On Hearing Eyes and Seeing Ears: A Media Aesthetics of Relationships between Sound and Image

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This essay analyzes the history of efforts to bridge hearing and seeing in terms of the aesthetic concepts and ideas for coupling sounds and images. It asks in what form and with what aesthetic result they are implemented. It focuses less on a general history of color-light music than on the various technical apparatus used to produce a correlation of colors, forms, and sounds.[1] In order to make the parallelism of media history and color music tangible, projects are given as examples of efforts to achieve the transfer of sounds into images and vice versa directly by means of transfer and connection using media technology. The role of media technology is explored as an interface between genres in terms of its tendency to create an aesthetic of technology.[2]

Fascination and Disappointment

The efforts of artists to relate hearing and seeing to each other form part of the long history of this fascination. The focus was always on the desire and promise to produce as close a connection as possible between sound and image, music and colors, or even to make them coincide. The early experiments with color music[3] or optophony[4] in the nineteenth and early twentieth centuries in particular were attended by the idea of universal correspondences between hearing and seeing.

Artists were guided by the ideal that the dominant distinction between optical and acoustic perception in art could be fundamentally overcome. This fascination was based on an analogy that had dominated since antiquity: that sounds could

1 For a general history, see, for example, Peter Weibel, "The Development of Light Art," in *Lichtkunst aus Kunstlicht / Light Art from Artificial Light*, eds. Peter Weibel and Gregor Jansen (Ostfildern: Hatje Cantz, 2006), 86–224. There are numerous catalogs on the history of sound/light art: Karin von Maur, ed., *Vom Klang der Bilder: Die Musik in der Kunst des 20. Jahrhunderts*, exh. cat., Staatsgalerie Stuttgart (Munich: Prestel, 1985); Kerry Brougher and Jeremy Strick, eds., *Visual Music: Synaesthesia in Art and Music since 1900*, exh. cat., Museum of Contemporary Art, Los Angeles (New York: Thames and Hudson, 2005); Sophie Duplaix and Marcella Lista, eds., *Sons et lumières: Une histoire du son dans l'art du XXe siècle*, exh. cat. (Paris: Centre Pompidou, 2004). More recent developments are discussed in Cornelia Lund and Holger Lund, eds. *Audio.Visual: On Visual Music and Related Media* (Stuttgart: Arnoldsche, 2009).

2 I am also involved in a practical way with sound/image relationships. As part of the artist duo mikomikona, I use overhead projectors in performances, placing transparencies printed with grids of lines and dots to produce moiré patterns that, by means of a circuit, are simultaneously audible and experienced as sound.

3 The term color music is used to describe works of art that attempt to bring color forms and music into a harmonious composition. By contrast, labels such as "audition colorée" and "color hearing" were used for research on how humans perceive modal phenomena. The term synesthesia is still used for the latter, and was first introduced in 1892 in a publication by the French psychologist Jules Millet. On the history of the concept, see Heinz Paetzhold, "Synästhesie," in *Ästhetische Grundbegriffe*, eds. Karlheinz Barck, Martin Fontius, and Dieter Schlenstedt (Stuttgart: J. B. Metzler, 2003), 840–868.

4 An Optophone is an apparatus for making visible structures audible, such as simple optical devices and machines to help the blind read. Most of these devices are based on the photoelectric properties of selenium cells. After World War I, when many invalids were returning home from the war, a great deal of hope was placed in this technology, and many different Optophones were patented. See Cornelius Borck, "Blindness, Seeing: An Envisioning Prosthesis; The Optophone between Science, Technology, and Art," in *Artists as Inventors, Inventors as Artists*, eds. Dieter Daniels and Barbara U. Schmidt (Ostfildern: Hatje Cantz, 2008), 108–129.

be assigned to visual experiences, just as images had corresponding tones. Both media formats were originally one on the level of perception, but—according to a view that was widespread in the nineteenth century—through the course of evolution, as the sense organs separated, human beings lost the ability to perceive light and sound simultaneously.[5] Physiological research into synesthesia seemed to confirm this view, and since the last third of the nineteenth century the term synesthete has been used to describe people for whom a single stimulus uncontrollably produces simultaneous perception by two different senses. Research into this phenomenon showed that for people with synesthesia, sensations are not simply inner ideas but are felt to be just as real as actual perceptions.[6] When artists sought to create a synthesis of the arts, they also aimed to introduce a fundamental expansion of the senses by means of new forms of art. One peculiarity of artistic proclamations regarding the possibility of such bridging of the senses was that the perceptual abilities of human sense organs and the production of sensory effects by media—two processes that should be systematically distinguished—were used synonymously on the linguistic level.

The postulate of an art form that links seeing and hearing holds a fascination that is undiminished today. Whereas around the year 1900 currents and waves were considered the universal currency of hearing and seeing,[7] in the 1990s this function was taken over by the digital code, which seems to fuse genres in the "universal machine" of the computer. Because the computer processes texts, images, and sounds by means of the uniform code of zeros and ones, it seamlessly takes its place in a long history of fascination with the unity of the arts. The universality of computer code leads to cryptographic play with signs and genres, which releases a generative aesthetics for which Max Bense had laid the foundations with his programmable aesthetics based on information theory.[8] The culture of VJing,[9] which has since been introduced into commercial software for playing music, explores the effects of this connection as a psychedelic play with forms. At today's media festivals, in turn, artists perform on instruments which they have developed to produce sounds and projections simultaneously.[10] All these technical connections between media for the purposes of the sonification of images and the visualization of sounds—upending the traditional coupling of control and interface—should be seen against the backdrop of the universal habit in the media culture of the twentieth century to consume

5 The idea was that the separation of the senses occurred only with phylogeny: many people have the ability to perceive synesthetically as children but lose it upon becoming adults. See, for example, Emil Du Bois-Reymond, "Über die Grenzen des Naturerkennens: Vortrag in der zweiten allgemeinen Sitzung der 45. Versammlung Deutscher Naturforscher und Ärzte" (1872), in idem, *Vorträge über Philosophie und Gesellschaft*, ed. Siegfried Wollgast (Berlin: Akademie, 1974), 54–77. Also see Christian Filk and Michael Lommel, "Media Synaesthetics: Eine Einleitung," in *Media Synaesthetics*, eds. Christian Filk, Michael Lommel, and Mike Sandbothe (Cologne: Halem, 2004), 9–21, esp. 11.

6 See Carol Steen, "Vision Shared: A Firsthand Look into Synesthesia and Art," *Leonardo* 34, no. 3 (2001), 203–208, esp. 203; for a general history of synesthesia and its cultural history, see Paetzhold, "Synästhesie," and Hinderk M. Emrich, Janina Neufeld, and Christopher Sinke, "Synesthesia," in *See This Sound: Audiovisuology Compendium*, eds. Dieter Daniels and Sandra Naumann (Cologne: Walther König, 2009), 414–423.

7 See, for example, Christoph Asendorf, *Ströme und Strahlen: Das langsame Verschwinden der Materie um 1900* (Giessen: Anabas, 1989), 72; Lorenz Engell, Bernhard Siegert, and Joseph Vogl, eds., *Licht und Leitung* (Weimar: Universitäts-Verlag, 2002).

8 See Barbara Büscher, ed., *Ästhetik als Programm: Max Bense; Daten und Streuungen*, Kaleidoskopien 5 (Berlin: Vice Versa, 2004).

9 Jan Rohlf, "Generieren, nicht collagieren: Ton-Bild-Korrespondenz im Kontext zeitgenössischer elektronischer Musik," in *Musik*, ed. Laura Daniel, Cinema 49 (Marburg: Schüren, 2004), 121–132.

10 For example, the Sonar Festival, Barcelona; netmage Festival, Bologna; Club Transmediale, Berlin; Ars Electronica, Linz; Shift Festival der elektronischen Künste, Basel; Némo, Le Rendez-vous Multimédia d'Arcadi, Paris.

music and moving images simultaneously. Projected light was the medium of choice, because it made it possible to cause visual impressions to move in sync with music. An early monograph on color music from 1926 reads: "An art of rhythmically moving coloured shapes would correspond broadly with music."[11] Optophony and color music had their first heyday during the early history of film at the end of the nineteenth century and from 1920 onward, when silent films were still accompanied by live music. Artists who worked with color-light music wanted nothing less than to replace painting with moving abstractions created by means of light. They promised a "new art" and thus developed new forms of media art that stimulated intermodal processes of perception.

The attempts to connect hearing and seeing to each other are as numerous as they are diverse. If the artistic outcomes are measured against their ambitions, however, the artists ultimately demonstrated that there are no universal correspondences between colors and sounds that can be determined physiologically and objectively; rather, the connections are arbitrary postulations. The schemas for assigning sounds and colors, music and forms, movement and rhythm to one another, which every artist derived anew, were too different.[12] An instrument that can make images and sounds coincide in perception universally could not be realized. Yet the history of color music is not a history of failure due to this gap between the ambition and the result. First, the many combinations of images and sounds repeatedly led to subjective results that certainly did liberate a new kind of perception that transcends genres. Furthermore, the assertion of a universal connection between music and painting was enormously productive for art, because the space between the two genres of music and painting provided considerable leeway for the creation of new forms. The promise of a supraindividual relationship between hearing and seeing spurred every artist to decide how to design the points of intersection between sounds and colors. Models for assigning such relationships changed, reflecting the history of ideas, technology, and art. In each case, they encouraged a new, intersecting approach to thinking about genres: thinking about images as music or music as images. This "mutual illumination of the arts," as the literary scholar Oskar Walzel expressed it in a title in 1917,[13] made it possible to relate "perceptions, the ways of seeing and hearing one type of art, to those of another type in a way that is more than merely associative."[14]

Crossed Organs

An 1872 lecture by Emil Du Bois-Reymond, "Über die Grenzen des Naturerkennens" (On the Limits of Knowledge of Nature), still provided ideas for linking

11 Adrian B. Klein, *Colour-Music: The Art of Light* (London: Crosby, 1926), 135.

12 The schemas for assigning the two are numerous. In his historical overview, Adrian B. Klein listed many such schemas, such as various assignments of pitch to color. See Klein, *Colour-Music*; see also the color schema reproduced by Olivia Mattis, "Scriabin to Gershwin: Color Music from a Musical Perspective," in Brougher and Strick, *Visual Music*, 210–229.

