# Between air and electricity : microphones and loudspeakers as musical instruments

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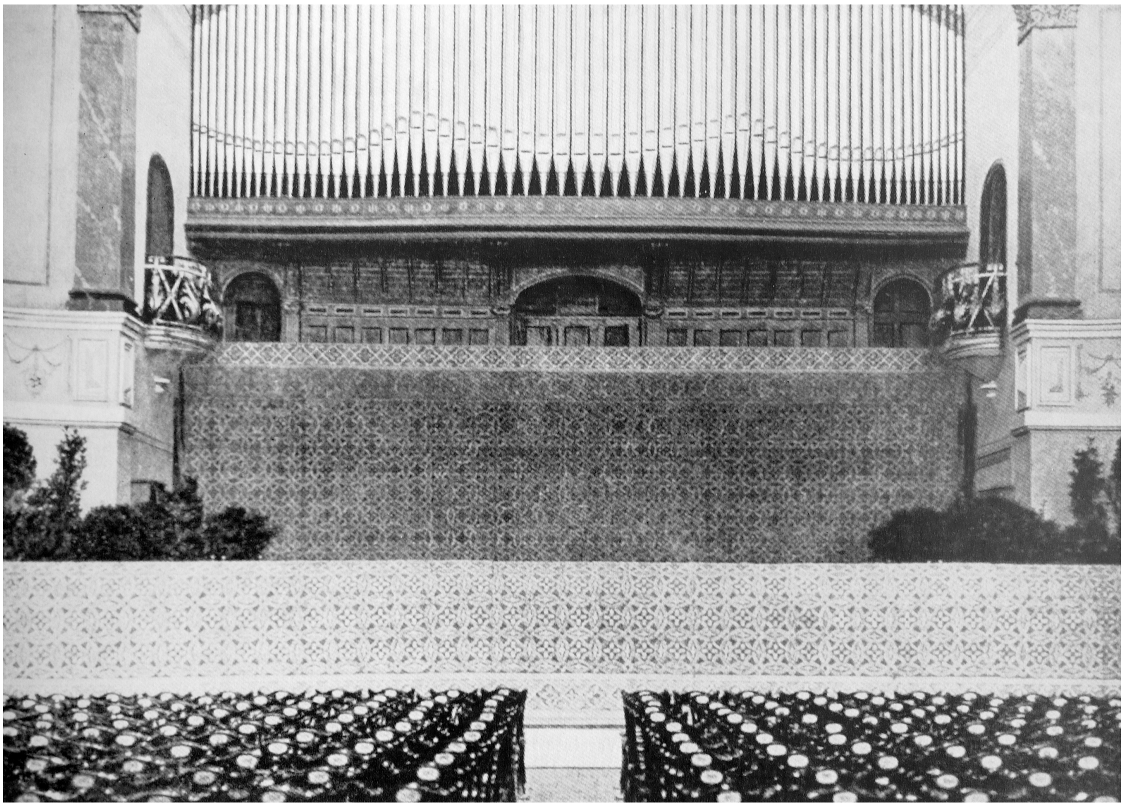
# 1 Beyond the curtain: virtual sound sources and the "true nature" of microphones and loudspeakers



Hidden choir and orchestra in the concert hall "Stadthalle" in 1903 in Heidelberg, Germany

## Konzertreform

*The audience sits quietly in the concert hall. The lights are dimmed. The music starts, but the performers are not visible. The musical performance reaches the audience only through sound, devoid of visual cues. Due to the invisibility of this musical performance—forcing the audience to focus on sound rather than sight—the poignancy of the performance becomes augmented (Wolfrum 1915, 5, 10). The picture at the beginning of this chapter was taken in a concert hall in Heidelberg (Germany) in 1903 and depicts the set-up in the concert hall as used for this kind of invisible musical performance. The orchestra and choir are hidden behind panels and curtains, with the aim of eliminating anything that might distract the eye and the ear of the audience (von Seydlitz 1903, 97). All distracting movements of the performers, for example the "prima donna coquetry by certain conductors" (Wolfrum 1915, 5), take place behind a curtain, and only that part of the audience which needed to "learn" from the performance, such as music students, was permitted to sit on the other side of this curtain, able to view the conductor and musicians.*

These conceptualisations of a concert practice which would focus as much as possible on only the audible elements of music were formulated and put into practice by several musicians at the beginning of the twentieth century, mainly in Germany, in the context of what contemporary theoreticians termed *Konzertreform*. Whereas the core idea of this movement—presenting music with the performers hidden behind curtains—did not persist, many of the postulations of this *Konzertreform* formed part of a drastically changing concert practice, from the end of the nineteenth through the beginning of the twentieth century. By the end of the nineteenth century, the audience was expected to be as silent as possible during the musical performance and not to talk out loud anymore, hum with the music or beat the rhythm with hands, head or feet (Johnson 1996, 232–233). Additionally, applause during symphonies was abandoned and only allowed to happen at the end of a piece of music, instead of after each movement or even during the music itself (Ross 2010). Apparently, all of this audience behaviour was previously considered normal, or at least possible, during concerts, otherwise the formulation of such rules would have been unnecessary. Many other common features of classical music concerts nowadays, were introduced in relation to the *Konzertreform*. For example, a large foyer between the entrance and the concert hall, creating a division between the social activities of the audience and the activity of listening, was deemed necessary (Marsop 1903, 433). In this way, the social interaction which used to take place within the concert hall during the performance could now take place outside. A sound signalling the start of the performance was initiated, giving the audience the chance to become completely silent (von Seydlitz 1903, 100). Concerts should take place in darkened concert halls, so that audience members would not be visually distracted. The aim of all these sanctions was to "give the sense of hearing full priority for the audience member, through putting to rest the eye, his biggest enemy"[3] (Holzamer-Heppenheim 1902, 1293).

