Notes

Unless otherwise indicated, translations are the author’s.

1. LISTENING TO INSTRUMENTS


9. Some of the most fascinating studies to emerge in recent years have focused on scientific and acoustic investigations of sound outside of the context of modernity that tends to dominate discussions of musical technology. See Penelope Gouk, Music, Science, and Natural Magic in Seventeenth-Century England (New Haven: Yale University Press, 1999); Myles W. Jackson, Harmonious Triads: Physicists, Musicians, and Instrument Makers in Nineteenth-Century Germany (Cambridge, MA: MIT Press, 2006); and Emily I. Dolan, The Orchestral Revolution: Haydn and the Technologies of Timbre (Cambridge, UK: Cambridge University Press, 2013).


13. For a historical elaboration of this point, see Karin Bijsterveld, “A Servile Imitation: Disputes about Machines in Music, 1910–1930,” in Music and Tech-
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22. This potential for unforeseen uses has been labeled technological multistability in analogy to the visual phenomenon in which a single graphical configuration can take on different spatial orientations. See Don Ihde, “Technologies—Musics—Embodiments,” in Embodied Technics (n.p.: Automatic Press / VIP, 2010), 17–36.


26. Kapp hailed Helmholtz’s work in experimental acoustics as the consummate synthesis of art and science: “Under the gaze of Helmholtz’s scientific eye, the ‘musical’ instrument became as it were an ‘instrument’ in the highest sense, a tool for the delivery of insight into the organic substrate of mental operations. Music is turned into acoustics, science is explained and clarified by art.” Ernst Kapp, Grundlinien einer Philosophie der Technik (Braunschweig:
Georg Westermann, 1877), 85. Kapp saw his theory vindicated by Helmholtz’s research, which revealed keyboard instruments as technological externalizations of the organic bundle of resonating strings in the organ of Corti, and the pipe organ as a mechanized voice (88–98). On Kapp, see also Carl Mitcham, Thinking through Technology: The Path between Engineering and Philosophy (Chicago: University of Chicago Press, 1994), 20–24.

27. “Artists as Inventors and Invention as Art: A Paradigm Shift from 1840 to 1900,” in Artists as Inventors / Inventors as Artists, ed. Dieter Daniels and Barbara U. Schmidt (Ostfildern, Ger.: Hatje Cantz, 2008), 39.


36. Ibid., 26.

37. Adolf Weissmann, Music Come to Earth, trans. Eric Blom (New York: E.P. Dutton, 1930), ix; originally published as Die Entgötterung der Musik (Stuttgart: Deutsche Verlags-Anstalt, 1928). I have slightly modified the translation of this passage. The word Entgötterung, which could be rendered as “desacralization,” was used by the great German writer Friedrich Schiller in his 1788 poem “The Gods of Greece,” where it appears in the phrase “entgötterte Natur.” Thus, Weissman’s image of a “godless” modern music resonates with a long intellectual tradition of concern with the side effects of the post-Enlightenment ascendency of secularization, mass society, and techno-science.

38. Weissmann, Music Come to Earth, 6–7.

39. Ibid., 1; 9–10.

40. Busoni, Entwurf einer neuen Ästhetik, 42.

41. Ibid. Significantly, this passage was omitted from all English translations of Entwurf einer neuen Ästhetik der Tonkunst until the most recent one:


44. Ibid., 4, 40.

45. Ibid., 5–7.

46. Ibid., 15.


52. This notion of technology as trickster is borrowed from Erik Davis’s book *TechGnosis: Myth, Magic, and Mysticism in the Age of Information* (London: Serpent’s Tail, 1998).

2. “THE JOY OF PRECISION”: MECHANICAL INSTRUMENTS AND THE AESTHETICS OF AUTOMATION


3. Readers interested in a formal investigation of this music should refer to Francis Bowdery’s “Music for Player Piano: A Study of Seventeen Selected Examples” (PhD diss., Loughborough University of Technology, 1995). Recordings of most of the pieces presented in Donaueschingen and Baden-Baden are


14. The relevant works are Haydn’s pieces for *Flötenuhr* (musical clock), Hob. XVIII, 1–32; Mozart’s three compositions for mechanical organ, K. 594, 606, and 616; and Beethoven’s *Wellingtons Sieg*, op. 91, which was originally composed for Johann Mälzel’s Panharmonicon and later rewritten for orchestra.


25. Bowdery, “Music for Player Piano,” 87; 94. Around the same time, Busoni prepared a Pianola arrangement of the overture to Mozart’s The Magic Flute, a work replete with themes of mechanism and enchantment. See Carolyn Abbate, “Magic Flute, Nocturnal Sun,” in In Search of Opera (Princeton: Princeton University Press, 2001), 55–106. Although the rolls containing this arrangement have not yet been recorded, a piano-roll recording of a 1927 performance of Busoni’s later two-piano version of the piece survives. See Hocker, Faszination Player Piano, 211.


28. Ibid.


35. Andreas Maul, “Die Idee einer ‘mechanischen Musik’: Über Experimente von Hindemith und Toch mit dem Welte-Mignon-Klavier und der Welte-Philharmonie Orgel,” *Neue Zeitschrift für Musik* 9 (1984): 6. It was likely that practices such as these inspired Schoenberg’s jeremiad against false interpreters: “Were there among a thousand musicians just one with the will and the ability to discover from the score what is true and eternally constant, to present it and to make it fit the needs of a contemporary listener, then for the sake of this one man, the Sodom and Gomorrah of false interpreters, aiming only to glorify themselves at the music’s expense, would deserve to be spared.” Schoenberg, “Mechanical Musical Instruments,” 328. See also Robert Hill, “Overcoming Romanticism: On the Modernization of Twentieth-Century Performance Practice,” in Bryan Gilliam, ed., *Music and Performance during the Weimar Republic* (Cambridge: Cambridge University Press, 1994), 38–39.