13 Oskar Walzel, *Wechselseitige Erhellung der Künste: Ein Beitrag zur Würdigung kunstgeschichtlicher Begriffe, Philosophische Vorträge, veröffentlicht von der Kantgesellschaft*, no. 17 (Berlin: Reuther & Richard, 1917). In this lecture Walzel analyzed concepts from architecture and from music that were used in the other field—for example, when music is described as flowing architecture or architecture as frozen music, or when rhythm and strophe are used as analytical terms for architecture and painting.

14 Helmut Plessner, *Die Einheit der Sinne: Grundlinien einer Ästhesiologie des Geistes* (Bonn: F. Cohen, 1923), 106. He continues: "The qualities from disparate areas of the senses are brought into immediate proximity so that the interference of the pure content of the senses causes the consciousness of essence to be that much more pure in the unity of perception." Both Walzel and Plessner are cited in Paetzhold, "Synästhesie," 855.

the arts in the early twentieth century.[15] In his lecture, Du Bois-Reymond proposed a physiological thought experiment by asking what would happen if the separated modes of sensory perception could be exchanged, fiber by fiber, without disturbing the brain. "If visual and auditory nerves that were crossed then healed, if the experiment were possible, we would hear lightning with our eyes as a bang, and would see the thunder with our ears as a series of visual impressions."[16] He put forward this thought experiment to show that consciousness cannot be reduced to matter, which follows from the separation of modes of sensory perception, since the same molecular process took place in all nerves, varying only in intensity. From this followed the physiological insight that sensory perceptions of sound and light, odor and pain exist only in the sense organs. "The 'Let there be light' of Genesis is physiologically wrong. There was only light when the first red eye dot of an infusorium [a single-cell organism; B. S.] first distinguished between bright and dark. Without the substance of the visual and auditory senses, this world around us, with its glowing colors and sounds, would be dark and mute."[17]

Du Bois-Reymond was imagining here an original material on which all perceptions were based.[18] Consequently, it was a great riddle why a certain chord should be pleasant, while touching a glowing piece of iron should cause pain, as knowledge of the material event alone could not determine which was the pleasurable process and which the painful one.[19] The aesthetics of art—Du Bois-Reymond imagined it as the movements of certain atoms in the brain—obtains on this level an inexplicable lack of orientation, which is first sorted out and given meaning in perception. Depending on which senses perceive the qualities, different feelings and impressions are produced.

Du Bois-Reymond's thought experiment not only showed the limits of scientific knowledge but also brought the imaginative faculty to its limits. For what he presented was not a visualization of thunder or a sonification of lightning but rather an eye that can hear and an ear that can see. This essay examines attempts to achieve a synthesis of the arts whereby, on the one hand, media technologies take the place of the perceiving sense organs or, on the other hand, codes are processed by the sense organs as *primal substances*. Eyes and ears are therefore replaced by media prostheses such as loudspeakers, televisions, and film technology.

Sonification and Visualization

The crossing of media technologies now known as sonification[20] was mentioned in a special issue of the newspaper *Berliner Zeitung* in March 1929: "Television successful in Berlin! Some radio listeners will have noticed a loud

15 Du Bois-Reymond, "Über die Grenzen des Naturerkennens," 54–77.

16 Ibid., 58.

17 Ibid., On the evolution of the sense of vision, see Andrew Parker, *In the Blink of an Eye* (Cambridge, Mass.: Perseus, 2003).

18 "The philosopher's stone that could transform materials that are today still unseparated into one another and produce a higher basic material—if not the original materials itself—would have to be discovered before even the first speculations about the origins of seemingly different but in reality identical materials." Du Bois-Reymond, "Über die Grenzen," 59.

19 Ibid., 71.

20 "Sonification" refers to the reproduction of data as sound events. In scientific fields, sonification can aid in recognizing structures in data that are not sufficiently clear when visualized, for example. The Geiger counter is an instrument based on this technology. See Florian Grond and Theresa Schubert-Minski, "Sonification," in *See This Sound: Audiovisuology Compendium*, eds. Dieter Daniels and Sandra Naumann (Cologne: Walther König, 2009), 284–295.

crackling in their speakers outside the official broadcast hours; its pitch fluctuated up and down and it sounded like the noise produced by alternating current. These mysterious signs represent the first practical experiments with television based on the Mihály system, which the Reichspost [German post office; B. S.] conducted as quietly as possible."[21] Radio listeners who turned on their radios outside the normal broadcast times were receiving images but hearing them as sounds; sonification took the form of the unpleasant sound of interference. The Reichspost's practical experiments had thus transmitted the first television images from the aforementioned "silence" as crackling sound waves.

Just a few months after these first test broadcasts, Fritz Winckel, a student of telecommunications and acoustics, conducted experiments in the opposite direction. At the time he was working in the private laboratory of Dénes von Mihály, who was also responsible for the technology used by the Reichspost. For his technical coupling of sound and image, Winckel used Mihály's television system, which was still partially mechanical and which broke down images by means of a perforated Nipkow disk into a series of light impulses with the low resolution of just 1,200 dots. A radio served as a loudspeaker. The point of departure for his effort to make something visible on the disk was the "radio's musical and spoken performances,"[22] especially classical music.

Winckel described the results of his research into sound images in, among other places, a small introduction to television technology.[23] He explicitly referred to Du Bois-Reymond's earlier thought experiment, which he took one step further with regard to media technology by asking about the possibility of "exchanging organs or, in practical terms, exchanging the loudspeaker for a television."[24] The result of his connecting a source of images with a source of sounds was "a moirélike image in contrasts of black and red that altered its appearance . . . to the rhythm of the music."[25] Unlike the unintentional sonification of the first television images on the radio, making sounds visible had an aesthetic appeal that captivated Winckel. He said it was an "artistic pleasure to see the optical presentation of a sound composition on the disk as a continuous weaving of mosaic patterns that emerge out of themselves and are unique to the character of the sound. For example, the blasts of the fanfares of a symphony are revealed as semi-oval cast shadows in syncopated rhythm, interrupted by timpani beats seen as jagged contours. That is followed by an andante cantabile, with the strings spinning out a melody in all its variations; delicately distributed patterns, in infinite variety, thus appear on the disk; in a diminuendo they fade more and more to the indistinct, cloudy figures of the pianissimo."[26]

Winckel emphasized his high aesthetic estimation of the experiment by treating it in his television handbook under the title "Die Anwendung des Fernsehens in der Kunst" (The Use of Television in Art). In the table of contents, this short chapter precedes a section titled "Die Anwendung des Fernsehens in Wissenschaft und Technik" (The Use of Television in Science and Technology). On the one hand, the reason the effect of transformation became an aesthetic pleasure

21 "Extrablatt," supplement to the *Neue Berliner Zeitung*, March 9, 1929.

22 Fritz Wilhelm Winckel, *Technik und Aufgaben des Fernsehens* (Berlin: Rothgiesser & Diesing, 1930), 59. Later he conducted experiments on, among other things, voices and language, developing the first model for the automatic recognition of spoken language in 1965.

23 Winckel, *Technik und Aufgaben des Fernsehens*, but see also his two articles in the Berlin-based journal *Fernsehen*: "Vergleichende Analyse der Ton- und Bildmodulation," *Fernsehen* 1 (1930), 171–175, and "Musikalische Forderungen für tonmodulierte Bildabtastung," *Fernsehen* 3 (1932), 170–173.

24 Winckel, *Technik und Aufgaben des Fernsehens*, 59.

25 Ibid.

26 Ibid.

was the patterns. On the other hand, it was more important that these patterns changed in sync with the music. The moving patterns thus enabled a new way to experience sounds that took form on the screen *on their own*. The different sound qualities produced their own image, like a dynamic fingerprint. With the possible exception of sound experiments with Chladni figures, such experiences of images were previously unknown. Winckel probably created the first synthetic images as part of his sound/image research.

By contrast, Winckel was less enthusiastic about the aesthetic effect of the reverse transformation of television images into sounds. In his view, the sound of an image could only reveal whether it is a photograph, a black-and-white drawing, a manuscript, or a fingerprint. According to Winckel, however, the television broadcasts received by radio that the Reichspost conducted for test purposes did not permit such differentiations. The Reichspost's test broadcasts produced only the sound of a gurgling hum much like an alternating current, "because the synchronization beats at each line drowned everything out."[27] The crackling that was heard was not the image itself but rather its breakdown into scanning lines as demanded by the technology.

It is possible to exchange television and loudspeaker and thus make the audible visible because the frequency range of these two technologies is similar. This circumstance inspired Winckel to an "entirely new definition of the term 'art' [. . .]. Every form of representation, whether music or painting, can be interpreted in its ur-form as a series of waves that are of the same physical character after their transformation."[28] By generalizing waves as the ur-form of perception, Winckel became convinced that the modulated alternating current into which music and images can be translated can be made conscious to the senses in other ways—in the future perhaps even by touching and smelling.[29]

The interface that Winckel chose for the transformation of sounds and images set its own aesthetic rules and limits. The quality of the sounds produced is far from the familiar melodiousness of classical music; rather, the new sound of interference comes to the fore. The patterns resulting from the music are, by contrast, "uniformly and harmoniously constructed."[30] They change their form in accordance with the timbre of an instrument. Because they are regular, the forms recall simple geometric fabric patterns. But even if the patterns have an aesthetic effect, the possibilities of their variation are extremely limited. The repertoire of their forms also derives from the area of technological interference, since the shimmering, weaving fabric patterns are an image of interference, with the difference that the shimmering on the television screen is more appealing aesthetically than the noise and crackling that are its acoustic pendants. In both cases, the resulting aesthetics is no longer part of a musical theory of harmony or of the artistic composition of images of the sort that influences the curriculum of art and music schools; rather, from our perspective today they are part of a technological aesthetic that is produced by means of apparatus.