Most of the aforementioned claims have become enduring conventions for classical music concerts. The extreme practice of hiding the musicians behind curtains during the concert as described at the beginning of this chapter should be regarded as a by-product of a larger aim or program to achieve more focus on the purely sonic aspect of the music. Many of the proclaimers of the *Konzertreform* were inspired by the sonic phenomenon of the famous invisible orchestra in Richard Wagner's theatre in Bayreuth (Marsop 1903, 428–429). The curtains hiding the musicians had not only a visual aspect, but served an acoustical purpose as well. Making use of the good acoustic conditions in the Bayreuth theatre (nowadays called Richard Wagner Festspielhaus) as well as the indirect sound of the orchestra, due to the orchestra pit being recessed, the sound was perceived as "cleaned" by this so-called "sound-wall" (von Seydlitz 1903, 99). Sound waves could not reach the audience directly because of the curtain, which transformed the sound of the orchestra into something mellower. As a result, the hidden musical

[3] My translation of "dem Gehör den Vollbesitz über mich zu verschaffen, dadurch, dass ich seinen grössten Gegner, das Auge, ruhen lasse" (Holzamer-Heppenheim 1902, 1293).

instruments could be located easily neither by the ears nor by the eyes of the audience. The aim was to avoid focusing in a specific direction, and thus to achieve a listening situation in which the audience would be completely overwhelmed by sound alone, absent of any material source recognisable as the cause of this sound. Considering that up to that time church organists were one of the few instrumentalists hidden from the audience, placed in the back of the church on a balcony, it might come as no surprise that this concert practice—as it was developed during the end of the nineteenth and the beginning of the twentieth century—has been called a religious ritual, eliciting remarks that the listening attitude might be compared with silent praying (Tröndle 2009, 47). The only important feature of a music performance was the contact between the listener and the sound of the music; all other elements were considered to be a distraction. The possibility of music performances existing in the form of sound alone arose, and for many audience members, such as the advocates of the *Konzertreform*, this situation was preferable to that of a conventional concert.

## Invention of sound reproduction technology: invisible music with the help of microphones and loudspeakers

Whereas the ideas of the *Konzertreform* did not endure in actual practice, listening to music without any distraction of, for example, musicians' movements or audience members' noises became possible in another way. In listening to music on a record or on radio, listening conditions similar to the ones set into practice by the *Konzertreform* became mainstream. In fact, the ideas developed around the phenomenon of the classical music concert, resulting in the sound of a musical performance being the most or even the only important element of music, were essential to the development of a music performance culture mediated through radios, gramophones and CD players. These devices are all commonly called sound reproduction technologies due to their primary function. This technology was developed in a cultural context calling for the emancipation of sound, which was understood as sound being recognised as the only element necessary for a complete perception of music, instead of the integral musical performance, all visual aspects included. The idea that nothing fundamental was missing when visual aspects of musical performance are excluded was therefore a necessary context for the successful rise of music recordings as replete musical experience during the last century. Listening to a musical performance on the radio can therefore feasibly be considered as a successor of listening to a concert in a concert hall where the performers are hidden (Schwab 1971, 186)

It is often averred that inventions like the phonograph or the radio force the audience to listen to music without viewing its source and effected "the physical separation of listening from performing" (Chanan 1995, 7). I would argue, however, that the ideals of the *Konzertreform* clearly reveal that this new mode of perceiving music was not necessarily preceded by the invention of new technology, but can be seen as an aesthetic development which took place during the nineteenth century, concurrent with the invention of sound reproduction technologies such as telephones, phonographs and radios. Although these kinds of devices did not instigate a new way of perceiving music, they did make it much easier to listen only to the sound of music instead of perceiving the whole performance, including its visual elements. A singular sound can only exist at a specific time and at a specific place, since it is formed by waves of pressure that are by definition in constant motion. Before the invention of sound reproduction technology, music never took place without the presence of musicians and their musical instruments, or—in the case of music automata—at the very least the presence of the musical instruments. Listening to music was directly connected to this presence of musical instruments. The *Konzertreform* attempted to disconnect the audience as much as possible from this presence by hiding the instruments behind a curtain, but it was through sound reproduction technology that, for the first time, they no longer needed to be present in the same space or at the same time as the listener. What all sound reproduction devices have in common is that they release sound from its direct connection to a certain time and space. This is done in two ways: either by storing sound (taking it out of its time) or by transporting or amplifying sound (taking sound out of its place). The sound waves—or, more correctly, air pressure waves[4] perceived by the human reception system as sound—are transformed into a form of energy which dissipates less than air pressure waves. As I make clear in the next paragraphs, microphones and loudspeakers are crucial to the transformation of sound waves, since they are transducers of air pressure waves to a more enduring form of energy: an electrical signal.

## Storage of air pressure waves

In order to store air pressure waves, their time-related form consisting of pressure differences needs to be translated into another, more sustainable material, such as wax, vinyl, magnetic tape or any form of contemporary digital storage, for example. The sound is now coded not through pressure differences in air but through differences in the depth or deviation of a groove, differences of magnetic power or binary numbers. This information is transformed back to air pressure waves either by using a mechanical (such as early phonograph needles) or an electric conversion system (used by nearly all sound reproduction devices nowadays) which brings into vibration a diaphragm (this diaphragm is part of what we commonly call a loudspeaker, see the appendix on microphone and loudspeaker technology).

[4] In fact, certain microphones like piezoceramic ones can measure pressure differences in material other than air. See the appendix on microphone and loudspeaker technology for more details. Sound can be propagated through all gases, as well as liquids and solid materials, however, since human beings listen to sound, especially music, primarily through air conduction, I will not consider these other materials here.

Jonathan Sterne*[5] did extensive research on sound reproduction technologies and their cultural origins. In his book *The Audible Past* he proposes the idea of the tympanic mechanism, informed by the human eardrum, as a mechanism for transducing vibrations (see chapter 3 for a more in–depth discussion of the tympanic function). This tympanic mechanism is (re)produced in the sound reproduction technology found in microphones and loudspeakers, their diaphragms being comparable with the membrane of the ear.[6] As Sterne describes clearly: "every apparatus of sound reproduction has a tympanic function at precisely the point where it turns sound into something else (usually electric current) and when it turns something else into sound. Microphones and speakers are transducers; they turn sound into other things, and they turn other things into sound" (Sterne 2003, 34). Devices used for the transformation of air pressure waves to "something else" and vice versa is therefore how I will define microphones and loudspeakers in my research. Although there have been many new inventions within sound reproduction technology since the end of the nineteenth century, such as electrical amplification, digital recording and processing, "it is still impossible to think of a configuration of technologies that makes sense as sound reproduction without either microphones or speakers" (Sterne 2003, 34–35). Whereas there have been many different technologies to store sound, like gramophone records, cassette tapes, CDs and MP3s, the connection between air pressure waves and the electrical signal is nearly always performed by microphones and loudspeakers.[7]

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[5] The asterisk behind names indicates that there is a short representation of the person in the appendix of this text.

[6] Although most microphones and loudspeakers utilise a diaphragm for picking up or emitting air pressure waves, some exceptions function without a diaphragm (Sennheiser 1999, 1052). Since the use of an element other than a diaphragm for picking up or radiating sound waves is very rare, I will not discuss these other possibilities in more detail here. The function of these other elements is still the same as the diaphragm in every microphone or loudspeaker: to transduce (air) pressure waves into another form of energy or vice versa.

