# Our music machines

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**This article gives an overview of the music machines created by Bosch and Simons from 1990 until the present. Special attention is given to vibratory projects which have been their main focus since 1993. As a consequence of physical properties – all of them being complex sprung constructions – the movements and sounds created by these machines can change almost imperceptibly from order into chaos and vice versa. The concept behind the software which controls the oscillation motors, used in this series of projects, is for the most part defined and restricted by physical conditions. This software does not dictate movement and its sonic consequences, it simply intensifies the inherent properties of the constructions. The music machines have been shown under numerous conditions which can be divided in two groups: the public vs the private space. The authors have a clear preference for the latter. This does not have to be a traditional art environment like a gallery or a museum, but at least it should be a space that offers the public a free choice to go to the exhibition. This way their work can be met with the rest and concentration needed to discover the often slow and subtle processes that take place. In the volatile atmosphere of a public space this is rarely possible.**

## 1. INTRODUCTION

From the beginning of our collaboration in 1985 we have been involved in a wide range of activities, including performances, concerts and theatre productions. During the past fifteen years, however, we have focused in particular on the development of autonomous installations. We like to call our creations 'music machines'. *Music* to emphasise our interest in the quality and organisation of sound, *machines* to suggest the presence of mechanical elements and productivity. All our machines are dynamic: sound and movement are in constant development. No trickery is involved. It is just the machines playing largely their own game in a fascinating world somewhere between order and chaos. Our influence is marginal over a process that needs both time and rest to flourish. The movements and sounds created by these machines can change almost imperceptibly from order into chaos and vice versa. In a certain way the machines themselves possess a creative potential. All are in some way or another driven by a computer in real time, which could easily open a door to interactivity; however, our favourite compositional tool to create a specific language for each work, in accordance with its physical properties, is chance operations. The role of the computer is paradoxical: although it controls the mechanics (usually electric motors), it can only partly foresee the physical outcome of its decisions.

## 2. WAS DER WIND ZUM KLINGEN BRINGT

*Was der Wind zum Klingen bringt* (1989/1990) was our first project which replies to the characteristics as described above. You might have experienced its extreme loud sonic world at the Kelvingrove Gallery in Glasgow during the ICMC 1990 or at the ZKM in Karlsruhe during MultiMediale2, 1991. At first sight, the project appeared to be no more than a rather extraordinary organ. But there was a lot more to it than that. The way the vacuum cleaners forced the air through the attached rubber tubes and the resulting turbulence had scientific significance. Each tube was an independent, small, but more or less chaotic system, and as a consequence the sound produced was extremely lively. Forty-eight vacuum cleaners arranged in four different groups provide air. This air is blown through vibrating rubber appendages into PVC and metal pipes which act as amplifying sound-chambers. The arrangement is controlled by a computer which switches the vacuums on and off according to a score which is displayed on a monitor. This self-generating score is based on the principle of 'cellular automata', developed in the early 1950s by von Neumann and Ulam in the United States (von Neumann and Burks 1966). Each vacuum cleaner can be either dead or alive (black or white in the score). The computer may choose the same procedure for all vacuums or apply different rules for different groups of pipes at the same time, as in figure 2. An apparently unpredictable sequence of timbres, harmonies and dynamics are combined to create the illusion of a living object. In addition to the concept of an auto-composing self-supporting installation, we developed several fixed scores with durations of 8 to 24 minutes, making finite concerts possible.