40. Ibid.

41. Heinrich Kaminski, “‘Mechanisierung’ der Musik?” *Pult und Taktstock* 2, no. 3 (1925): 36.


43. Pringsheim, “Die Mechanisierung der Musik,” 291. Although Pringsheim defends the inherent sociality of performed music, he implicitly rejects the idea that listening, too, could be a social act, arguing that it can as well be done in private: “With headphones in bed, in the bathtub, or even while smoking and reading the newspaper in a lounge chair, we could hear all that much more comfortably at home.”


51. The translation “New Objectivity” is potentially deceptive, as John Willett notes, since the German *Sach* at the root of the word *Sachlichkeit* could mean “affair” or “matter” as well as “object.” Willett opted for the freer rendering of “New Sobriety” for the title of his book on the period, *Art and Politics in the Weimar Period: The New Sobriety 1917–1933* (New York: Da Capo, 1996).


55. Heinrich Strobel, “‘Neue Sachlichkeit’ in der Musik,” *Musikblätter des Anbruch* 8, no. 6 (1926): 256.


57. Paul Bekker, “Wesensformen der Musik,” in *Organische und mecha-nische Musik* (Stuttgart: Deutsche Verlags-Anstalt, 1928), 42. Intriguingly, Bekker compares the mystique surrounding the act of composition to that accompanying the technological object: “The natural does not cease to be miraculous because I recognize its natural lawfulness. The distinction lies merely therein, that the miracle in the first case appears as the outcome of *magic*, in the second case as the manifestation of *natural forces*. The radio is as much a wonder for me as it is for the South Sea Islander, only I don’t view it as magic, but rather am aware of the forces that achieve it.” Thus the desire to explain does not, according to Bekker, destroy wonder but merely undermines the “superstition and fetishism” that accompany it (46).


61. Many of these ideas were channeled from the Soviet Union, which had close artistic ties with the German avant-garde throughout the 1920s. Moholy-Nagy’s influential distinction between artistic “production” and “reproduction,” for example, was adopted from Soviet constructivism, to which he was exposed through his friendship with the Russian artist El Lissitzky in Berlin in the early 1920s. The Soviet theorist Alexei Gan declared that “the fact that all so-called art is permeated with the most reactionary idealism is the product of extreme individualism. […] Art is indissolubly linked with theology, metaphysics, and mysticism.” Quoted in Stephen Bann, ed., The Tradition of Constructivism (New York: Da Capo, 1974), 35. See also Christina Lodder, Russian Constructivism (New Haven, CT: Yale University Press, 1983), 75.


65. Nils Grosch, Die Musik der neuen Sachlichkeit (Stuttgart: Metzler, 1999), 68–9. Reviews of this concert were reprinted in Kunst der Zeit 3, no. 1–3 (1928): 48, 82.


nicht das Sichtbare wieder, sondern macht sichtbar.” Following a similar impulse, visual artists such as Man Ray and Christian Schad sought new applications of the photograph, using it as a means of not simply reproducing reality but creating innovative and often decidedly nonrealistic images. These connections will be explored further in chapter 4.

75. Toch, “Musik für mechanische Instrumente,” 348.
76. Ibid.
80. Quoted in Scheper, Oskar Schlemmer, 49.
81. Scheper, Oskar Schlemmer, 12.
82. Quoted in Scheper, Oskar Schlemmer, 34.
88. Paul Hindemith, “Zu unserem Programm,” in Aufsätze, Vorträge, Reden, 17. Although the original organ rolls containing Hindemith’s music for the Triadic Ballet are lost, the composer excerpted parts of the score for a Suite for Mechanical Organ, which was recorded in 1931. Parts of this recording have survived and were released on CD in 1995. Paul Hindemith, Organ Concertos / Suite for Mechanical Organ, Koch Schwann CD 312022, 1995, compact disc.
89. Schlemmer, “Ausblicke auf Bühne und Tanz,” 523.
90. Scheper, Oskar Schlemmer, 55.
93. Quoted in Scheper, Oskar Schlemmer, 49.
94. Schlemmer, “Man and Art Figure,” in Gropius, Theater of the Bauhaus, 22. This notion was no doubt inspired by the passage in Kleist’s marionette story in which the narrator ponders what would happen if even the motions of the puppeteer were “transferred entirely to the realm of mechanical forces.” See Heinrich von Kleist, “On the Marionette Theatre,” trans. Thomas G. Neumiller, The Drama Review 16, no. 3 (1972): 22–26.
95. “Nicht Jammer über Mechanisierung, sondern Freude über Präzision!” Quoted in Grosch, Musik der neuen Sachlichkeit, 57. Schlemmer goes on to declare that “artists are ready to convert the disadvantages and dangers of their mechanistic age into the advantages of exact metaphysics.”
96. Schlemmer, “Man and Art Figure,” 28–29.
97. Schlemmer, “Theater (Bühne),” 81. The convergence of opposites was a key tenet of Schlemmer’s worldview. In this light, his invocations of such seemingly paradoxical notions as “mechanistic organisms” and “mystical objectivity” become comprehensible.
99. See Grosch, Musik der neuen Sachlichkeit, 57–58.
100. An accomplished composer and concert pianist, Haass became director of recording for Welte in 1925. He recorded over three hundred rolls of popular and classical music and knew as well as anyone the capabilities and limitations of the machine.
106. Ibid., 24.
107. Stuckenschmidt had previously alluded to Thaddeus Cahill’s Dynamophone as a more advanced example of a mechanical instrument. See Stuckenschmidt’s essay “Mechanische Musik,” Der Kreis 3, no. 11 (1926): 507.