[7] As exceptions, there have been other ways of (re)producing sounds, for example using flames (see *Der sprechende Flammenbogen und die Telephonie ohne Draht vermittelst Lichtstrahlen - Zwei Instrumentarien zur Demonstration* (Ernecke 1897) and *Chemische Harmonika - Über die Entstehung eines Instruments zwischen Phlogiston und Pyrophonie* (Gethmann 2010)) or plasma speakers such as Tesla coils (see *Tesla Coil* (Trinkaus 1989)).

## Transportation of air pressure waves

What distinguishes the tympanic principle from other ways of producing sound is that—theoretically—all kinds of sounds can be produced by the same membrane, hence also the term sound reproduction technology. The idea of using a membrane for converting sound waves into "something else" can for example also be demonstrated in so-called tin can telephones. Two tin cans, paper cups, or similar objects are attached to each end of a wire. Speaking softly in one of the cans causes the bottom of the can to vibrate. This bottom functions as a membrane able to vibrate in response to various air pressure waves. These vibrations are transported along the wire to the bottom of the other tin can. A person at the other side of the wire will therefore be able to hear the sound, as transported from one tin can bottom to the other by the wire. This simple "telephone" reveals how crucial the tympanic mechanism as described by Sterne is for sound reproduction technology. To reproduce a sound, there is no longer need for a mechanical reconstruction of the objects that produced that sound, as for example in the case of musical automata. Therefore, instead of creating a different sound-producing device for every sound, the membrane—more specifically called diaphragm—was incorporated as a general solution for the conversion of sound into mechanical vibrations or an electrical signal and back: a metaphorical tin can is used at both ends of the wire, functioning once as microphone and once as loudspeaker. The tin can telephone is nowadays replaced by a telephone which uses electricity to transport the transduced sound waves. An electrical signal is transported by a wire, with a small microphone and loudspeaker at either end to make transductions between air pressure waves and electricity.

## Amplification of air pressure waves

Air pressure waves lose energy when they move through the air. Already in ancient history solutions were sought for this problem. Sound is normally dispersed in all directions. By focusing sound waves with a horn, the sound waves are all forced to move into one direction. As a result, audiences will hear the sound louder. Horns are therefore used for sound amplification (although physically speaking they are only focusing and not amplifying sound waves). In ancient Greek and Roman theatre, masks were introduced which not only helped the spectators to distinguish the characters, but also served as amplifiers for the actor's voice. The opened mouth of the mask was shaped in the form of a horn (Floch 1943, 53). The horn was used to amplify the human voice, so more spectators could clearly hear what the actor was saying. This horn could therefore be seen as fulfilling the same function as microphones, amplifiers and loudspeakers nowadays, to amplify the actors' and/or singers' voices on stage.

Till the end of the nineteenth century, "amplification" (in fact focusing) of sound waves was mostly achieved using horns, often much bigger than those integrated into the Greek masks. A late example is the large megaphone (1878) developed by Thomas Edison*. This megaphone is nothing more than an enormous enlargement of the human ears and mouth, similar to the enlargement of the mouth by the Greek mask. Two large metal or wooden horns around 180 centimetres in length were used as ear enlargements, and a third horn was placed in front of the mouth. In this way Edison was able to communicate over distances of more than three kilometres (Dyer 2004, 89–90). Edison claimed that he was even able to hear "a cow biting off and chewing grass" (Baldwin 2001, 91). What these horns evidence is that for a significant amplification of sound, whether sending or receiving and without the use of electricity, an enormous object is needed. After the introduction of electricity into the process of sound amplification, the amplifier horn became obsolete. Since Edison invented his megaphone at the same time as the telephone (invented in 1876), his megaphone was, in the end, not used for communication over long distances. This was done much more effectively with the new telephone technology. Amplification of air pressure waves with the help of electricity became an important function of sound reproduction devices. During concerts, the amplitude of sound waves produced by singers, guitarists and all other instrumentalists could now be increased by making use of electricity. Due to the use of the Audion, an electronic amplifying tube invented by Lee De Forest* in 1906, it became possible to enlarge the electrical current produced by the output of microphones. The loudspeaker diaphragms could therefore produce much larger air pressure waves than those which the diaphragms of the microphones had originally picked up. This form of electronic amplification became mainstream in the 1920s (Morton 2006, 65).

## Between air and electricity

As the examples above reveal, the aims of sound reproduction technologies are much older than devices like phonographs, radios and telephones. It is therefore much more accurate to see the development of sound reproduction technologies, and thus the development of microphones and loudspeakers also as a long process, during which ideas concerning sound as well as technology mutually influenced each other. As Sterne makes clear, these sound reproduction technologies using microphones and loudspeakers should be understood therefore as "embodiments and intensifications of tendencies that were already existent elsewhere in the culture" (Sterne 2003, 34).

What can be concluded as well from my analysis above is that the use of electricity turned out to be the most efficient medium to counteract the dissipation of sound into the air. Sound could be reinforced and transported without the use of electricity also, as my examples show, but electricity made all these processes much more effective. Many of the disadvantages of purely mechanical sound reproduction technologies were improved by the use of electricity. It is therefore not surprising that it was only after the introduction of electrical recording and amplification in the mid 1920s that these new sound reproducing devices became truly valuable for music-listening culture, as has been analysed by many authors.[8] Horns such as those used in early phonographs, for example, add much more of their own sonic characteristics to the sound waves than a loudspeaker diaphragm does. Due to the use of electric valves, horns were no longer needed for the recording or amplification of sound, so the resulting electric recording had less sound distortion. The advantage of converting sound waves into an electrical signal was already described in 1877: "The original sound dies like any other sound, but its photograph, as it were, has been copied in a more subtile medium than air, and so it lives and moves and is born again" (Lovewell 1877, 28).

As previously mentioned, microphones and loudspeakers are located in between air pressure waves and something else. This "something else" is usually an electrical signal, so microphones and loudspeakers could be regarded as being *between air and electricity*. These devices are in touch with the physical world of pressure waves that dissipate in the air as well as with an endless electrical signal that need never end as long as it is connected to an energy source. I will investigate during my research this in-between position—between the acoustical world consisting of physical material and laws (*air*) and the electronic world which has the possibility to become entirely virtual (*electricity*)—occupied by microphones and loudspeakers, which is unique compared to all other sound-producing devices.