The concluding sentences of Winckel's articles point to a shift in the experiment from the context of art to the field of applied technology. "The synthesis of art on the path of electricity also leads us to analysis, to the unambiguous, objective assessment of a work of art as a supplement to and control on personal,

27 Ibid.

28 Ibid., 60.

29 Ibid.

30 Ibid.

vacillating taste."[31] Here Winckel no longer viewed his experiment as an aesthetic interplay of music and images on equal footing; rather, the image takes on the role of visualizing sounds. For Winckel, the synthesis of the arts logically led to various procedures of sound analysis, for which he would soon thereafter register with the German patent office.[32] The transformation of initially free artistic experiments into fixed, useful functions typifies a common shift. In the logic of the patent applications, there is no room to emphasize aesthetic qualities: the only use suggested for them was research into electric technology. The television-loudspeaker switch is described in sober terms as a "procedure for the automatic analysis of waves" or "sound analysis" of the "production of optical sound-image representations." With the use of "oscillographs" based on this technology, it became possible to get an electronic beam controlled by two sine waves in the corresponding phase relationship of the two waves to move in a circle, then figure eights, and on to increasingly complex formations.[33]

Direct Composition

The transformation of sounds and images into waves did more than raise the possibility of crossing them. The form of the wave also permitted new artistic means of expression, such as those practiced after 1920 by the Russian musician and physicist Leon Theremin (1896–1993), who composed electronically directly. An interface for direct composition had been conceived several years earlier by the artist Raoul Hausmann; with this device, he could produce and control not only sounds but also images at the same time. Unlike Winckel, he did not require any artistic raw materials such as music or images. He himself described his apparatus as an instrument on which "optical-phonetic compositions" could be played.[34] Because only simplified sketches and descriptions of his device survive, and no recordings of the optical and acoustic impressions exist, the aesthetic effect and technological operation of his apparatus can be only very roughly sketched today.[35]

According to Hausmann's description, the apparatus consisted of a keyboard with approximately one hundred keys, which controlled a cylinder divided accordingly into one hundred fields.[36] The fields of the cylinder were printed with various series of chromogelatin lines using a collotype process. Hausmann placed a pane of quartz and a glass prism in front of the cylinder; opposite the cylinder he placed a neon lamp and next to it a selenium cell (a type of photoelectric cell) which was pointed at the lamp and controlled an amplifier and a

31 Ibid., 61.

32 Berlin patent nos.: 16.3.1933: no. 573752, 8.6.1933: no. 579338, 27.4.1933: no. 576538, 6.8.1936: no. 634348.

33 Winckel also served the cause of electronic music with his later activities. From the mid-1950s onward, he ran the program for sound engineers which he founded as a collaboration between the Technische Universität and the Hochschule für Musik Berlin. Furthermore, along with Boris Blacher, he was one of the founders of the Arbeitskreis für Elektronische Musik (Working Group for Electronic Music), which was located at the Technische Universität. There he helped develop the spherical pavilion that Karlheinz Stockhausen conceived for the World's Fair in Osaka in 1970. He worked together with the Groupe de Recherche de Musique Concrète in Paris, and in 1966 he was involved in a production of an electronic opera in Hamburg. See Carl Dahlhaus, ed., *Tiefenstruktur der Musik: Festschrift Fritz Winckel zum 75. Geburtstag am 20. Juni 1982* (Berlin: Fachbereich 1, Fachgebiet Kommunikationswissenschaft der Technischen Universität Berlin, 1982), 219–220.

34 Raoul Hausmann, "Die überzüchteten Künste: Die neuen Elemente der Malerei und Musik," in *Sieg, Triumph, Tabak mit Bohnen*, vol. 2 of *Texte bis 1933*, ed. Michael Erlhoff (Munich: Text + Kritik, 1982), 133–144, esp. 144.

35 There is no proof that his Optophone was ever built or demonstrated in public. It is therefore also possible that Hausmann's Optophone existed only as an idea on paper.

36 Hausmann, "Die überzüchteten Künste," 133–144.

loudspeaker. By striking the keys, a wide variety of “groups of spectral colors and bands of line” could be directed to the optical system, which then projected “color-form performances,” while at the same time the photoelectric cell transformed the brightness and darkness values into electrical impulses and transmitted them to the loudspeaker, where they produced an “acoustic effect.”[37] The optical output of the device was supposed to be abstract rainbow patterns that were refracted in a crystalline way by the quartz and the glass prism and that projected moving, kaleidoscope-like forms into the room. Acoustically, the instrument may have crackled like the first television broadcast did on radios, but it would also have been possible to produce technical sounds of various pitches.[38]

Unlike Winckel’s musical patterns on the screen of a television, and also unlike the Optophones built from the 1910s onward as prostheses for the blind,[39] Hausmann’s apparatus did not transform sounds into images, or images into sounds, but rather produced sounds and images simultaneously. Hausmann emphasized this unique feature when he described how the Optophone transformed the induced light into sounds with the aid of a selenium cell: “What appears as an image at the receiving station is already a sound in the places in between.”[40] Even though, strictly speaking, within this technical structure the acoustic effects are first generated by the projections, this causal sequence can no longer be perceived by the Optophone player. Rather, the simultaneity of the effects plays the crucial role in the way the art is generated here. Playing the instrument challenges perception in a previously unknown way. Players have several paths available for artistic improvisation with the instrument, as they may concentrate on the visual level of the color-form performances, on the acoustic effects, or on getting involved in both effects at the same time. Anyone who manages to achieve the latter would indeed be a color musician.

Hausmann’s Optophone resists straightforward interpretation and contextualization. In his writings, typescripts, and letters, he understands and presents his color organ in terms of complex, often contradictory concepts from art, technology, and science that can only be hinted at here. For example, the Optophone can be seen as a logical development of his sound poetry, which he had earlier presented under the name *optophonetic poems*,[41] or of his collages and photographs, in which he addressed the subject of expanded perception through a variety of means. At the same time, Hausmann had grappled with the technical proposal for a synthesis of sound and image, such as the sound-image processes of film and the color organs of his day.[42] In his earliest writing on optophonetics, he quoted a now forgotten text by the Prussian captain Maximilian Plessner,

37 Ibid., 144.

38 The artist Peter Keene reconstructed an Optophone using Hausmann’s idea (1999–2004). His reconstruction is also based on the aesthetic effect of spectral colors and the sounds of interference.

39 See note 4.

40 Raoul Hausmann, “Optophonetik” (May 1922), in Erlhoff, *Sieg, Triumph, Tabak mit Bohnen*, 50–57, esp. 54.

41 For his optophonetic poems, which Hausmann presented from 1919 onward, he juxtaposed the letters for a poster from a type case in such a way that their sequence made the words and syllables unrecognizable. This technique was supposed to elevate the typographically notated sound poems to the level of genuinely experienced perception. When reading them, the senses were supposed to be connected with one another and thus lead to a new kind of perception, in which breathing, hearing, seeing, and the brain formed a previously unknown unity. See Michael Erlhoff, *Raoul Hausmann, Dadasoph: Versuch einer Politisierung der Ästhetik* (Hanover: Zweitschrift, 1982).

42 See Raoul Hausmann, “Vom sprechenden Film zur Optophonetik” (1923), in Erlhoff, *Sieg, Triumph, Tabak mit Bohnen*, 72–75.

who as early as 1892 had published several pages outlining a hypothesis about the possibilities for "optography" in a text entitled *Die Zukunft des elektrischen Fernsehens* (The Future of Electric Television). He recognized in the selenium cell the potential for transforming sounds and images on the basis of waves, which would make it technically possible to realize Du Bois-Reymond's thought experiment.[43] Maximilian Plessner—who had also conceived a device called an Antiphone, to be introduced into the ear to block out noise—must be considered the real pioneer of sound and image transformations in the style of Hausmann and Winckel.

In addition to his interest in technology, Hausmann grappled with physiological research—for example, Ernst Mach's analysis of sensations. Mach stated that "colors, sounds, temperatures, pressures, spaces, times, and so forth, are connected with one another in manifold ways."[44] Mach presented unlimited psychological and physical processes with infinitely many connections to one another. Hausmann claimed that the Optophone could connect ear and eye in just this way and thus have direct access to the human central nervous system. For him it made no difference whether this occurred on the basis of a natural brain or one separated into mechanics. "Sensory apparatuses" and "technical apparatuses," of the sort he depicted in many of his collages as well, are seen here as interchangeable; they can be bridged unproblematically. The physical unity of light and sound was supposed to reinstate the atrophied organic unity of eye and ear.

The wave as a medium of these connections is omnipresent in Hausmann's work as well. Under the title "Biodynamische Naturanschauung" (Biodynamic Contemplation of Nature), he stated that there is "only one dimension that is universal: waves."[45] The optophone, he claimed, was capable "of showing the equivalent in sound of very Optical phenomenon or, to put it another way: it transforms the difference in the waves of light and sound—since light is an electrical wave and sound is also an electrical wave."[46] Here too we see the influence of Du Bois-Reymond's lecture, which is also referenced in Hausmann's notes.[47]

Hausmann's dadist, artistic background, which contrasts with Winckel's, is clear from a 1924 typescript with keywords and notes titled "Das Prinzip der universalen Funktionalität und der Welteislehre" (The Principle of Universal Functionality

43 "If the light can be forced (using a selenium cell) to produce or alter induced currents, then an audio telephone switched into the circuit would transform such induced phenomena into sounds." Maximilian Plessner [misprinted as "Plenner"; B. S.], quoted in Hausmann, "Vom sprechenden Film zur Optophonetik," 74. Plessner too had been inspired by Du Bois-Reymond. For example, one of his chapters is titled "Sichtbarmachen des Donners, Hörbarmachen des Blitzes" (Making Thunder Visible, Making Lightning Audible). Moreover, under the rubric "phenomena of energy transformation" he reflected on the relationships between the visibly and audibly beautiful, on the sound images of buildings, and on setting physiognomies to music.