3. “THE ALCHEMY OF TONE”: JÖRG MAGER AND ELECTRIC MUSIC
6. Hans Kuznitzky, “Neue Elemente der Musikerzeugung, Melos 6, no. 4 (1927): 156. For Kuznitzky, electric instruments were the logical continuation of the quest for “elementary tone production” that had long allured Western music history. This striving, exemplified by such phenomena as the ancient hydraulos (water organ), the microtonal instruments of the Renaissance, and the
nineteenth-century revival of Pythagorean mysticism, finds its consummation in the technological breakthroughs of the early twentieth century: “The intellectual kernel forms itself again and again around the same point of energy, but the fructifying impulse is lacking—must be lacking—because the technical prerequisites [. . .] are not yet fulfilled. The age of radio-electricity provides this impulse!” Ibid., 157.


9. Quoted in Emil Schenck, Jörg Mager: Dem deutschen Pionier der Elektromusikforschung zum Gedächtnis (Darmstadt: Städtischen Kulturverwaltung, 1952), 6–7. This statement is something of an exaggeration, as Mager would later admit. In other writings, he acknowledged the previous work of Richard Stein, Georg Capellen, F.A. Geissler, and others.


11. Ibid. According to Willi Möllendorf, Mager applied for a patent for this instrument in 1912. Möllendorf, Musik mit Vierteltönen (Leipzig: F.E.C. Leuckart, 1917), 53; for an English translation, by Klaus Schmirler, see http://tonalsoft.com/monzo/moellendorf/book/contents.htm. Shortly after Mager built his quarter-tone harmonium, Möllendorf constructed a similar device, but with a novel design that featured brown keys between the existing black and white, with each successive step tuned a quarter tone apart.


13. Ibid., 7.


University Press, 1958). The essay was originally published as Wissenschaft als Beruf (Munich: Duncker und Humblot, 1919) and was based on a lecture Weber gave in 1917.

20. Ibid., 141.

26. Jörg Mager, Eine neue Epoche, 5. Mager states that this meeting took place in the winter of 1923, but Richard Stein’s spring 1923 account has the date as the fall of 1922. Stein, “Vierteltonmusik,” Die Musik 15, no. 7 (April 1923): 514. By this time, Mager had already built a prototype electric instrument: in a letter dated 3 November 1922, Hába hailed Mager’s device as “suited to usher in an epochal development not only in instrument building, but in music itself.” (Quoted in Mager, Eine neue Epoche, 13.)


28. Fleming called his device a valve, because of the one-way flow of electrons from cathode to anode; this term persists in British English. The equivalent U.S. English term is vacuum tube, referring to the lack of air inside the bulb.

29. Similar discoveries were made shortly thereafter by the American Irving Langmuir and the German Alexander Meissner.


33. Mager, Eine neue Epoche, 2.
35. Mager, Eine neue Epoche, 10.
36. The phrase “radio-music without transmission” comes from Richard Stein’s article “Zukunftsmusik im Rundfunk,” Der deutsche Rundfunk 3, no. 12
(1925): 733–36. The article was credited with making Mager’s work known in the wider field of radio: see Donhauser, *Elektrische Klangmaschinen*, 27.

37. The date of Mager’s first prototype, which is not clearly stated in the primary sources, is given as 1921 in Donhauser, *Elektrische Klangmaschinen*, 27.

38. The instrument was “simple,” of course, only in comparison to its later forms. Even the humble hand crank has a deep history: for an enlightening overview, see Lynn White, Jr., “The Act of Invention,” in *Machina ex Deo: Essays in the Dynamism of Western Culture* (Cambridge, MA: MIT Press, 1968), 116–19. White notes that the continuous rotary motion exemplified by the crank is “typical of inorganic matter, whereas reciprocating [back-and-forth] motion is the sole movement found in living things. […] To use a crank, our tendons and muscles must relate themselves to the motion of galaxies and electrons. From this inhuman adventure our race long recoiled.”

39. Mager, *Eine neue Epoche*, 5. Mager’s mention of the omnitonium reveals his knowledge of the history of enharmonic and microtonal instruments, in which he had done considerable research. He discovered an 1890 article that mentioned a *Clavemusicum omnitonium*, a keyboard instrument built in 1606 with thirty-one keys to the octave, specially designed to allow for the playing of “enharmonic” (microtonal) intervals, including quarter tones: Shohé Tanaka, “Studien im Gebiete der reinen Stimmung,” *Vierteljahrschrift für Musikwissenschaft* 6 (1890). Mager mentions this article by name in *Eine neue Epoche der Musik durch Radio*, without making explicit the provenance of the term omnitonium. Tanaka’s reference to the instrument depends, in turn, on an article published two years earlier: “Die Musikausstellung zu Bologna,” *Zeitschrift für Instrumentenbau* 9, no. 8 (1888): 122–23. This article describes an instrument built by a certain Gonzaga and modeled closely on Nicola Vicentino’s better-known arcicembalo. Curt Sachs notes that Tanaka incorrectly gives the name as Omnitonium, instead of Omnitonum, an error inherited by Mager; Sachs also refers to the instrument as the only extant enharmonic harpsichord. See the entry “Clavemusicum omnitonom” in Curt Sachs, *Reallexikon der Musikinstrumente* (Berlin: Julius Bard, 1913), 88.


The phrase *universal instrument* comes from Busoni’s article “Futurismus der Tonkunst,” in *Von der Einheit der Musik*, 184–86. Wolfgang Hagen suggests that Busoni’s misunderstanding of the instrument’s playing interface may have been influenced by his reading of the science fiction novels of Jules Verne, where one encounters machines replete with dials, meters, and other techno-scientific accoutrements. Hagen, “Busoni’s Invention: Phantasmagoria and Errancies in Times of Medial Transition,” in *Artists as Inventors / Inventors as Artists*, ed. Dieter Daniels and Barbara U. Schmidt (Ostfildern, Ger.: Hatje Cantz Verlag, 2008), 106–7. Curiously, Busoni elsewhere acknowledges that the instrument was played from a conventional keyboard. Busoni, *Entwurf einer neuen Ästhetik*, 64.