## Microphones and loudspeakers in music

### *Reproducing music*

Sound reproduction technologies, of which microphones and loudspeakers are an essential part, can be seen as a repercussion of the ideas of the *Konzertreform*, as argued above. So-called radio concerts as well as music recordings might be seen as a prolongation of the idea that sound

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[8] Michael Chanan, for example, describes the introduction of electricity in his book *Repeated Takes* as follows: "The audible limitations of the early phonograph were musically restrictive, and remained so, despite a constant stream of improvements, until the introduction of electrical recording in the mid 1920s, when the disc was joined to amplification and the loudspeaker" (Chanan 1995, 37). In *The Audible Past*, Jonathan Sterne mentions how electric amplification was clearly preferred by the audience: "By all accounts, audiences preferred the sound of radio—which used vacuum tubes and electricity to receive, transmit and reproduce sound across space" (Sterne 2003, 276), and Mark Katz underlines the improved sound quality, as concerns the reproduction of sounds, that was introduced by the use of electricity: "The development of electrical recording made it possible to reproduce a much larger spectrum of sound" (Katz 2004, 83).

alone is the only essential element for the (re)production of a musical performance. No wonder that direct comparisons were often made between listening to a loudspeaker at home and listening in the concert hall: "The listener who hears a symphony or string quartet through his loud-speaker loses little that is essential. His impression of the work is nearly, if not quite, as vivid and complete as if he were seated in the concert hall" (Damrosch 1935, 93). The microphone and loudspeaker were able to record and reproduce a musical performance because by the time that sound reproduction technology became mainstream at the beginning of the twentieth century, it had also become common to think of sound as being the only desirable component of a musical performance. If viewing the gestures of a singer had been regarded as an essential aspect of a musical performance, it would have been much more difficult to convince audiences that listening to a record at home is comparable to attending a musical performance in a concert hall.

To become ideal reproducers of musical performances, sound reproduction technologies, and especially their input and output in the form of microphones and loudspeakers, should reproduce sound without themselves being audible. "The ideal loud speaker should be entirely free of resonance and should reproduce all audible frequencies equally without adventitious aids" (Rivers-Moore 1929, 405). Listening to music through loudspeakers at home in the living room should be comparable to attending a concert in the style of the *Konzertreform*: the impression should be that the musicians are present in the same space, but hidden behind a curtain.

*Composing music*

Alongside using microphones and loudspeakers to reproduce music performances or to amplify musical instruments, there were speculations about new opportunities for composers, now that they could use microphones and loudspeakers for their work. Otto Kinkeldey* discusses future opportunities of the "sound film" and the "loudspeaker" in 1937:

> If the musician could be enabled to manipulate his sound effects as the painter handles his pigments, if he could mix his tones and overtones, his tone-colors and tone-shadings in infinite variety without the aid of the artificial sound producers which we now call musical instruments, and if finally he could fix the resulting complicated sound curve upon a lasting medium like the sound film, capable of being acoustically reproduced at will with the aid of electric apparatus, he will have reached the autonomy and independence of the painter (Kinkeldey 1937, 4).

What Kinkeldey describes here is exactly what many composers engage in after the 1950s, when composing electronic music for magnetic tape. Part of chapter 2 is devoted to this new approach to composing, which I term the generating approach. Composers may produce music without the help of any musical instruments and are indeed able to define the spectrum of the sounds they create. To accomplish these tasks the composer "will possess a standard, almost perfect amplifier and loud-speaker, and will have the inestimable advantage of being able to hear his work played to him, with all its tone colours" (Stevenson 1936, 798). According to this article, the listener will have a similar standard amplifier and loudspeaker, so that exactly the same sound can be heard by the listener as by the composer. The next consequence is "to abolish the performer", since the process of performance and composing has now become one. Whereas the idea of both composer and audience using exactly the same equipment was never fulfilled, much music produced nowadays is only meant for listening to through loudspeakers or headphones in a private atmosphere. The recording is not a copy anymore of the live performance, but is a genuine musical performance in itself. By the time the Beatles had become a studio band, and participated in the producing work for albums such as *Revolver* (1966) and *Sgt. Pepper's Lonely Hearts Club Band* (1967), it had become indisputable that music could be composed for recording instead of for performance.

Apart from the private situation of listening to records, loudspeakers were also introduced in the concert hall. For listening to music for which only loudspeakers are used as sound producers during a concert, without any musicians on stage, Pierre Schaeffer* proposed in the 1960s the idea of acousmatic listening. Schaeffer refers to the teaching praxis of the Greek philosopher Pythagoras as an example (Schaeffer 1966, 91). Pythagoras would seat himself behind a curtain, and his students would listen to him in complete silence, without seeing anything, so his visual presence would not distract the students. Schaeffer compares this kind of listening, to sound with the source hidden behind a curtain, with listening to sounds through a loudspeaker. "In addition, the difference between the experience offered by Pythagoras and the one we have with radio and recorded sound, whether listening directly (through a curtain) or listening indirectly (through a loudspeaker) becomes, in the end, negligible" (Schaeffer 1966, 93).[9] The Pythagorean listening situation is evidently very similar to the ideas of the *Konzertreform* mentioned at the beginning of this chapter, both using curtains to hide the source of the sound. Schaeffer, who was probably not acquainted with this German idea of music performance, postulates similar ideas towards listening to music as those proposed by the advocates of the *Konzertreform*: "[the acousmatic situation, CvE] symbolically forbids us every connection with the visible, touchable and measurable" (Schaeffer 1966, 93).[10] The *Konzertreform* could thus not only be seen as a

[9] My translation of: "Par ailleurs, entre l'expérience de Pythagore et celle que nous font faire la radio et l'enregistrement, les différences séparant l'écoute directe (à travers une tenture) et l'écoute indirecte (par haut-parleur) deviennent, à la limite, négligeables" (Schaeffer 1966, 93).

[10] My translation of: "[la situation acousmatique, CvE] nous interdit symboliquement tout rapport avec ce qui est visible, touchable, mesurable" (Schaeffer 1966, 93).

predecessor of the listening conditions created through recorded music and radio broadcasting conventions, but also with the listening attitude adapted during a so-called loudspeaker concert. During these concerts, there are no longer any musicians present to be hidden behind curtains, since all sound comes from loudspeakers.

## Microphones and loudspeakers: the musical instruments of our age?

Most music is produced nowadays with the help of microphones and loudspeakers, and most of the music people are listen to is heard through loudspeakers (Worby 2004). They are used to produce and reproduce music recordings as well as for diffusing sound during concerts: "listening to music over loudspeakers has become a virtually inescapable condition of life" (Moore 1980, 225). Music of every scale and genre is said to be recordable (Chanan 1995, 70). The use of microphones and loudspeakers in music has made music more intimate, since a single person can listen to a recording at home, or, even more privately, on headphones (which are of course nothing but small loudspeakers). And the opposite became possible as well: microphones and loudspeakers increased the possible audience size for a single performance, with the result that tens of thousands of audience members can enjoy the same concert, amplified, in a stadium. Under these circumstances, one could say that nearly all music has become microphone and loudspeaker music. Listening to music which uses no electric means has become the exception, taking place mostly during classical music concerts. And even in this field, electricity has been seen to have advantages as well: the lute player Rolf Lislevand even sees microphone technology used during CD recordings as a possibility to recreate the intimacy of 17th century performances: "The intimate sound of the clavichord, once whispered into a young noblewoman's ear, now flies into a nearby microphone" (Lislevand 2006, 18).