44 Ernst Mach, "Introductory Remarks: Anti-Metaphysical," in *The Analysis of Sensations, and the Relation of the Physical to the Psychical*, trans. C. M. Williams and Sydney Waterlow (New York: Dover, 1959; orig. pub. in German in 1885), 2.

45 Raoul Hausmann, "Biodynamische Naturanschauung" (typescript, 1922), in *Raoul Hausmann in Berlin, 1900–1933: Scharfrichter der bürgerlichen Seele; Unveröffentlichte Briefe, Texte, Dokumente*, ed. Eva Züchner (Ostfildern: Hatje Cantz, 1998), 170–176.

46 Raoul Hausmann, "Optophonetik," 54.

47 Hausmann's familiarity with the lecture is clear from a note from 1923 titled "Was heißt Energie" (What Does Energy Mean). In it he reflects on the extent to which it is necessary to conclude that the earth and all heavenly bodies are "the most senseless of everything senseless" and thus to accept Du Bois-Reymond's insight of "ignoramus et ignorabimus," or "we decide to accept divine forces." See Züchner, *Raoul Hausmann in Berlin*, 188.

and World Ice Theory).[48] In this sketch for a table of contents, optophony is mentioned again: "Chap. VI: World ice theory and the optical-acoustic question. The life of bees. Does the bee have an eye? The Optophone of bees. The geometric meaning of bees—interpretable optophonetically . . . The antenna of feelers, real antennas."[49] Hausmann viewed the bee's eye as an organ for "spatial consciousness," which perceived acoustically and optically in equal measure.[50] In the article "Die überzüchteten Künste" (The Overly Refined Arts) of 1931, he derives the history of the Optophone from a potpourri of ideas from biology, art history, and ethnology. He sees the evolution to his color organ as a consequence of the history of seeing, the limits of painting, and the regular rhythm of the mating urge. At the same time, he asks how an ear unfamiliar with music would perceive Beethoven's music—that is, conceived as pure form decoupled from an understanding of its content.[51]

Within the general context of dadaism, Hausmann arrived at a radical technological realization of a utopia that in retrospect seems astonishingly topical. It anticipates ideas from Max Bense's programmed aesthetics as well as the aesthetic aspects of the media art of Nam June Paik and Steina and Woody Vasulka. The similarity lies not so much in the dadaist result as in the appropriation of media technology for artistic ends, by means of which, on the one hand, the media conditions are revealed and, on the other hand, artistic creativity is replaced by media technology. For where the color-light composers of his day still related the human performer to the world of sounds and the world of light formations, and therefore a human being still interpreted the music and transformed it into light formations by means of mixing consoles and organs, Hausmann eliminated emotion, artistic intuition, and human interpretation. Unlike his colleagues, Hausmann wanted to decouple the relationship of perception and articulation, as he had earlier attempted to do in the form of abstract sound poems. With his vision of the Optophone, he found a way to generate art automatically, though it no longer resulted in the familiar perceptual structures of visual and acoustic sense but rather in nonsense.

In his euphoric assessment of nonsense as art, Hausmann should thus also be placed within the paradigm shift that went hand in hand with the spread of psychophysics, which no longer focused on the mind but rather on the brain and its functions. Within this framework, attention no longer focused on what could be achieved meaningfully or didactically but rather on what functioned automatically in perception.[52] When human functions such as reading, hearing, and

48 Although it was never recognized by scientists, the world ice theory of the Austrian engineer Hanns Hörbiger (1860–1931) found many followers in the late 1910s who sought to dismiss the findings of classical astronomy. Hörbiger proposed the idea that the solar system resulted from a cosmic unification of glowing "Sun Mothers" and an "Ice Giant." As a consequence, according to this history of the universe, the moon is still surrounded by a thick layer of ice.

49 Raoul Hausmann, "Das Prinzip der universalen Funktionalität und die Welteislehre" (typescript, April 26, 1924), in Züchner, *Raoul Hausmann in Berlin, 1900–1933*, 218.

50 See Hausmann, "Optophonetik," 56–57.

51 See Hausmann, "Die überzüchteten Künste," 134ff. That same year Hausmann produced a series of black-and-white photographs that resemble, in a purely formal and aesthetic sense, Winckel's depictions of sounds by means of a television. He had used wickerwork from baskets and chairs to create shadows on their surroundings and then photographed these settings with high contrast. He gave them titles such as "Lichtumwandlung eines geflochtenen Papierkorbs" (Light Transformation of a Wicker Wastepaper Basket).

52 See Friedrich Kittler, *Discourse Networks 1800/1900*, trans. Michael Metteer with Chris Cullens (Palo Alto: Stanford University Press, 1990), 214. Kittler describes the experiments of Hermann Ebbinghaus, a professor of psychology in Breslau who tested the storage capacity of the brain by using series of nonsense syllables. Such series of tests were central to psychophysical research where it concerned reading and writing, and it subsequently employed apparatus to measure eye movements and perception times, for example. Kittler, *Discourse Networks*, 214ff. and 222ff.

seeing were tested in psychophysical research using a wide range of apparatus, the experimenters often exposed the experimental subjects to noise and not meaning. By doing so, they hoped to observe the brain during pure thought. The human being was merely the sum of the experiments and tests of the psychophysical apparatus, a condition which represented, in the view of Friedrich Kittler, a departure from the humanist ideal. A culture of "engineers and doctors" who focused on facts and objectivity liberated noise and senselessness, which previously had been precluded within the discourse network of 1800 under the hegemony of meaning and idea.[53]

When Hausmann attempted to patent the Optophone, he failed precisely because of the issue of noise and nonsense. The patent application was rejected in 1927 with the argument that his apparatus did not produce "any pleasant effect in the usual sense"[54]—an argument that Hausmann repeated in his descriptions as proof of the absolute novelty of his color organ.[55] For unlike Winckel's experiments, in the case of Hausmann's Optophone not only was the visual form decoupled from conventional meaning but so was the sound. Whereas Winckel had still fed musical harmonies into his device, Hausmann had the pure sound of technology decoupled from any meaning.

Composing with Notation

Hausmann's color organ shows how a keyboard can be used as a control module for performances employing both colors and sounds. An impulse (depressing a key) triggers two events (sound and color projections) at the same time. Another possibility for crossing artistic genres, one closely related to the principle of the color organ, is to exchange codes and notations rather than have a shared interface for sounds and images. The combination of acoustic and optical qualities need not be achieved by transmitting waves but can instead be based on their notational systems. In his 1926 book, the light musician Adrian Bernard Klein even introduced a "formal art-language" as a general necessity for synchronizing sounds and colored light.[56]

In the history of notation, cylinders with pins and perforated rolls first made it possible to connect musical scores and images to machines. Historically, the punch code was particularly important as a way to notate sounds and images together. Winckel suggested the possibility of composing on the basis of punch code when he referred to "direct punching of the rolls by artists in whatever arrangement is desired" as "direct, original creation of music on the roll."[57] The composer Conlon Nancarrow (1912–1997) used this technique to compose works for player piano featuring superhuman speeds and an innovative aesthetic.

53 Kittler, *Discourse Networks*, 328.

54 Hausmann, "Die überzüchteten Künste," 144.

55 According to Eva Züchner, the Raoul-Hausmann-Archiv has no documents relating to the failed patent application; see Züchner, *Raoul Hausmann in Berlin*, 410 n. 2. Apparently Hausmann first tried to register the apparatus in Germany together with Daniel Broido under the name "Method and device to combine several factors and transmit the results to a mechanical results register"—but was unsuccessful. Patent no. 446338 granted to Hausmann and Broido in England in 1935 was not for the Optophone, as is often incorrectly asserted in the literature, but rather for an electronic calculator. Hausmann and Broido proposed the latter device for the automatic issuance of train tickets. In Berlin in the 1920s, Hausmann ran his own company for patents, of which there is no trace other than a patent from 1929 numbered 473166. Hausmann received that patent for a medical "device to observe cavities and canals in the body"; its significance for art and medical history has yet to be assessed.

56 Klein, *Colour-Music*, 118: "Compositions of light could only be recorded by a notation of some kind."

57 See Winckel, *Technik und Aufgaben des Fernsehens*, 61.

In the history of technology, it was the computer that made the codes of images and sounds interchangeable. Hypothetically, a merger of the codes for music and images would have been possible at a much earlier point in time. That is clear both from the technology, more than three centuries old, for notating notes with pins on cylinders, and from the technology for translating weaving patterns into a pattern of holes in a cylinder, which is nearly that old. This comparison is made possible by the historical knowledge that as early as the eighteenth century silk weavers in France had technologies to control the weaving of floral patterns using punched cards and cylinders.[58] The earliest surviving model of such a loom was built by Jacques Vaucanson between 1745 and 1748.

Vaucanson had begun his career by building three androids in 1738 and 1739. They provided him with a spectacular debut as a mechanic and engineer at the French court before he joined the civil service as an inspector of France's silk industry. In the case of his two automatons that played music—a shepherd boy who played the flute and a tambourine player—a cylinder with pins controlled the androids' movements and hence the melodies that they played. Because Vaucanson used a cylinder to control in equal measure the delicate movements of the androids, the musical automatons, and the machines for producing textile images, it is clear he envisaged an expanded horizon with respect to the technologies for movement and control. If in the eighteenth century patterns of raised and indented areas could be transferred to cylinders and even cards, it suggests a relationship between the controlling of music and that of images. But does the basis for a similar form of notation for music and images also mean that they can be converted into each other? Or to put it another way: Does it make musical and aesthetic sense to swap the notations for woven patterns and those for music?

Cylinders with pins had been used for some time in music boxes, striking mechanisms, and organs; they were exhibited in cabinets of curiosities alongside androids and clock mechanisms. A publication by Salomon de Caus from 1615 demonstrates how advanced such mechanical musical instruments already were in the seventeenth century.[59] The pins on the cylinders were made of metal or wood and had various forms depending on whether they were used with pull rods, pipe valves, or gear mechanisms.[60] In the eighteenth century, there was a growing fascination with and spread of organs controlled by pins on cylinders; like androids that played music, they were part of the repertoire of making automatons for courtly audiences. In the eighteenth century, however, the focus expanded to include both notation using pins on cylinders and the possibility of composing directly in this way. This interest is documented, for example, in a fairly long article in the *Mercure de France* in 1747, which discusses an organ operated by a cylinder with pins.[61] The main section of this account discusses the possibility of composing directly on the cylinder. In 1774, Johann Friedrich Unger presented a "design for a machine that notates every-

58 See Birgit Schneider, *Textiles Prozessieren: Eine Mediengeschichte der Lochkartenweberei* (Zurich: Diaphanes, 2007), 138–150.