61. Quoted in Glinsky, *Theremin*, 68.

62. Mager, *Eine neue Epoche*, 14. Mager also put forward a curiously biomorphic argument for microtonality. Noting that acousticians had determined the ability to distinguish intervals much smaller than the tempered semitone and referring to Helmholtz’s “place theory,” according to which each nerve fiber in the cochlea of the inner ear responds to a tiny frequency band, Mager suggested that musicians were bound by a physiological imperative to exercise these fibers, lest they wither through disuse: “Doesn’t the subtle apparatus of pitch differentiation in the ear, which encompasses the entire tonal spectrum, all but demand the use of finer tonal degrees in music? Doesn’t the exclusivity of our semitone system leave valuable parts of the organ of Corti unused, uncultivated, and subject to atrophy?” Mager, *Eine Neue Epoche*, 6.


64. Note also, however, that he sees a way of partially transcending the “mechanism” of mechanical instruments by employing them for original composition. The categories “electric” and “mechanical” are thus implicitly mapped onto another key duality in Weimar techno-aesthetics, that of “production” and “reproduction.”


68. Weiskopf, “Das Sphärophon,” 389. Note that Weiskopf is using *mechanical* in the broad sense, referring simply to the products of modern technology.


73. Helmholtz, *Sensations of Tone*, 119ff. The use of the term *synthesizer* for Helmholtz’s device, though anachronistic, is by now well established.


76. Ibid., 421.


80. In fact, replicating Helmholtz’s technique of additive synthesis proved difficult with the electroacoustic technology of the time, because the relationship between electrical variables such as circuit capacitance and the resulting timbre was still too crudely understood to enable the precise shaping of the overtone spectrum. In any case, Helmholtz’s artificial timbres were hardly musically viable, being stationary sounds that could not in any sense be “played.” For this reason, Hindemith’s idea of using an ensemble of Spherophones to create synthetic timbres also remained, to all appearances, unrealized. See Donhauser, Elektrische Klangmaschinen, 246.


86. Ferruccio Busoni, Entwurf einer neuen Ästhetik, 65.


90. Jörg Mager, “Verfahren zur elektrischen Erzeugung von Geräuschen,” DE Patent 541,812, filed on August 1, 1929 and issued on December 24, 1931,

91. Mager, “Einrichtung zur Erzeugung von Klangfarbeneffekten.” It was likely such experimental sound research that Peter Lertes had in mind when he wrote that “through electrical musical instruments, ‘noises’ will be given artistic forms and occupy a larger space in composers’ work than they have previously.” Lertes, *Elektrische Musik*, 4. Mager’s interest in *Seismophonie*, or the amplification and study of the movements of the earth’s crust, also indicates the experimental applications of his instruments; see Donhauser, *Elektrische Klangmaschinen*, 210.


95. Schenck, Jörg Mager, 13.


97. Schenck, Jörg Mager, 16.


100. Schenck, Jörg Mager, 17.


102. Quoted in Donhauser, *Elektrische Klangmaschinen*, 204. The enigmatic phrase “eccentric music” reappears in a 1932 review of a demonstration of the Partiturophon, suggesting that such sounds were not used only to accom-
pany staged action. See “Elektroakustische Hausorgel,” 25. Elsewhere Mager spoke of an “indirect music” to be created through the use of subtle background noises. 103. Mager, Eine neue Epoche, 15.

4. "SONIC HANDWRITING": MEDIA INSTRUMENTS AND MUSICAL INSCRIPTION

2. Guido Bagier, “Der sprechende Film,” in “Musik und Maschine,” special issue, Musikblätter des Anbruch 8, nos. 8–9 (1926): 380–84. A year later, Bagier demonstrated the Tri-Ergon (the German trademark for optical sound film) recording procedure at the same festival, now relocated from Donaueschingen to Baden-Baden. Bagier is an intriguing figure about whom little information is available. Born in 1888, his writings include a book on the German composer Max Reger (1923), Der kommende Film: Eine Abrechnung und eine Hoffnung (1928), and an apparent work of fiction entitled Das tönende Licht: Die Schilderung einiger seltsamer Begebenheiten seit der Erfindung der Kinematographie, unter Verwendung wichtiger und unbekannter Dokumente (1943). He also worked as a producer on G.W. Pabst’s 1931 film version of Brecht and Weill’s Die Dreigroschenoper.
5. Another such instrument from around the same time was the radioelectric organ of the French inventors Givelet and Coupleux, which combined electric tone generation via vacuum tube oscillators with a paper-tape reader that allowed for automatic playback. See E. Weiss, “Nouveaux instruments de musique radioélectriques,” La Nature 58 (1930): 258–67. Almost no information about this instrument is available in English.
8. Piet Mondrian, “Die neue Gestaltung in der Musik und die futuristischen italienischen Bruitisten,” in Neue Gestaltung (Munich: Albert Langen Verlag, 1925), 33. However, Mondrian remained wary of analogies between the arts; see Blotkamp, Mondrian, 130.
11. Mondrian, “Die neue Gestaltung in der Musik,” 39. Mondrian was challenged in this assertion by Nelly van Moorsel, a pianist and the future wife of Mondrian’s colleague, Theo van Doesburg. Van Moorsel argued, as would John Cage in the 1950s, that silence, not noise, was the negation of tone, as Mondrian suggested. See Blotkamp, *Mondrian*, 162.