It might be no surprise that, due to the omnipresence of microphones and loudspeakers in music, it might be possible that "the true instrument of our age is not the lute or guitar or piano or drum or organ or even the electronic synthesiser—it is the loudspeaker" (Moore 1980, 214). What would this imply, if the loudspeaker, and therefore its partner the microphone also, are the musical instruments of our age? This question might be seen as the starting point for my research, resulting in the many different questions and observations which I explore during the following chapters. If almost all music is heard with the help of microphones and loudspeakers, what kind of instrumental identity is connected to these devices? (See chapter 2.) And is it not indispensable that a musical instrument be recognisable through a typical sound of its own? (See chapter 3.) How do composers and sound artists work with these instruments? (See chapters 4 and 5.) Due to the omnipresence of microphones and loudspeakers in music, their applications are innumerable and cover a very broad spectrum of possibilities for music, performance and sound. To exemplify this, I would like to finish this chapter with a short exploration of two works with microphones and loudspeakers by Dick Raaijmakers*. These works could be seen as diametrically opposed to the ideas of acousmatic music and the *Konzertreform*.

## The "true nature" of microphones and loudspeakers

Raaijmakers thinks of the transformation of sound into an electrical signal as a reduction of three-dimensional, spatial music to a narrow, one dimensional, electric current. "[...] due to the presence of microphones in our society, there has come to exist a surplus of passively reproduced sound generated and a shortage of autonomous composed music" (Raaijmakers 2007, 318).[11] Raaijmakers develops several pieces in which he is looking for the "distinctive voice" (Raaijmakers 2007, 318) of the microphone itself (*Intona* (1991)) as well as the "true nature" (Raaijmakers 1971, 14) of the loudspeaker (*Drie Ideofonen* (1969-1973)). Comparing this undertaking of Raaijmakers with the aims of sound reproduction technology, it becomes clear that they are diametrically opposed: microphones and loudspeakers should be as "inaudible" as possible while converting air pressure waves to an electrical signal and back in reproducing a recording. There is thus no possibility for a "distinctive voice" or revealing their "true nature".

To understand what the "distinctive voice" or "true nature" of microphones and loudspeakers could be, I would like to call to attention the term for these devices as employed by Roelof Vermeulen*. He designates microphones and loudspeakers as "acoustical motors", since they are, similar to the function of other motors, converting mechanical energy (the diaphragm movements caused by for example air pressure waves) into electrical energy and vice versa (Vermeulen 1937, 378). To call microphones and loudspeakers acoustical motors turns them into "active" devices that produce energy instead of passive reproduction devices, implied by the name "transducer", which just translates air pressure waves to something else and back. Evidently, in technical terms, nothing changes in the actual functioning of these devices. However, considering Raaijmakers' approach towards them, it seems to be more appropriate to see them as motors for acoustical purposes. Raaijmakers was at one time working at Vermeulen's department, so he it is possible that he was acquainted with this acoustical motor idea.

In approaching microphones and loudspeakers as acoustical motors, it becomes clear that these devices consist of material that must vibrate in order to realise the transformation of mechanical energy to electrical energy (or some other form of energy) and back. Since every vibrating

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[11] My translation of: "is er door de aanwezigheid van microfoons in onze samenleving een teveel aan passief gereproduceerd geluid ontstaan en een tekort aan autonome met elektronische middelen vervaardigde en gecomponeerde muziek" (Raaijmakers 2007, 318).

material will vibrate more easily, and therefore with greater amplitude at certain frequencies (so-called resonant frequencies), the vibrating material will always have an influence on the final sound result. Already the many different types of loudspeakers, and especially microphones, reveal the fact that there is not one type of "ideal" device that can "inaudibly" reproduce sound, and that all these devices might sound different according to their intended purpose. It is for this reason that many artists have become interested in using microphones and loudspeakers in their works as sound producers and sound shapers. Such artists use them, indeed, as a kind of "acoustical motor" playing an active part in the musical performance (see examples in chapter 4 and 5).

An exploration of these acoustical motors was made by Raaijmakers in *Drie Ideofonen*[12] (see the video fragement of *Drie Ideofonen*). In line with what was mentioned before, the loudspeakers in these three installations should reveal their "true nature" through "talking" to themselves in the absence of any input. As Raaijmakers says:

> For once the gaping loudspeaker should turn inwards and listen to itself: in short, the loudspeaker should be made to hear the sound of its own loud voice, the Loud Speaker should be turned into a Soft Hearer, Hearer and Speaker should be joined together and, for the first time in the history of acoustic communication, the loudspeaker has found itself [...] (Raaijmakers 1971 no page numbers).

Raaijmakers wants the loudspeaker to *shape* the electrical signal to be transformed into air pressure waves, instead of simply transducing an already-existing electrical signal. The loudspeaker is thus both a microphone (called Soft Hearer in the citation above by Raaijmakers) and a loudspeaker at the same time. The short circuit between the two connections of the loudspeakers results in a system in which the loudspeaker continually triggers the movement of its own diaphragm. But is this still a loudspeaker? In fact the system has just two states: connected or disconnected. The method of sound production might therefore be regarded as a kind of percussive musical automaton. The commonly held identity of the loudspeaker—as output of sound reproduction technology—is no longer valid. The loudspeaker has indeed become a sound producer instead of a reproducer.

In his piece *Intona*, Raaijmakers looks for the "distinctive voice" of microphones, by drilling, sawing, cooking, burning or dissolving them (see the video fragment of *Intona*). The performer is, as Raaijmakers emphasises, playing the microphone as a musician. To produce sounds solely with the diaphragm itself, the diaphragm is brought into vibration, not by air pressure waves as is usually the case, but by, for example, a drill, a saw and boiling water. In this manner, the

