMC) (1951–58) and the Groupe de Recherches Musicales (GRM) (1958–60) are the most important iterations of the Studio d’Essai. See Évelyn Gayou, *GRM: Le Groupe de Recherches Musicales: cinquante ans d’histoire*, Les chemins de la musique (Paris: Fayard, 2007); Évelyn Gayou, ‘The GRM: Landmarks on a Historic Route’, *Organised Sound*, 12/3 (2007), 203–11,

- and Évelyn Gayou, ed., *Éliane Radigue: Portraits Polychromes* (Paris: Institut national de l'audiovisuel, 2013).
37. Hutton, 'Radiophonic Ladies'; Langton Hutton, 'Beyond the Instrumental', and Louis Niebur, *Special Sound: The Creation and Legacy of the BBC Radiophonic Workshop* (New York: Oxford University Press, 2010).
 38. Sonic Boom (stage name of Peter Kember), 'Delia Derbyshire: Electronic Music Pioneer', *Surface* (May 2000), www.delia-derbyshire.org/interview_surface.php.
 39. Bernstein, ed., *The San Francisco Tape Music Center*, 269.
 40. Bob Gluck, 'Nurturing Young Composers: Morton Subotnick's Late-1960s Studio in New York City', *Computer Music Journal*, 36/1 (2012), 65–80, at 65.
 41. Alice Shields, who worked at the centre and later became the associate director of the Columbia University Computer Music Center, an organization that replaced the original one, credited Ussachevsky with encouraging women to work in the studios. Holmes, *Electronic and Experimental Music*, 189.
 42. Annea Lockwood, 'Hearing a Person – Remembering Ruth Anderson (1928–2019)', *New Music USA* (19 December 2019), <https://nmbx.newmusicusa.org/hearing-a-person-remembering-ruth-anderson-1928-2019/>.
 43. Luke Nickel, 'Occam Notion: Collaboration and the Performer's Perspective in Éliane Radigue's *Occam Ocean*', *Tempo*, 70/275 (2015), 22–35, and Eckhardt and Radigue, *Éliane Radigue*.
 44. Ellen Fullman, 'A Compositional Approach Derived from Material and Ephemeral Elements', *Leonardo Music Journal*, 22 (December 2012), 3–10, 3.
 45. Ellen Fullman, *Streetwalker* (1980). Available at: <https://vimeo.com/45207205>.
 46. Salomé Voegelin, *Sonic Possible Worlds: Hearing the Continuum of Sound* (New York: Bloomsbury Academic, 2014).
 47. Andra McCartney, 'Gender, Genre and Electroacoustic Soundmaking Practices', *Intersections*, 26/2 (2006), 20–48; Hannah Bosma, 'Bodies of Evidence, Singing Cyborgs and Other Gender Issues in Electrovoical Music', *Organised Sound*, 8/1 (2003), 5–17; Andra McCartney, 'Musical Washing Machines, Composer-Performers, and Other Blurring Boundaries: How Women Make a Difference in Electroacoustic Music', *Intersections*, 26/2 (2006), 97–117; Rodgers, *Pink Noises*; Georgina Born and Kyle Devine, 'Gender, Creativity and Education in Digital Musics and Sound Art', *Contemporary Music Review*, 35/1 (2016), 1–20; and Cathy Lane, 'Sound:: Gender::Feminism::Activism: Research and Challenges to the Orthodoxies of Sound Arts', *Contemporary Music Review*, 35/1 (2016), 32–9.
 48. Lucy Green, *Music, Gender, Education* (Cambridge: Cambridge University Press, 1997), 113–4; Frances Morgan, 'Pioneer Spirits: New Media Representations of Women in Electronic Music History', *Organised Sound*, 22/2 (2017), 238–49, at 246–7.
 49. Morgan, 'Pioneer Spirits', 246–7.

50. Jacques Brissot's gauzy photograph, taken in 1955, of Radigue holding a conch shell to her ear has been reproduced numerous times in books and on album sleeves. Three examples are: Gayou, ed., *Éliane Radigue: Portraits Polychromes*, 71; the cover of François J. Bonnet, *The Order of Sounds: A Sonorous Archipelago*, trans. R. Mackay (Falmouth: Urbanomic Media, 2016); and the reissue of Radigue's *Feedback Works, 1969–1970* (Alga Marghen Records, 2021).
51. Aura Satz, *Making a Diagonal with Music/Hacer una Diagonal con la Musica* (2019).