13. Ibid., 34.

14. Ibid., 37. Elsewhere Mondrian declared that “it is quite possible for music to become ‘abstract’ and cease to be dominated by the natural to the extent that its expressive means (sound) allow. [. . .] In music the expression of the art is becoming almost ‘mineral.’ [. . .] Nature, from mineral to animal, is expressed less and less abstractly, less and less purely.” Mondrian, “Manifestation of Neo-Plasticism,” 151–53. The mineral plane suggests here an undifferentiated physical primacy: mineral sounds are those that are entirely free of the aura of the individual that characterizes conventional vocal and instrumental timbres. This aesthetic materialism was a common theme among the avant-garde movements of the early twentieth century; in 1912, Marinetti, the spokesman of Italian futurism, declared the impulse “to substitute for human psychology, now exhausted, the lyric obsession with matter. [. . .] The warmth of a piece of iron or wood is in our opinion more impassioned than the smile or tears of a woman.” Quoted in Daniel Albright, ed., *Modernism and Music: An Anthology of Sources* (Chicago: University of Chicago Press, 2004), 173.

15. Mondrian, “Manifestation of Neo-Plasticism,” 153. Mondrian had given voice to the fantasy of a performerless music in an earlier text as well: “The more music becomes pure expression of equilibrated relationships, [. . .] the more it will find itself hampered by existing instruments. Other instruments will be sought—or mechanical means! [. . .] What effort a concert requires on the part of the musicians and the conductor, to avoid slackening the pace. Wouldn’t it be fine, and far more reliable—if one could invent a machine to which the real artist, the composer, could entrust his work?” Piet Mondrian, *Natural Reality and Abstract Reality: An Essay in Trialogue Form*, trans. Martin S. James (New York: George Braziller, 1993), 98. This text was originally published in *De Stijl* in twelve installments from June 1919 to July 1920.

16. Quoted in Blotkamp, *Mondrian*, 162. Although Russolo’s intonarumori provided the immediate inspiration for Mondrian’s musings, this connection is something of a red herring. As Karin Bjisterveld has argued, Russolo and Mondrian were drawn to the sonic ideal of the machine for quite different reasons: Russolo placed emphasis on the continuous or “enharmonic” pitch spectrum of mechanical “noise-sounds,” while Mondrian valued precise determination and clear-cut boundaries between sounds. Karin Bjisterveld, “A Servile Imitation: Disputes about Machines in Music, 1910–1930,” in *Music and Technology in the Twentieth Century*, ed. Hans-Joachim Braun (Baltimore: Johns Hopkins University Press, 2002), 121–36. Further, Mondrian and others criticized the intonarumori for cleaving too closely to natural sounds. (See Mondrian, “Manifestation of Neo-Plasticism,” 155.)


24. Ibid., 7.


28. Moholy-Nagy, “Musico-Mechanico, Mechanico-Optico,” 367. Moholy-Nagy also considered the possibility of working on giant, blank gramophone discs that would allow the composer to easily see the groove patterns on which he worked. These oversized “production discs” could then be reproduced at regular size for playback purposes. This idea never came to fruition.

29. There are anecdotal accounts of other experiments in gramophone music. For example, Henry Cowell said that the Russian composer Nicolai Lopatnikoff “[planned] to make phonograph recordings of various factory and street noises, synchronizing and amplifying them as a percussion background for music written for keyboard recordings.” Henry Cowell, “Music of and for the Records,” *Modern Music* 7, no. 3 (1931): 32–34.


33. Mark Katz, “The Rise and Fall of Grammophonmusik,” in *Capturing Sound: How Technology Has Changed Music* (Berkeley: University of California Press, 2004), 102. As Katz aptly puts it, “These short, simple pieces may be thought of as etudes, but not in the traditional sense, for they explore the technical abilities not of the performer but of the instrument.” For a meticulous
historical examination of these pieces, see Elste, “Hindemiths Versuche,” 195–221. For more on Toch’s pieces, see Carmel Raz, “From Trinidad to Cyberspace: Reconsidering Ernst Toch’s ‘Geographical Fugue,’” Zeitschrift der Gesellschaft für Musiktheorie 9, no. 2 (2012), http://www.gmth.de/zeitschrift/artikel/698.aspx; and “‘Gesprochene Musik’: The Lost Movements of Toch’s ‘Geographical Fugue,’” Current Musicology 97 (forthcoming).


36. As we have already seen, Moholy-Nagy laid out the principles of “optophonetics”—sound-image correspondence based in the technological equivalence of all phenomena—in the early 1920s, imagining the gramophone as the means of realization.

37. See Thomas Levin’s essay “‘Tones from out of Nowhere’: Rudolf Pfenninger and the Archaeology of Synthetic Sound,” in New Media, Old Media: A History and Theory Reader, ed. Thomas Keenan and Wendy Hui Kyong Chun (New York: Routledge, 2005), 45–81. Levin finds the earliest such relationship in the Klangfiguren, or “sound figures,” of the acoustician E.F.F. Chladni, who discovered that sand dispersed on a metal plate formed patterns around nodal points when the plate was vibrated with a violin bow. As Levin notes, in an irony of media history the reproducibility of sound recording was won at the cost of its legibility: the traces read by the gramophone needle were inscrutable to the human eye.


42. Highlighting this technological lineage, Ruhmer’s device was even referred to in the press as the “Film Photophone.” See “The Film Photophone,” Science, new series, 54, no. 1399 (1921): 373.

43. Edison spoke of sound film as early as 1899, but technical developments such as the photoelectric cell, the amplifier tube, and the loudspeaker were needed to make it possible. See F. Noack, “Die Technik des Tonfilms,” Anbruch 11, no. 5 (1929): 174. The photoelectric cell found use in a number of playable electric instruments of the 1920s and ’30s as well, including the Saraga-Generator, the Superpiano, and the Welte Lichtton-Orgel.


48. Ibid., 319.

49. Ibid.

50. Ibid. Remarkably, Moholy-Nagy anticipated the opposition of what would become known in the 1950s as musique concrète and *elektronische Musik*. Ever the systematist, he also envisioned a third phase in which these two distinct forms would be used in conjunction.