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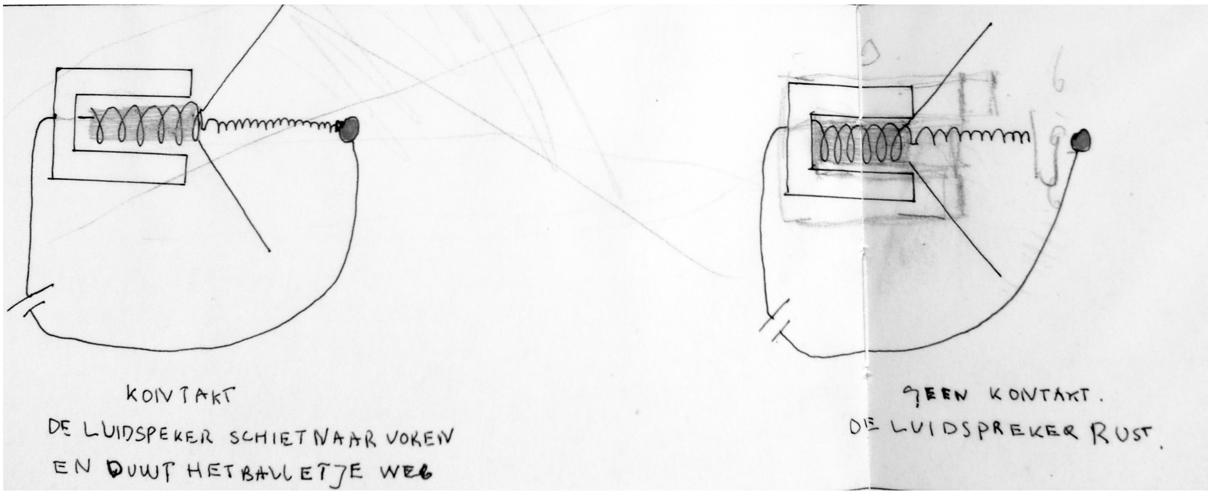
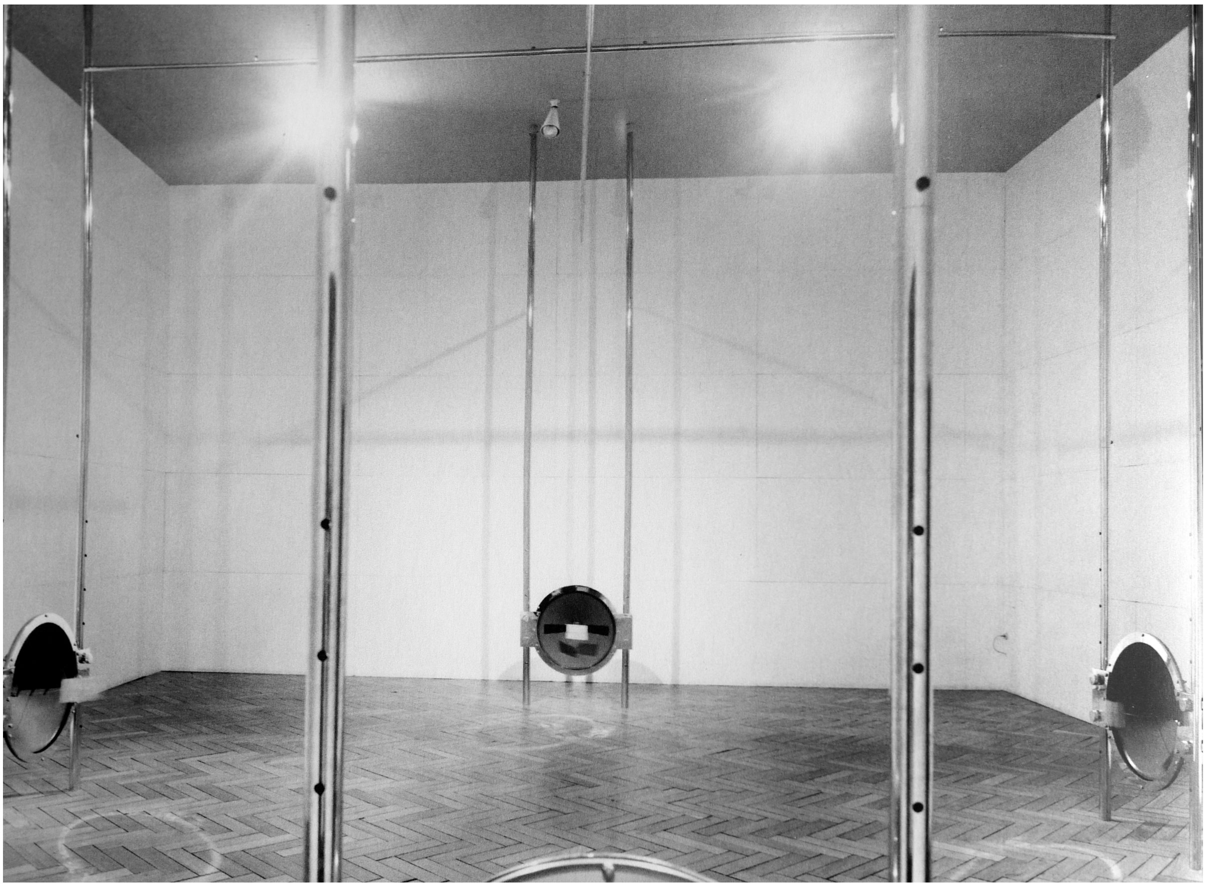
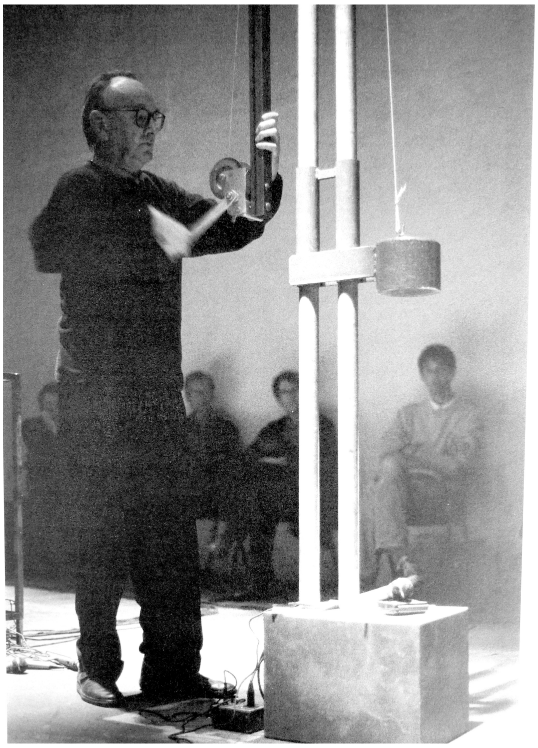
[12] Dutch for *Three Ideophones*.