59 Salomon de Caus, *Von gewaltsamen Bewegungen: Beschreibung etlicher, so wol nützlichen alß lustigen Machiner* (Frankfurt, 1615; Halle an der Saale: Stekovics, 2003).

60 By contrast, punched ribbons were not used for mechanical musical instruments until the nineteenth century. In 1842 a mechanic from Lyons, Claude Félix Seytre, invented something central to mechanical performances of music—a pneumatic control using a punched ribbon—having been inspired by Jacquard looms. The Scotsman Alexander Bain—famous today above all for inventing a forerunner of the fax machine—improved on this control system in 1848.

61 See "Projet d'un nouvel orgue sur lequel on pourra exécuter toute piéce de Musique à deux, trois, quatre, cinq parties & davantage, instrument également à l'usage de ceux qui sçavent assés de Musique pour composer, & ceux qui sçavent point du tout," *Mercure de France*, October 1747, 92–109. In 1725, *Mercure de France* had published Louis-Bertrand Castel's idea for a color organ.

thing played on its keyboard."[62] Using a rotating cylinder and a lever gear, the pressing of the keys is automatically put to paper as a record of the performance. The source of this fascination was the possibility of having in one's hands a graphic pendant to the music which, unlike musical notation, not only made music itself but also recorded it.

In order to compare the use of cylinders with pins or holes in music and weaving, I refer here to an engraving of a mechanical, hydraulic organ that illustrated Athanasius Kircher's book *Musurgia Universalis* of 1650. I chose this engraving because it paradigmatically illustrates the principle of the cylinder. Kircher was not the organ's inventor, but he had analyzed it while it was being repaired and later described it.[63] The engraving shows a cylinder powered by a waterwheel; its pins strike the keys of an organ, while small figures—smiths and a boy conducting—are set in motion. Kircher proposed that melodies could be composed by drawing lines on a sheet of paper the size of the cylinder before inserting the pins and then drawing the notes on this "quadratum phonotacticum." The vertical columns notated the string or pipe notes; the horizontal ones, the subdivision into bars. With the cylinder placed prominently in the foreground, it becomes evident where the order on the cylinder originates. The checkered structure of the cylinder corresponds to the combination of levers, keyboard, and cylinder. The lines running around the cylinder represent the keyboard of the organ. Every column corresponds to a key and hence to a pitch or movement. The cylinder functions as a two-dimensional graphic order within which pitches and durations appear as places in the sequence in which they are controlled. The cylinders are graphic storage systems; when pins are added, they become "mechanical sheet music."[64]

Unlike the pin structure used to move the androids, Vaucanson's cylinder-driven loom has holes to control the movements of the loom. Different hole patterns were punched into sturdy paper for each weaving pattern and then wrapped around a cylinder with holes. As the hole patterns were automatically turned in sequence and a carriage was used to press a needle system to read the pattern, the corresponding threads rose and fell to produce the pattern. Vaucanson's cylinder with holes reversed the principle for communicating information. Whereas on a cylinder with pins, one inserted pin triggered one note, a punched hole in Vaucanson's pattern cylinder meant that the corresponding needle was passive. The pattern was thus made not by the holes but by the unpunched areas of the cardboard. Whereas the melody is reflected in the order of the pins on the cylinder, in the case of the fabric pattern it is the undamaged places in the paper that represent the pattern. It is possible to store weaving patterns on cylinders punched according to an either-or principle because of the way they are composed of intersections of thread: one

62 Johann Friedrich Unger, *Entwurf einer Maschine, wodurch alles auf dem Clavier gespielt wird, sich von selber in Noten setzt* (Brunswick: Waisenhaus, 1774). On this, see Sebastian Klotz, "Tonfolgen und die Syntax der Berauschung," in *Das Laokoon-Paradigma: Zeichenregime im 18. Jahrhundert*, eds. Inge Baxmann, Michael Franz, and Wolfgang Schäffner (Berlin: Akademie, 2000), 306–338.

63 The organ was originally built for manual performance by Luca Blasi, an organ builder from Perugia, between 1596 and 1598 and was described by Heinrich Schickhardt in his diary in 1599. In 1647 and 1648, Kircher and the Roman organ builder Matteo Marione replaced the damaged water organ with a new, mechanical instrument. See Angela Mayer-Deutsch, "Frühneuzeitliche Bilder von Musikautomaten: Zu Athanasius Kirchers Trompe-l'oreille-Kontemplationen in den Quirinalsgärten von Rom," in *Das technische Bild: Kompendium für eine Stilgeschichte wissenschaftlicher Bilder*, eds. Horst Bredekamp, Birgit Schneider, and Vera Dünkel (Berlin: Akademie, 2008), 198–207. Mayer-Deutsch describes in detail how the organ and the composition with cylinders worked, and also illuminates the context in which Kircher located the organ as a "symbol of the principle of creation" and a "cosmic world machine."

64 See Mayer-Deutsch, "Frühneuzeitliche Bilder," 205.

thread runs either above or below another. Thus the patterns of holes on the cylinder depict the arrangement of the pattern as an arrangement of threads to one another. For patterns with a repeat longer than permitted by the circumference of the cylinder, Vaucanson proposed that the punched ribbons of paper be quickly changed. It was not until the nineteenth century that the principle of controlling by means of perforations was used for mechanical instruments as well, when piano music was punched on rolls of paper.

Although the fundamental techniques and structures of the storage systems have great similarities, the differences of scores for sound and for images is already clearly evident from the arrangement of the pins and holes on the paper. Unlike those for a mechanical organ, the holes for pattern cylinders are always identical in form, whereas the pins on cylinders for music vary in length in order to produce pitches of different durations. There is also a structural difference in how the cylinders are read mechanically: whereas the pins on the musical cylinder are read continuously and progressively, in the case of a loom several rows of holes on the cylinder represent a single row of the pattern. The patterns of raised and indented areas thus represent two very different orders, which signify that each respective structure results in a different process. The order of the pattern is simultaneous, whereas the sounds of a piece of music are ordered in time.

Furthermore, the harmony of music and the symmetry of a pattern are two systems that are not directly reflected in the respective notation. Whereas individual elements of the music such as the beat, the pitch, chords, and melodic sequences are illustrated in the pattern of pins—so that the columns on the cylinder, when rotated 90 degrees, could be interpreted as staff lines—the arrangement of the holes scarcely allows one to draw any conclusions about the form of the pattern notated by it. The hole pattern does not represent the order of the pattern, which is revealed only in its woven state; a dot or a single woven row in the pattern is an arbitrary postulation due solely to the logic of the weaving technology. But even without this technical circumstance, the aesthetic principles of patterns and music can be harmonized. Because the structures of pins and holes work in different ways, cylinders that produce acoustic harmonies do not produce beautiful patterns in the classical sense; conversely, sounds that produce beautiful patterns in fabric will not be harmonious on a musical level.[65] It was only in the twentieth century that art creations resulting from such a combination promised the possibility of aesthetic enjoyment.

Summary

When László Moholy-Nagy formulated the idea of an “écriture acoustique” in his article “Produktion, Reproduktion” in 1922,[66] he was also inspired by the principle of storage media recording themselves by means of technology. The indexical relationship between sound and soundtrack is evident from the fact that sound is stamped into a record in the form of grooves. Like the sound figures of Ernst Chladni (1756–1827) on disks strewn with sand, every acoustic event produces a form characteristic of it.

Moholy-Nagy explored this form as the relationship between the acoustic and the graphic, with the term graphic understood in its older meaning of “engrav-

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65 On the translatability of aesthetics, see also Jörg Jewanski, *Ist C=Rot? Eine Kultur- und Wissenschaftsgeschichte zum Problem der wechselseitigen Beziehungen zwischen Ton und Farbe: Von Aristoteles bis Goethe* (Sinzig: Studio, 1999).

66 László Moholy-Nagy, “Produktion, Reproduktion,” *De Stijl* 5, no. 7 (1922), 97–101.

ing." Starting out from the relationship of sound and groove as one of imprinting, Moholy-Nagy asked whether or not a detailed analysis of the relationship between sound and groove might not make it possible to find a general formal logic in the form of an alphabet of sounds. Consequently, the gramophone would make all instruments unnecessary,[67] as, theoretically, at least, their sound effects could simply be simulated by soundtracks. Moholy-Nagy thus imagined a medium that writes the sound directly without having produced it previously; the relationship of representation and production would therefore be reversed. This method represented a completely new way to create sounds: the instrument was replaced by the synthetic production of its sound.[68]

In the early 1930s, Rudolf Pfenninger (1869–1936) and Oskar Fischinger (1900–1967) took advantage of the fact that sounds leave a visible trace when they are recorded. They used this circumstance to create an alphabet of sounds of the sort envisioned by Moholy-Nagy. The alphabet was not able to simulate every known instrument, but it could produce sounds never heard previously. Instead of the grooves on records, they used the technology of the optical soundtrack of sound films, introduced in the early 1920s. It entailed photographically recording the sound on a part of the filmstrip just a few millimeters wide. The sound appeared on the filmstrip as a "variable area" soundtrack, which ran along the black background of the film as an amplitude.[69]

Pfenninger and Fischinger recognized that the photoelectric production of sound represented an opportunity to reverse the principle of recording sound and produce sounds synthetically by painting the soundtrack directly onto the film. In 1931, under the title "Tönende Handschrift: Das Wunder des gezeichneten Tons" (Sounding Handwriting: The Miracle of Drawn Sound), Pfenninger created long bands of various sine waves, which produced previously unheard sounds and compositions.[70] Whereas Pfenninger stuck strictly to the amplitude as a representation of sound, Fischinger viewed the soundtrack as ornamental. In 1932 he painted not only sine waves and saw teeth but also forms that look as though he had taken them from edging patterns in a handbook on ornaments; logically, he called his process "Tönende Ornamente" (sounding ornaments). What interested him was not so much which formal elements resulted in a specific sound effect but rather what beautiful patterns sound like, even though they are no longer seen when scanned from the film soundtrack.