63. Ibid., 386.
64. Ibid., 388.
65. Arnold Schoenberg, Theory of Harmony, trans. Roy E. Carter (Berkeley: University of California Press, 1978), 432: “I am a musician and have nothing to do with things atonal. The word atonal could only signify something entirely inconsistent with the nature of tone.”
69. Ibid., 376–77.
70. Ibid., 390.
74. Hagen, “Walter Ruttmanns Großstadt-Weekend,” 2. Weekend also had precedents in the experimental radio plays (Hörspiele) of the 1920s, such as Hans Flesch’s Zauberei auf dem Sender (1924) and Friedrich Wilhelm Bischoff’s Hallo! Hier Welle Erdball (1928). It is distinguished from these works, however, in being composed entirely via montage and in its almost complete lack of dialogue. See Daniel Gilfillan, Pieces of Sound: German Experimental Radio (Minneapolis: University of Minnesota Press, 2009), 67–86.
79. Dieter Daniels, “Artists as Inventors and Inventions as Art: A Paradigm Shift from 1840 to 1900,” in Artists as Inventors / Inventors as Artists, ed. Dieter Daniels and Barbara U. Schmidt (Ostfildern, Ger.: Hatje Cantz, 2008), 45.
81. In particular, theorists of synthetic sound drew inspiration from the pioneering works of “visual music” or “absolute film” created the early 1920s by filmmakers such as Walter Ruttmann, Oskar Fischinger, Hans Richter, and
Viking Eggeling. For an excellent anthology of texts stemming from this movement, see *Der Absolute Film: Dokumente der Medienavantgarde (1912–1936)*, ed. Christian Kiening and Heinrich Adolf (Zurich: Chronos Verlag, 2012). Ironically, “absolute film,” which drew inspiration from the German romantic tradition in musical aesthetics, in turn exerted a decisive influence on the first experiments in optical sound film. The intertwined history of experimental film and music in the 1920s has scarcely been explored outside of German sources.


87. Ibid.


91. Here I differ with Levin, who claims that Fischinger’s work is “fundamentally antitechnological.” Levin, “‘Tones from out of Nowhere’”, 80.


95. The only substantial source on Pfenninger in English is Thomas Levin’s article “‘Tones from out of Nowhere’.”

96. Three films have been released in a commercial edition—*Serenade, Pitsch und Patsch*, and *Barcarole* (all created in 1932)—and can be found on *Animerte*
Avantgarde: Der künstlerische Animationsfilm der 20er und 30er Jahre, curated by Ulrich Wegenast, Absolute Medien, 2011, DVD.

97. These effects call to mind the techniques of early video game music, in which the limitations of the monophonic sound chips were circumvented by trompe l’oreille illusions of harmony created by the rapid arpeggiation of multiple tones.


99. R. Prévot, quoted in Levin, “‘Tones from out of Nowhere,’” 65.

100. Quoted in Passuth, Moboly-Nagy, 322. Moholy-Nagy goes on to say that “it is said that Pfenninger is in a position today to write down every word and name; that is, he can read sound writing on sight!”

101. Levin, “‘Tones from out of Nowhere,’” 81. Levin refers to Moholy-Nagy’s approach as “surprisingly Fischingerian.”

5. “A NEW, PERFECT MUSICAL INSTRUMENT”: THE TRAUTONIUM AND ELECTRIC MUSIC IN THE 1930S


3. The RCA Theremin was a market failure—only about five hundred were produced at a time when the company was manufacturing about nine thousand radios per day. Although the cause of the instrument’s failure has been attributed to the “Black Thursday” stock market crash, which took place just ten days after the RCA Theremin’s public debut, price was surely a factor as well: the instrument cost over $3,000 in today’s currency. See Andrew Baron and Mike Buffington, “The RCA Theremin,” RCA Theremin.com, 2015, accessed August 21, 2015, http://rcatheremin.com; and Albert Glinsky, Theremin: Ether Music and Espionage (Chicago: University of Illionois Press, 2000), 92–128.


10. Trautwein’s patents date back to the early 1920s (1922 for DRP 462,980 and 1924 for DRP 469,775).
11. This design had been developed independently as early as 1927 by Peter Lertes and Bruno Helberger and implemented in their instrument called the Hellertion: see Donhauser, *Elektrische Klangmaschinen*, 68. The wire interface was apparently an example of independent invention: Nikolai Ananiev’s Sonar (1926) was based on the same principle (see Smirnov, *Sound in Z*, 94–95), and Mager filed a patent for an instrument with a similar “electric string” playing interface around the time of the original Lertes-Helberger patent. See Jörg Mager, “Elektrisches Musikinstrument,” DE Patent 578,477, filed on October 6, 1927 and issued on May 24, 1933, UbuWeb Electronic Music Resources, http://www. ubu.com/emr/patents/_docs/patents/01individuals/mager/DE578477C.pdf.
14. Ibid., 228.
17. My thanks to Peter Donhauser for this suggested translation of the term.
19. Ibid., 36.
20. Ibid., 17.
30. Ibid., 271–72.
31. Donhauser, _Elektrische Klangmaschinen_, 44.
32. Hindemith was friends with Oskar Fischinger, who suggested that the composer assign his students the task of writing a sound track for Fischinger’s abstract animated film _Studie Nr. 6_ (1930). Music by Hindemith, Harald Genzmer, and Oskar Sala was captured on gramophone discs, but the recordings are believed to have been destroyed in the Second World War. Whether the sound tracks made use of the Trautonium is unknown. See Schenk, “Die Rundfunkversuchsstelle,” 268; and William Moritz, _Optical Poetry: The Life and Work of Oskar Fischinger_ (Bloomington: University of Indiana Press, 2004), 29–30.
34. Donhauser, _Elektrische Klangmaschinen_, 68–69; Schenk, “Die Rundfunkversuchsstelle,” 263.
36. Trautwein, _Elektrische Musik_, 5. The later installments in the series did not in fact appear and were likely casualties of the deepening economic crisis that afflicted Germany in the early 1930s. Trautwein’s book is not to be confused with Peter Lertes’s volume of the same title, published in 1933.
39. Hugo Gernsback, “Electronic Music,” _Radio-Craft_ 4, no. 9 (1933): 521. Gernsback’s use of the phrase _electronic_ (rather than _electric_) _music_ may be one of the earlier instances of the term in English; it is uncertain whether there is any intended semantic distinction between _electronic_ and _electric_. Gernsback, best known for his work in popularizing the fledgling literary genre of science fiction, also had invented several electric instruments in the 1920s.
40. Clifford E. Denton, “The Trautonium: A New Musical Instrument,” _Radio-Craft_ 4, no. 9 (1933): 522. Certain aspects of Denton’s article, such as his list of eight criteria for the success of a new instrument, suggest that he had read Winckelmann’s book, which features a very similar list of six requirements. See Winckelmann, 3–4.
42. Lertes, _Elektrische Musik_, 183.
that the same economic factors would lead to performers being supplanted by mechanical instruments.