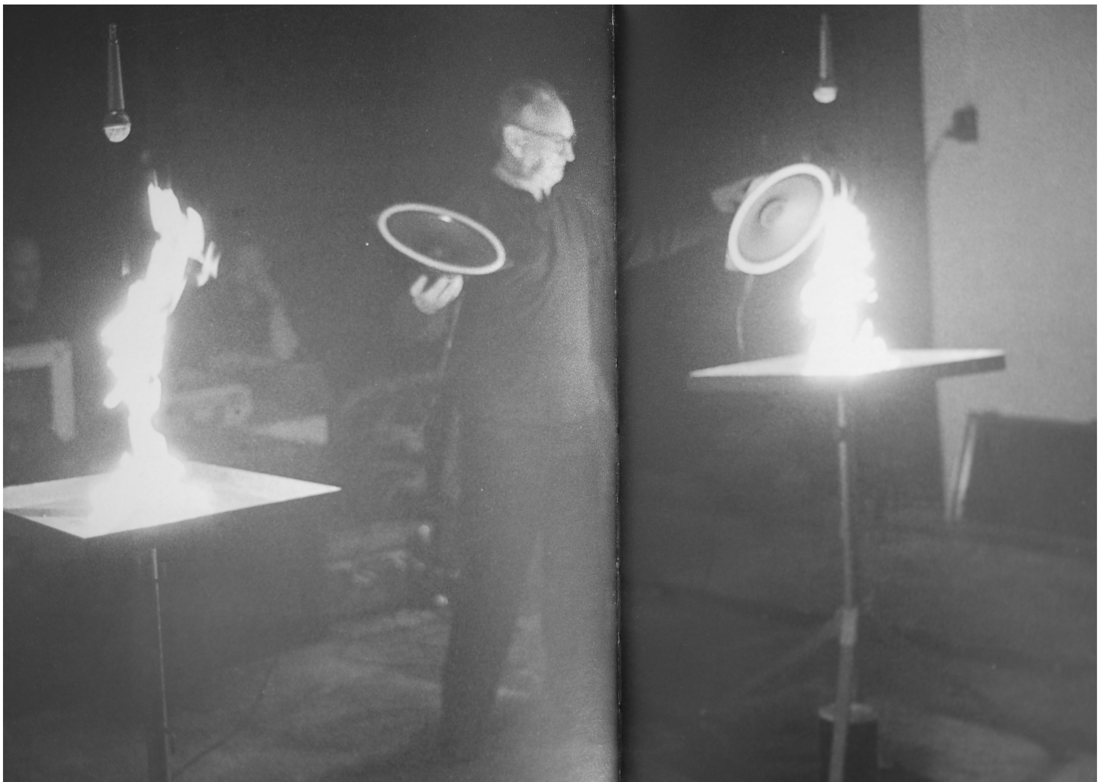

Raaijmakers explains the principle of the ideophone with these drawings: on the left there is contact and the circuit is closed, on the left there is no contact.



Dick Raaijmakers *Ideofoon 3* (1971)



A metal weight of twenty kilos will destroy this microphone in *Intona*.



Raaijmakers burns the loudspeakers at the end of *Intona*.

transducing device "microphone" should reveal its own voice. This time, the function of the device has not only been changed from reproducing to producing sound, but the microphones themselves are even destroyed by the attempt to make their diaphragms, as such, audible.

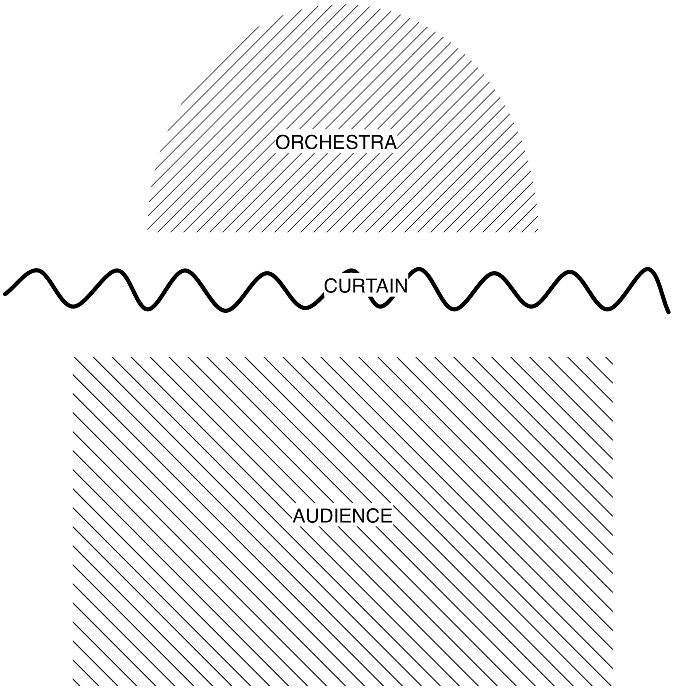
As the two examples of Raaijmakers' work reveal, whilst trying to discover the "distinctive voice" and "true nature" of microphones and loudspeakers, these devices, as a direct result of this search, cease to exist. Underlining this idea is the burning of the loudspeakers through which the microphones were amplified at the end of *Intona*, which action, according to Raaijmakers, causes the material qualities of microphones and loudspeakers to be lost. If microphones and loudspeakers were truly to be able to reproduce sound, they should possess no material characteristics, something which is of course impossible. Kees Tazelaar*, who collaborated on several of Raaijmakers' music theatre pieces, says that "[t, CvE]his ritual burning of loudspeakers seems to have stood as a symbol for a utopian idea according to which Raaijmakers demands the invention of technology to enable the holographic projection of sound through space, without any help from loudspeakers" (Tazelaar 2011, 28). This idea of holographic sound production in space without loudspeakers is described by Raaijmakers himself in his book *Cahier M* (Raaijmakers 2000, 102–103). The closest realisation of this holographic projection of sound can be found nowadays in Wave Field Synthesis (WFS). In this practice, many loudspeakers are used to project virtual sound sources into the performance space (Boone 2001, 4). The loudspeakers

A transportable Wave Field Synthesis system by The Game of Life foundation.