Winckel used waves to combine sounds and images. It was the music itself that represented the interface with the image, or rather the image that produced the sound effects. Sonification and visualization would be the words for this approach today. Hausmann, in turn, used a keyboard as an interface and control module to simultaneously generate sound and image effects, which also were transformed into each other on the basis of waves. His instrument was supposed to permit an entirely new way to create art in two genres at the same time. Finally, hole patterns, filmstrips, and digital codes also can be used as interfaces to play back music as images and images as music. This approach is possible because sounds and images are recorded using the same waves and codes.

67 László Moholy-Nagy, "Neue Gestaltung in der Musik: Möglichkeiten des Grammophons," *Der Sturm*, no. 14 (July 1923), reprinted in *Broken Music: Artists' Recordworks*, eds. Ursula Block and Michael Glasmeier (Berlin: Berliner Künstlerprogramm des DAAD; Gelbe Musik, 1989), 57.

68 This argument is made in Thomas Y. Levin, "Tones from out of Nowhere: Rudolph Pfenninger and the Archaeology of Synthetic Sound," *Grey Room*, no. 12 (fall 2003), 32–79, esp. 45.

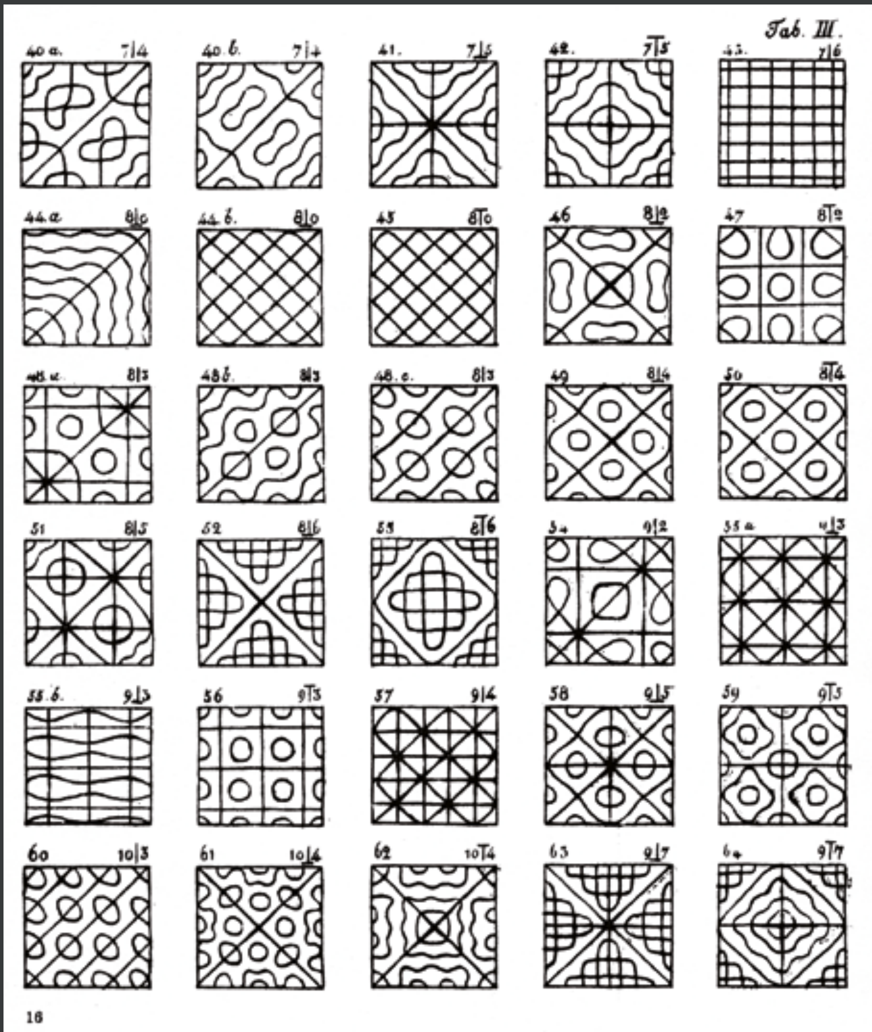
69 An alternative method was to record the sound in "variable density" in vertical strips along the film.

70 On Pfenninger, see Levin, "Tones from out of Nowhere." Other artists who used optical soundtracks as a way to paint sounds included Zdeněk Pešánek and Norman McLaren; see Weibel and Jansen, *Lichtkunst aus Kunstlicht*, 170ff.

Media technology and its formats provided a means to couple sounds and images not just loosely but also directly. They did so on the basis of a fundamental property of technical media: namely, translation and transformation. Even a simple apparatus for visual telegraphy does not process the images as impressions of light but rather in the form of a sequence of electric waves. According to Friedrich Kittler, the image of translation is not suitable for media in general: “A medium is a medium is a medium. Therefore it cannot be translated. To transfer messages from one medium to another always involves reshaping them to conform to new standards and materials. In a discourse network [. . .] transposition necessarily takes the place of translation. Whereas translation excludes all particularities in favor of the general equivalent, the transposition of media is accomplished serially, at discrete points.”[71] This makes every transposition “arbitrary, a manipulation.” By that logic, what results from coupling images and sounds are not the effects of a unity of the senses as perceived by synesthetes. Rather, sound-and-image experiments produced a new and strict technological aesthetic for which there was no comparison at first. Its visual repertoire included stripes, interference patterns, sine waves, saw teeth, and ladders in strong contrasts; the sounds included crackling and bubbling noises as well as sirens. A heterogeneous mix of avant-garde artists, technicians, and engineers prepared the way for the creation of electronic, technological refuse to be recognized as having its own value and to be evaluated as an art form.

71 Kittler, *Discourse Networks*, 265.

Ernst Chladni
Sound Figures (1787)



– Sound patterns (1787) by Ernst Chladni. Source: Ernst Florens Friedrich Chladni, *Entdeckungen über die Theorie des Klanges* (Leipzig 1787), plate IV.

Ernst Chladni (1756–1827) initially studied law in Wittenberg and Leipzig before turning away from jurisprudence and devoting his energies to the study of sound. Because of his great interest in music—he was himself a pianist—he began to occupy himself with acoustics and music theory. His resulting monograph, *Entdeckungen über die Theorie des Klanges* (Discoveries in the Theory of Sound), published in 1787, is considered in the history of science to be the first comprehensive treatise on scientific acoustics.[1] In addition to his interest in the theory of music, Chladni also constructed innovative musical instruments such as the euphonium, which consisted of a row of metal rods sounding different pitches when struck by glass rods. Chladni furthered his knowledge on the one hand by means of practical experiments which he carried out in his home in Wittenberg from 1792 onward; on the other hand, studies by mathematicians Leonhard Euler, Daniel Bernoulli, and Jacopo Riccati inspired his research.

Among the most well known of Chladni's discoveries today are his so-called sound figures. He created these figures by stroking a violin bow along the edge of a glass or metal plate that had been sprinkled with fine sand. The resulting vibration in the plate caused the sand to move. The grains of sand were pushed away from the vibrating parts of the plate and remained in place on the non-vibrating areas, resulting in frequency-related patterns that changed depending on where and how the violin bow was applied. The purpose of this procedure was the determination of vibration frequencies.

Chladni interpreted the patterns as "knot lines" and "knot circles." Each sound created its own characteristic pattern. Chladni was surprised by how many different patterns could be created in this way and how aesthetically appealing they were. "Each of these sound figures is subject to multifarious modifications that could supply carpet- and calico-makers with a wealth of material for enriching their pattern samples."[2] He carried out his experiments on sound figures for twenty years, using differently shaped plates. A treatise published in 1817 presents particularly complex sound figures.[3] Chladni's experiments have always been an important point of reference for the history of color music and synesthesia; his sound figures must be considered the first systematic attempt to visualize sounds as images.[4]

1 Ernst Florens Friedrich Chladni, *Entdeckungen über die Theorie des Klanges* (1787; photomechanical repr., Kassel: Bärenreiter Verlag, 1980).

2 Ibid., 53.

3 Chladni, *Neue Beyträge zur Akustik* (1817; Kassel: Bärenreiter Verlag, 1980).

4 For further reading, see Dieter Ullmann, *Chladni und die Entwicklung der Akustik von 1750–1860* (Berlin: Birkhauser Verlag, 1996); Ernst Florens Friedrich Chladni, *Die Akustik* (1802; Hildesheim: Georg Olms, 2004).

Maximilian Plessner
Die Zukunft des elektrischen Fernsehens (The Future of Electric Television, 1892)

The text *Die Zukunft des elektrischen Fernsehens* (The Future of Electric Television) appeared in 1892 as the first part of a two-volume publication entitled *Ein Blick auf die grossen Erfindungen des zwanzigsten Jahrhunderts* (A Look Forward to the Great Inventions of the Twentieth Century).[1] This work is significant for the topic of synesthesia in media technology given that much of it is dedicated to interconnections between hearing and seeing—and this in an era when such linkages were at best the stuff of science fiction. In terms of the history of television, the publication is best compared with works such as those by Adriano de Paiva (1880)[2] and Constantin Senlecq (1881)[3], which also outlined the future of television on the basis of contemporary basic research in the area. Raoul Hausmann considered the text a significant inspiration for the design of his Optophone in around 1920.[4]

Little is known today about the text's author, Maximilian Plessner. He lived in Berlin, and his main profession was as captain in the Royal Prussian Army. In addition, he devoted himself at both the theoretical and the practical levels to all sorts of technical inventions, firmly convinced that technical progress would improve and enrich people's lives. For example, he published his ideas on a "device for rendering sounds inaudible," which he called an Antiphone.[5]

In his text on the future of electric television, Plessner conceived of numerous areas of application for phenomena involving electrical transformation, ranging from the artistic to the aesthetic-analytical to the practical domains. Thus, for example, much of this text was devoted to possibilities for using a selenium cell to transform sounds into images or to listen to images as sounds—phenomena that today are described by such terms as sonification and visualization.