47. Ibid.


50. Ibid., 133, image 4–4.


58. Donhauser, *Elektrische Klangmaschinen*, 141–43. The score for this piece was lost; in the 1980s Sala reconstructed and recorded a version based on an old gramophone recording of the original.


66. Ibid., 68; Prieberg, *Handbuch deutsche Musiker 1933–1945*, 7233. Prieberg states that Trautwein’s promotion took place in 1937, while Donhauser says simply “after the closing of the Radio Research Section in 1935,” suggesting it may have been earlier than 1937.


69. See Peukert, *Weimar Republic*, 164. Indeed, the notion that the Nazis based their cultural favors according to sound stylistic or aesthetic distinctions
gives them too much credit. The inconsistency of their judgments stemmed in large part from the racial pseudoscience on which their ideology was based. Potentially “dangerous” art, such as twelve-tone music, was allowed if it was composed by those of good Aryan stock, while music that was steeped in the German tradition became suspect if its author was of Jewish heritage, as in the example of Mahler.

84. Ibid., 146, 148.
85. Ibid., 166.
86. The full quotation is “Ohne Kraftwagen, ohne Flugzeug, ohne Lautsprecher hätten wir Deutschland nicht erobert.” Quoted in Heinz Pohle,

88. Ibid., 184. The Theremin, played by Lucie Bigelow-Rosen, enjoyed one last tour through Germany in early 1936. According to Donhauser, this was allowed by the authorities only because the Nazis wanted to keep up appearances so as not to generate bad publicity in advance of the Berlin Olympics. Ibid., 153–54.

89. Ibid., 184.
94. Although this name has been adopted by historians, a more literal translation would be “symphony of steam whistles.” See Miguel Molina Alarcón, liner notes to *Baku: Symphony of Sirens*, ReR Megacorp Compact Disc (2008): 71.
95. Ibid.
96. Quoted in Smirnov, *Sound in Z*, 152. In a 1928 article, the American writer Irving Weil noted that “magnitude of sound, like so many other things, goes back to the French Revolution,” thus linking, in a roundabout way, the musical and political impetus of the modern mass spectacle. Apparently unaware of Avraamov’s massive event in Baku in 1922, Weil invoked as historical precedent the *Fête of the Supreme Being*, for which the composer Étienne Méhul supposedly conducted a chorus of 300,000 voices, accompanied by the firing of amassed batteries of artillery. For his part, Weil envisioned the high-amplitude music of the future being provided by “little amplifying devils, minute in size but huge in magnifying sound; little inventions that, placed for example within the belly of a single violin, will give forth the tone of a thousand fiddles.” Weil, “The Noise-Makers,” *Modern Music* 5, no. 2 (1928): 24–28.
100. Ibid., 16. In yet another version of this trope, the composer Richard Stein extended the fantasy from a collective *listening* experience to a collective act of music making. According to Stein, the orchestra of players, each with his own instrument, was a relic of the “age of individualism”; the “age of collectivism,” on the other hand, demanded the collaboration of many musicians working upon one massive instrument. Stein envisioned a huge ring-shaped organ played by some thirty to sixty musicians and surrounded by tens of thousands of listeners arrayed in concentric circles around the instrument. “An electric music organized in this way will not longer be a ‘mechanical music’; it will express
the collective will of a multitude, whose artistic and and human instensity is immeasurably greater than that of the an individual conductor, however prominent he might be.” The passage concludes, “Utopia? We will wait until Jörg Mager has come to an ultimate outcome of his years-long studies and practical work. Only then will one be able to discuss the problem of electric music in its full scope.” Stein, “Elektrische Musik,” Die Musik 22, no. 11 (1930): 862. Compare this to the language of Heinrich Besseler, the musicologist who helped coin the term Gebrauchsmusik, describing the social conditions of premodern musical performance: “Just as the familiar distance between music and listener seems to disappear, so to the otherwise strictly separated individuals are fused into a kind of vital rhythmic collective being, through which the music circulates as a connective fluid. […]. Here there can be no question of listening as one would in a concert.” Besseler, “Grundfragen des musikalischen Hörens,” Jahrbuch der Musikbibliothek Peters 32 (1926): 35–52; reprinted in Aufsätze zur Musikästhetik und Musikgeschichte, ed. Peter Gülke (Leipzig: Reclam, 1978), 29–53.