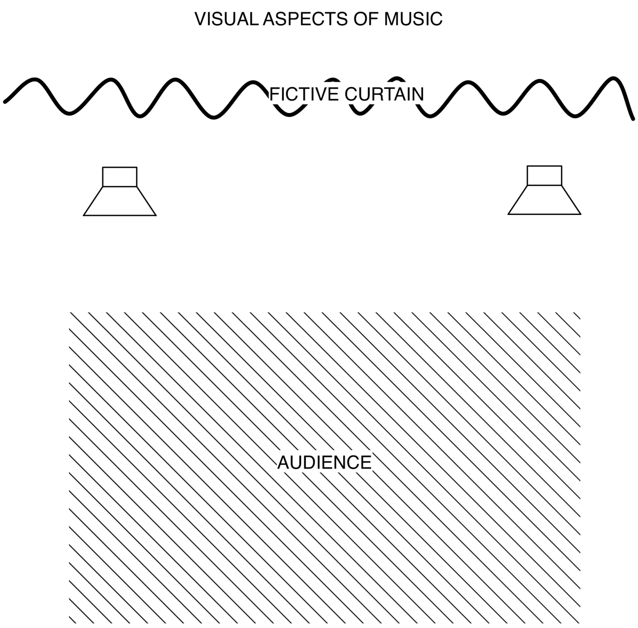
themselves (in general hundreds or even more than a thousand are used) should not be audible at all in this kind of application. The sound seems to be diffused from a source in space only recognisable by the ear, without any visual cue whatsoever, not even a black loudspeaker that might serve as visual reference for the sound that is produced. This act of producing such an illusion of a virtual sound source can already be found in stereophonic sound reproduction, as developed during the 1930s and -40s: "an illusion of a single sound pulse coming from a virtual sound source located somewhere in the space between the outer loudspeakers" (Snow 1955, 46). The main aim of stereophonic sound is not to reproduce sound with two channels, as is often thought, due to familiarity with the common living room stereo set with two loudspeakers. Stereophonic sound is a technology in which the illusion of several sound sources is created in between the loudspeakers (of which there can be more than two). The sound should be projected in space as if coming from a "screen" (Snow 1955, 45). During experiments in the 1930s to determine how many loudspeakers needed to be used in order to create these virtual sources in stereophonic sound, the loudspeakers were hidden by a curtain (Steinberg and Snow 1934, 12). By hiding the loudspeakers behind a curtain, it should have become impossible for the listener to hear how many loudspeakers were on stage and what their placement was.

This curtain is the third one to appear in this chapter. A curtain is used in the *Konzertreform* to hide the musicians. Schaeffer evokes a curtain hiding visual aspects of sound sources as an analogy for listening to sounds through a loudspeaker. This third curtain employed in stereophonic sound reproduction is now used to hide even the loudspeakers themselves. Listening to music through loudspeakers should approach pure sound listening, without any visual cues. The sound source should become an illusion. The use of a WFS system could therefore be seen as an advanced version of the *Konzertreform.* WFS technology places virtual sound sources inside as well as outside the performance space, since there are no physical constraints. Although the loudspeakers are no longer hidden by a curtain in this type of set up, it is often advised to listen to the system with the eyes closed, a solution that in fact is not very different from using a curtain to hide the sound sources.

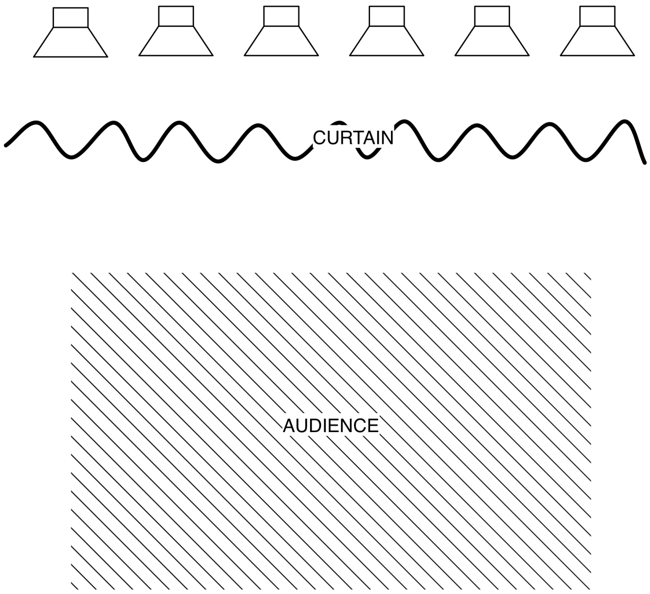
At first the concept of "virtual sound sources" (as in stereophonic sound reproduction and in the WFS system) seems to be in opposition to the concept of the "distinctive voice" of microphones and loudspeakers (as in *Drie Ideofonen* and *Intona* by Raaijmakers). To remain in the same analogy, Raaijmakers opens the curtain, which in stereophony hides the loudspeakers. By opening this curtain he searches for their "true nature". That this might not be so easy is signified by the transformation which microphones and loudspeakers undergo in both performances: the devices are modified to such an extent that it becomes difficult to say whether they might still be regarded as microphones and loudspeakers. The loudspeakers in *Drie Ideofonen* are talking to themselves, as Raaijmakers says, and all microphones and loudspeakers used in *Intona* are completely destroyed by the end. When Raaijmakers opens the curtain, what




The curtain of the *Konzertreform* hides the musicians.




The curtain of Pierre Schaeffer hides the visual aspects of music.




The curtain in stereophonic sound reproduction hides the loudspeakers.

he finds are microphones and loudspeakers for reproducing sound. He brings their materiality into vibration, looking for their "distinctive voice". But is this indeed the only way to find their "distinctive voice", or is the reproduction of sound perhaps also not a part of their "distinctive voice"? All sound radiated by loudspeakers is produced by the loudspeaker diaphragm; viewed this way, one might assert that they are not able to produce anything else than their own sound. The same is true for the microphone: the electrical signal coming from it is always derived from the diaphragm movements themselves. Raaijmakers himself seems to have been aware of this paradox and demonstrates the conflict between immaterial sound and microphones and loudspeakers by burning the loudspeakers at the end of *Intona*, as Tazelaar observed (see quote above). Raaijmakers discovers the voice of microphones and loudspeakers only through annihilating them, ending with an empty stage behind the curtain. A search for the "distinctive voice" results in the disappearance of microphones and loudspeakers. This dissolution of the sound source is exactly the aim that has been pursued by the developers of virtual sound sources. Raaijmakers demonstrates the impossibility of real transparency: at the end of *Intona*, when the microphones and loudspeakers all have disappeared, there is no possibility to produce any sound at all. Holographic sound reproduction such as WFS still depends on loudspeakers, only hidden by closing the eyes.

It is in between these two extreme positions that my research has been situated: sound produced out of "nowhere" with inaudible microphones and loudspeakers on one hand, and making microphones and loudspeakers audible by playing them as a musician on the other. To investigate the extent to which microphones and loudspeakers might be called musical instruments and function as such on stage, I look closely in chapter 2 at possible approaches revealed in various relationships between microphones, loudspeakers and musical instruments.

In chapter 3, I look at how the idea of microphones and loudspeakers as sound transducers was developed during the nineteenth century. I then focus, in chapter 4, on how artists have made the use of microphones and loudspeakers audible in their work. The last chapter is devoted to compositional strategies for microphones and loudspeakers as developed by several artists during the last decades as well as framing a perspective on possible future developments. The first appendix contains some basic information on the technology of microphones and loudspeakers. The second appendix gives some very short biographical information about composers, musicians and scientists I mentioned in this thesis as well as mentioning in more detail the work of some artists that did not end up to be a part of the main text, but whose work has contributed to my research.