Plessner first presents one possibility for sound visualization whereby a light source is controlled within a dark chamber by a resonating harp string. To this end, he proposes transforming sounds into optical phenomena by using an adaptation of Alexander Graham Bell's Photophone. An instrument of this kind should be called an "Optophone," he writes.[6] Plessner attaches great hope to the Optophone for scientific knowledge: "Which surprises will await natural scientists when all visible things in the physical world become audible through illumination and, by inverting the process of energy transformation, all audible

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1 Maximilian Plessner, *Die Zukunft des elektrischen Fernsehens*, vol. 1 of *Ein Blick auf die grossen Erfindungen des 20. Jahrhunderts* (Berlin: Ferdinand Dimmler, 1892). Vol. 2: *Die Dienstbarmachung der Windkraft für den elektrischen Motorenbetrieb* (Berlin: Ferdinand Dimmler, 1893).

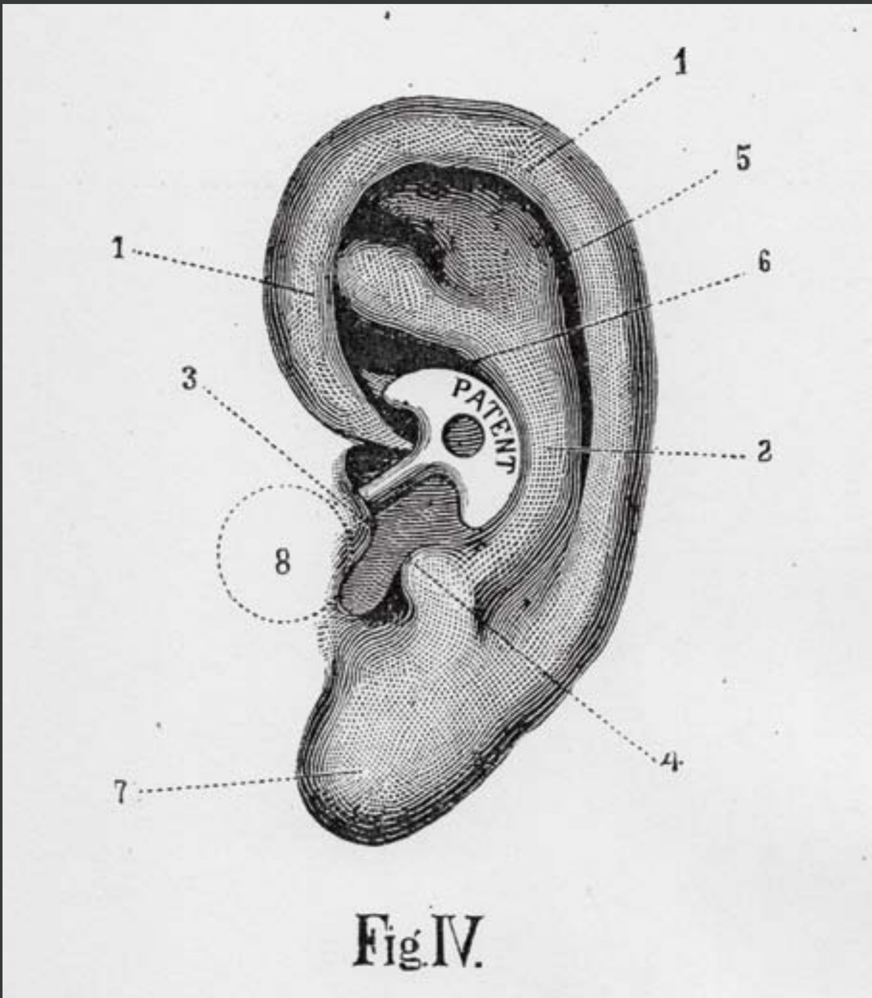
2 Adriano de Paiva, *La téléscopie électrique basée sur l'emploi du sélénium* (Porto: José da Silva, 1880), online: http://histv2.free.fr/de_paiva/telescopie0.htm.

3 Constantin Senlecq, *Le télectroscope* (Saint-Omer: D'Homont, 1881).

4 Raoul Hausmann, "Vom sprechenden Film zur Optophonetik" (1923), in *Sieg, Triumph, Tabak mit Bohnen*, vol. 2 of *Texte bis 1933*, ed. Michael Erlhoff (Munich: Text + Kritik), 72–75, here 74 n. 27.

5 Maximilian Plessner, *Die neueste Erfindung: Das Antiphon; Ein Apparat zum Unhörbarmachen von Tönen und Geräuschen* (Rathenow: Verlag von Schulze und Bartels, 1885).

6 Plessner, *Die Zukunft des elektrischen Fernsehens*, 49.



– *Ein Apparat zum Unhörbarmachen von Tönen und Geräuschen* (1885) by Maximilian Plessner. Source: Maximilian Plessner: *Das Antiphon. Ein Apparat zum Unhörbarmachen von Tönen und Geräuschen* (2nd edition, Rathenow, Verlag von Schulze und Bartels, 1885).

phenomena can also be rendered visible?"[7] He then rapidly moves on to the sonification of complex images. Thus, he asks what the acoustic impression of geometric shapes such as circles, squares, and cones might be, and what they would sound like if they were also set in motion.[8] But Plessner also believes that it must be possible to transform atmospheric and trans-terrestrial phenomena into audio images. This method might be used to elicit sound from meteorological events such as lightning, clouds, and rainbows, as well as from the rings of the moon and the sun: the Optophone could reveal the "characteristic natural sound picture" of the moon, while "Saturn will sound its ring-a-ring-a-roses."[9] Plessner thus adheres to the traditional notion of a music of the spheres in assuming that electrical oscillations "are only different manifestations . . . of one and the same energy filling the cosmos."[10]

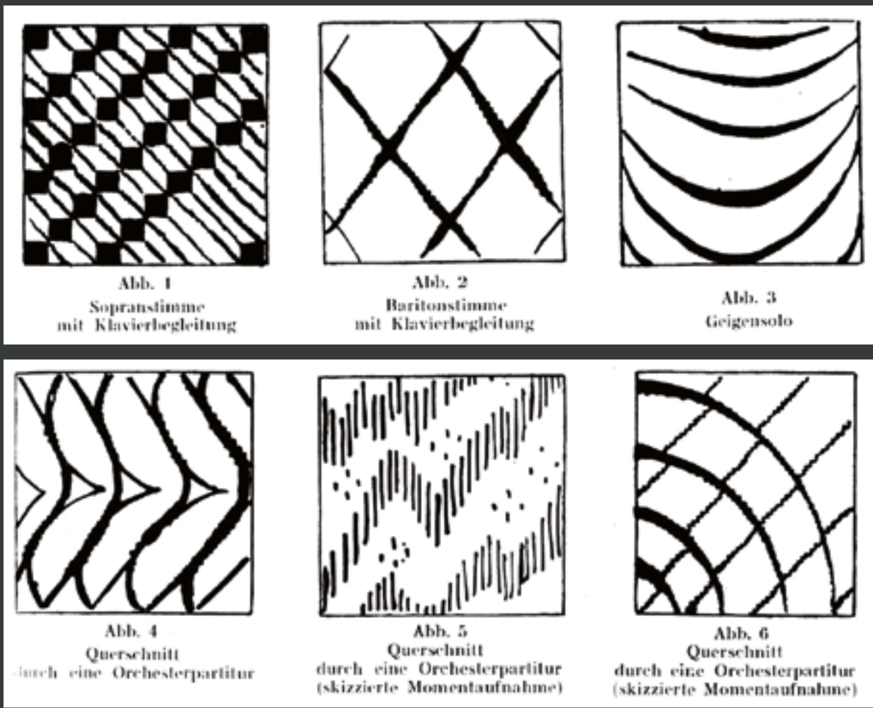
Plessner hopes that ultimately, through the phenomena of transformation, a "unity of beauty" will reign between sound art and spatial and visual art,[11] one which can be scientifically studied and proven using the methods of optophonetics. His brief deliberations on an "acoustic beauty contest"[12] must thus be considered a conception of an experimental sound and image analysis, similar to that imagined by Fritz Winckel in his TV experiments on sound/image transformation. An aesthetic analysis by means of optophony would demonstrate that hearing the sound of a statue of Apollo would be just as beautiful as viewing the stone work. Plessner wanted to compare the acoustic properties of the facades of Ancient Greek buildings with those of facades from later eras. He longed to use the same method to acoustically compare the "sound paintings" (*Tongemälde*) of visual artworks by artists such as Titian with the naturalistic "ugliness" of his own age.[13] He also believed that the innovative audio images could serve composers as inspiration for new works.

Another area of application for optophony proposed by Plessner evokes the idea of rendering people's auras audible. Thus, he believes it must be possible to make each human physiognomy sound as a characteristic melody or "to render it visible . . . as a musical score!"[14] In this way it would be possible to replace a person's family name with his or her audio image.

In all of the transformational phenomena described here, Plessner proceeds on the assumption that the result of such a transformation will always be of a musical nature; the idea that such media technology interlinkages might also produce crackling sound interference as their outcome did not occur to him.

7 Ibid.
8 Ibid., 50.
9 Ibid.
10 Ibid., 51.
11 Ibid.
12 Ibid., 52.
13 Ibid.
14 Ibid., 52–53.

Fritz Wilhelm Winckel
Sound/Image Transformations by Means of Television (1930)



– Generation of sound patterns of classical music on the screen of a Nipkow television system (1930) by Fritz Wilhelm Winckel. Source: Fritz Wilhelm Winckel, "Vergleichende Analyse der Ton-Bildmodulation," in: *Fernsehen* 4 (Berlin, 1930), 171-175, here 173.