101. Glinsky, Theremin, 106.
103. Ibid., 41–42.
108. Lertes, Elektrische Musik, 162, 164.
112. Ibid.
113. Ibid.
116. Donhauser, Elektrische Klangmaschinen, 212. Trautwein claimed to have heard from a third party that Mager stated he had switched his allegiance from the Communists to the Nazis because the latter paid better.
118. Donhauser, Elektrische Klangmaschinen, 216–17. A contemporary account suggests the possibility that original music for the Partiturophon was performed at this event, but no scores or recordings survive. See “Elektromusikinstrumente auf dem Weimarer Tonkünstlerfest,” Zeitschrift für Instrumentenbau 56, no. 19 (1936): 322.
124. “369 neue Musikinstrumente in zehn Jahren,” Zeitschrift für Instrumentenbau 59, no. 11 (1939): 173. The text of the article is at variance with the headline: it puts the figure at 396, not 369.

6. THE EXPANDING INSTRUMENTARIUM


21. Take, for example, this remark by Jean-Jacques Nattiez: “Indeed, it is not impossible to see the foundation of IRCAM in 1974—along with a similar idea of Varèse, the studios in Cologne and Milan, and even the enterprises of Xenakis—as the final realization of Cage’s vision.” The Boulez-Cage Correspondence, ed. Jean-Jacques Nattiez (Cambridge: Cambridge University Press, 1993), 9.


30. Robert Beyer, “MUSIK UND TECHNIK,” in Darmstadt-Dokumente I, Musik- 
KONZEPTE Sonderband, ed. Heinz-Klaus Metzger and Rainer Riehn (Munich: 

restated his belief in the importance of Raummusik—the spatialized sound im-
age captured by the microphone and projected by loudspeakers (discussed in 
chapter 4). He sought to draw out the implications of the fact that listeners 
to electronic music confront sound not in the shared space of the concert hall 
but rather in the distanced form of an electroacoustic projection. The resulting 
sonic image (Klangbild), he suggested, is to “live” acoustic sound as the filmed 
scenes of cinema are to the staged theater. Beyer foresaw the development of 
new compositional principles such as “spatial counterpoint,” a notion that was 
arguably put into practice in such works as Stockhausen’s Gesang der Jünglinge 
and Kontakt. These themes are treated at great length in Gisela Nauck’s Musik 
im Raum, Raum in der Musik: Ein Beitrag zur Geschichte der seriellen Musik 
(PhD diss., Technische Universität Berlin, 1995).


33. See Helmut Kirchmeyer, Kleine Monographie über Herbert Eimert (Leipzig: 
Verlag der Sächsischen Akademie der Wissenschaften zu Leipzig, 1998), 47.

34. See Herbert Eimert, “SO BEGANN DIE ELEKTRONISCHE MUSIK,” Melos 39 
(1972): 42. Eimert referred to Meyer-Eppler’s coinage as “unfortunate.”


36. Herbert Eimert, “Elektronische Musik,” in Die Musik in Geschichte und 
Gegenwart (Kassel: Bärenreiter, 1954), 1264.


38. Trautwein was also involved in providing sound machines for the Co-
logne Studio at this time: in 1952, he was commissioned to design an instrument 
called the Electric Monochord. (The title is significant, given the fundamental-
ist concern with the basic properties of sound among the composers of elek-
tronische Musik.) This was essentially a stripped-down version of the Concert 
Trautonium with two monophonic manuals, lacking the subharmonic mixtures 
and the foot pedal controls for the switching of register. The instrument was 
built according to his design in 1953. See Friedrich Trautwein, “The Electronic 
Monochord,” trans. H.A.G. Nathan, Technical Translation TT-606 (Ottawa: 
National Research Council of Canada, 1956), 1–12; and Eimert, “So begann 
die elektronische Musik,” 42.

39. These pieces, with the exception of Ostinate Figuren und Rhythmen, can 
be heard on Cologne—WDR: Early Electronic Music, BV Haast Records 9106, 
2005, compact disc.

40. Eimert, “So begann die elektronischen Musik,” 42.

41. See Elena Ungeheuer, Wie die elektronische Musik ‘erfunden’ wurde . . . 
Quellenstudie zu Werner Meyer-Epplers Entwurf zwischen 1949 and 1953 
(Mainz: Schott, 1992), 123–27.

42. Herbert Eimert, Atonale Musiklehre (Leipzig: Breitkopf & Härtel, 1924).
43. See Marietta Morawska-Büngeler, *Schwingende Elektronen*, 33. Morawska-Büngeler quotes the composer Gottfried Michael Koenig recalling that the sine wave was “so ideologically important back then.”


45. Ironically, in his criticisms of the Cologne studio, Beyer also found himself in the same boat with Friedrich Trautwein, whose instrument he had harshly attacked in the early 1930s. See Friedrich Trautwein, “Das Klangfarben-Musikinstrument,” *Musica* 7, nos. 7–8 (1953): 301–5.


47. Ibid., 455.


53. Elena Ungeheuer, “Imitative Instrumente und innovative Maschinen? Musikästhetische Orientierungen der elektrischen Klangerzeugung,” in *Zauberkraft Klangmaschine: Von der Sprechmaschine bis zur Soundkarte*, ed. Institut für Medienarchäologie (Mainz: Schott, 2008), 49. Elsewhere, however, she offers a more balanced view: “Robert Beyer represents an unbroken tradition of electric tone generation whose origins can be traced to the beginning of the twentieth century. It is clear that a study of the reception of the idea of electronic music must be embedded in the context of the entire history of electric tone generation.” Ungeheuer, *Wie die elektronische Musik*, 17.


59. The software is available at http://www.gleetchplug.com/gleetchplug/berna.html. Software such as Sancristoforo’s seems to validate Marshall McLuhan’s dictum that the content of new media is old media. See *Understanding Media: The Extensions of Man* (1964; Cambridge, MA: MIT Press, 1994), 8.


64. This phenomenon is also discussed, though not by this name, in Théberge, *Any Sound You Can Imagine*, 255.