Fritz Winckel (1907–2000), today considered a pioneer of electronic music, was a student of telecommunications and acoustics in Berlin when he began experimenting with television technology in Dénes von Mihály's private laboratory. In 1930 he wrote one of the first German-language publications on the subject of television, in which he outlined the "technology and tasks of television" for the general public. Here he also described his efforts made the same year in Mihály's laboratory to transform music into images. In these experiments he used a mechanical television and a Nipkow disk to break down images line by line into 1,200 light impulses. He then attached a radio to the television. Given that these two media process electrical oscillations within a similar spectrum, Winckel believed that it must be possible to represent acoustic impulses in optical form. He then observed the optical effects created by different sound materials on the television screen. Because he judged the outcome to be an "artistic pleasure,"[1] he also viewed his studies in terms of potential uses for television in art, in particular envisioning a technically based evalu-

1 Fritz Wilhelm Winckel, *Technik und Aufgaben des Fernsehens* (Berlin: Rothgiesser & Diesing, 1930), 59.

ation of art, in addition to the aesthetic pleasure derived from his experiments. The fanfares of a symphony manifested themselves "as semi-oval cast shadows in syncopated rhythm," while timpani beats showed up as "jagged contours" and a pianissimo generated indistinct, cloudy figures.[2] Winckel described the synchronous visualization of music in time as an analogous relationship of dependencies: "The figures resulting from the music are uniformly and harmoniously constructed because they are simply mathematical curves represented in two dimensions. The fuller the timbre of an instrument, the more overtones are contained in the sound, and the more complex, therefore, is the corresponding pattern."[3]

Winckel also discovered dynamic sound visualization as a method for sound analysis and outlined the resulting possible uses of such analysis. Soon after this work, he registered patents under the terms "procedure for the automatic analysis of waves"[4] and "sound analysis"[5] for the "production of optical sound-image representations."[6]

Sound/Image transformation always remained an important aspect of Winckel's later research. In addition to his numerous studies on voice and language research, room acoustics, and musicology while serving as professor for acoustics at the Technische Universität Berlin, his interest in experimental music led him to cofound the Arbeitskreis für Elektronische Musik (Working Group for Electronic Music). Within this context, he used the university's experimental studio from the 1950s onward to advance not only experiments on electronic music, but also new procedures for controlling image patterns. Live improvised sound/image performances were staged in the university's experimental concert hall, which was equipped with a large-screen television projector and electro-acoustical facilities for a public of one thousand. One highlight was the Experimental Music Week held in 1968. Here, via the mixing console, images were controlled by varying color filters, by the electronic beam control of the projector, and by the floating and wavelike changes of the image as a result of the striation on an oil film. The spherical pavilion for the World's Fair in Osaka (1970) was also developed in the university's studio in collaboration with Karlheinz Stockhausen and in accordance with Winckel's methods.[7]

2 Ibid.

3 Ibid., 60.

4 Fritz Winckel, *Verfahren der automatischen Schwingungsanalyse*, Berlin patent no. 573752 (April 5, 1933).

5 Fritz Winckel, *Verfahren der automatischen Schwingungsanalyse*, Berlin patent no. 579338 (June 27, 1933).

6 Fritz Winckel, *Verfahren zur Lichtstrahlabtastung bei Schallplatte, Phonographenwalze u. dgl. zur Erzeugung von optischen Bild- und Ton-Darstellungen*, Berlin patent no. 576538 (May 5, 1933) and Fritz Winckel, *Verfahren zur synthetischen Erzeugung von Toenen, die einer musikalischen Tonskala angehoeren, und zur optischen Darstellung derselben*, Berlin patent no. 634348 (August 25, 1936).

7 For further reading, see Carl Dahlhaus, ed., *Tiefenstruktur der Musik: Festschrift Fritz Winckel zum 75. Geburtstag am 20. Juni 1982* (Berlin: Fachbereich 1, Fachgebiet Kommunikationswissenschaft der Technischen Universität Berlin, 1982); Fritz Wilhelm Winckel, "Vergleichende Analyse der Ton- und Bildmodulation," *Fernsehen* 4 (1930), 171–175; Fritz Wilhelm Winckel, "Musikalische Forderungen für tonmodulierte Bildabtastung," *Fernsehen* 3 (1932), 170–173; Fritz Wilhelm Winckel, "Ton-Form-Wandlung durch Rasterabtastung," *Film und Bild* 6 (1941).

Raoul Hausmann
Optophone (1922)

Raoul Hausmann was active in many different fields. As a visual artist, he dedicated himself to painting, photography, collage, and dadaist actions; as an author, he wrote poetry, novels, and scientific treatises. He also constructed technical inventions whose purpose oscillated between the practical and dadaism. One of these inventions was the Optophone.

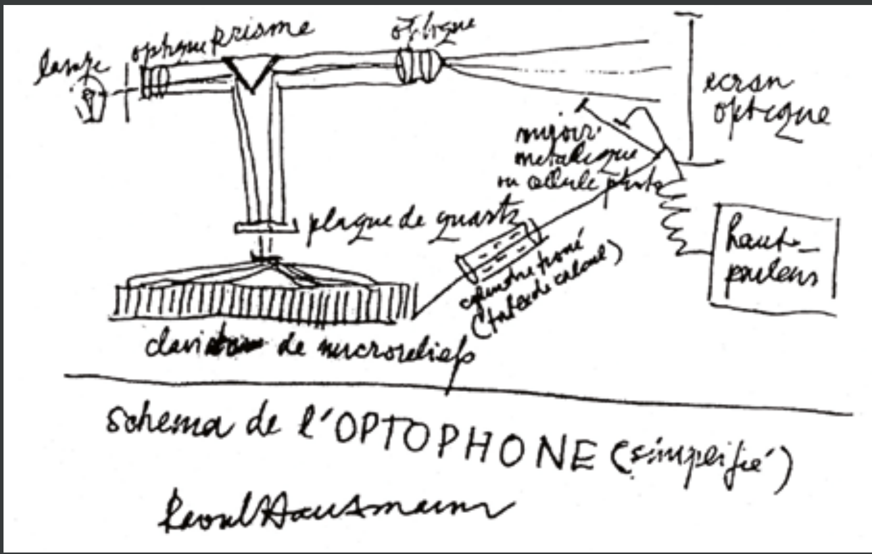
The first optophones presented by the "dadasoph" Hausmann, around the year 1919, were phonetic poems consisting of a series of alphabetic letters that together made no literal sense. Hausmann recited this poetry at dadaist events. Shortly afterward, he developed the concept of a type of Optophone based on media technology that he imagined could be used to play "optical-phonetic compositions."[1] This concept now no longer involved the onomatopoeia of letters, but rather consisted of a color-light organ that could be controlled technically by sound.

Unlike most of the other color organs of the same era, there are no photographs or reports of this device in operation. It must thus be judged possible that Hausmann never actually built his Optophone. This possibility does not render the device any less interesting as an artistic vision, however. Hausmann himself first described the Optophone in 1922 in an article published in the journal *Вещь—Objet—Gegenstand* (publishers El Lissitzky and Ilja Ehrenburg), and again in 1931 in his article "Die überzüchteten Künste" (The Overly Refined Arts).[2] The only existing drawing of the device hails from after 1930.

According to Hausmann's descriptions, the Optophone consisted of a keyboard with around one hundred keys. These keys controlled a cylinder divided into one hundred corresponding fields. The fields of the cylinder were printed with various series of lines. Hausmann used a collotype process with chromogelatin for this purpose, because of the latter's properties as a conductor. He placed a pane of quartz and a glass prism in front of the cylinder; opposite the cylinder he positioned a neon lamp and next to this a selenium cell (a type of photoelectric cell). The cell was pointed at the lamp and in turn controlled an amplifier and a loudspeaker.

1 Raoul Hausmann, "Die überzüchteten Künste: Die neuen Elemente der Malerei und Musik," in *Sieg, Triumph, Tabak mit Bohnen*, vol. 2 of *Texte bis 1933*, ed. Michael Erlhoff (Munich: Text + Kritik, 1982), 133–144, here 144.

2 Ibid., 133–144.



– Sketch of the 1919 version of the Optophone by Raoul Hausmann, made in the 1930s. Source: *Leonardo* 34, no 3 (2001), 218.

By striking the keys, the person playing the Optophone would be able to send different series of “groups of spectral colors and bands of lines” to the optical system, which then would project “color-form performances,” while at the same time the photoelectric cell would transform the brightness and darkness values into electrical impulses and transmit them to the loudspeaker, where they would produce an “acoustic effect.”[3] The optical output of the device was supposed to be abstract rainbow patterns that were refracted in a crystalline manner by the quartz pane and the glass prism and that projected moving, kaleidoscopelike forms into the room. Acoustically, the instrument may have crackled or produced technical sounds of various pitches.[4]

3 Ibid., 144.

4 The artist Peter Keene built an Optophone based on Hausmann’s concept (1999–2004). His reconstruction is also based on the aesthetic effect of spectral colors and sound interference. For further reading, see Raoul Hausmann, “Optophonetik” (May 1922), in *Sieg, Triumph, Tabak mit Bohnen*, vol. 2 of *Texte bis 1933*, ed. Michael Erlhoff (Munich: Text + Kritik, 1982), 50–57; Raoul Hausmann, “Vom sprechenden Film zur Optophonetik” (1923), in *Sieg, Triumph, Tabak mit Bohnen*, vol. 2 of *Texte bis 1933*, ed. Michael Erlhoff (Munich: Text + Kritik, 1982), 72–74; Michael Erlhoff, *Raoul Hausmann. Dadasoph: Versuch einer Politisierung der Ästhetik* (Hanover: Zweitschrift, 1982); Cornelius Borck, “Blindness, Seeing: An Envisioning Prosthesis; The Optophone between Science, Technology, and Art,” in *Artists as Inventors, Inventors as Artists*, ed. Dieter Daniels and Barbara U. Schmidt (Ostfildern: Hatje Cantz, 2008), 108–129; Jacques Donguy, “Machine Head: Raoul Hausmann and the Optophone,” *Leonardo* 34, no. 3 (2001), 217–220.