## 3. ELECTRIC SWAYING ORCHESTRA

Ever since the *Electric Swaying Orchestra* (1991/92) (Bosch and Simons 1996), sound, construction and

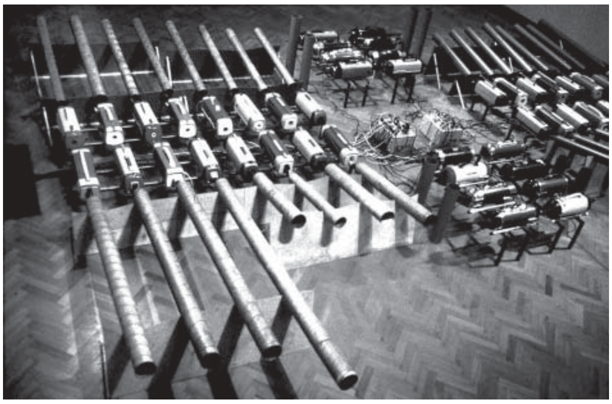

**Figure 1.** *Was der Wind zum Klingen bringt*, Stedelijk Museum, Amsterdam, 1990.

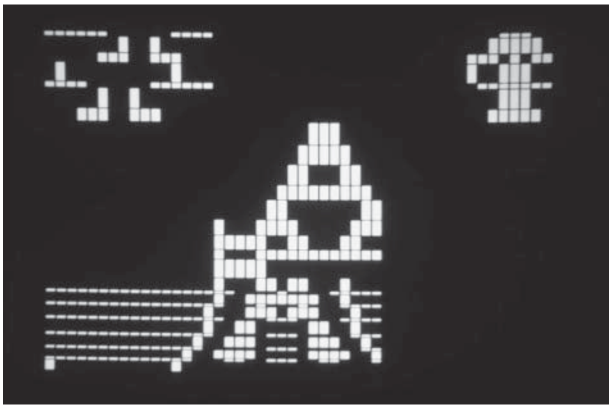

**Figure 2**. Page from score for *Was der Wind zum Klingen bringt*, 1990. The horizontal axis displays the forty-eight vacuum cleaners (on/off), the vertical axis represents development in time.

**Figure 3.** *The Electric Swaying Orchestra*, MultiMediale2, ZKM, Karlsruhe, 1993.

scientific background have been inseparable in our projects. The work consists of six huge pendulums which are activated by the up and down movement of their hanging mounts. Historically, the pendulum was used to create order; in the *Electric Swaying Orchestra* it brings chaos. Some similarities in the concept with the music piece *Pendulum Music*, written by Steve Reich in 1968, are remarkable. Reich describes his piece as follows:

> Four or more microphones are suspended by their cables above a loudspeaker. Each amplifier is turned up just to the point where feedback occurs when a mike swings directly over its speaker. The performance begins with performers pulling each mike back like a swing and releasing them in unison. The piece ends shortly after all mikes have come to rest and are feeding back a continuous tone. (Reich 1971)

Not everyone who has seen the *Electric Swaying Orchestra* would think at once of *Pendulum Music*. Nevertheless, these projects have a lot in common. In both projects, the musical outcome is determined by the change in distance between sound input and sound output devices; here, however, the performers of *Pendulum Music* are replaced by motors and the analogue feedback by digital feedback. In Reich's piece, the small differences in periods and stop times of the pendular movements are unpredictable factors. In the *Electric Swaying Orchestra*, this unpredictability is realised by parametrically driven pendulums, a well-known subject that has been thoroughly researched and documented by physicists within the cadre of order and chaos theories (Nayfeh and Mook 1979). Since the behaviour of the pendulums depends on the oscillating frequency of their mounts, a vari-speed electric motor is used. As a consequence, the pendulums command an exceptionally wide range of movement; what starts off as a traditional to and fro swing can become an unpredictable and irregular motion or even a startlingly vigorous full circum-rotation. A microphone or loudspeaker is attached to the end of each pendulum and electronic music (sampled brass instruments) is heard from the loudspeakers. The computer interprets the sounds received from the three swaying microphones and responds by playing new notes over the three speakers. The determining factors for this live improvised music are the unpredictable movement of the pendulums and the listening and composition rules executed by the computer. The computer is constantly listening to itself in a repetitive process without end. The complexity and unpredictability of the system ensures that each performance is unique in both movement and sound. A simple scheme of the different elements used in the set-up is shown in figure 4.

The project was developed within the framework of the Technique and Art Festival '91 (TARt '91) in cooperation with students from the faculty of mechanical engineering of the University of Twente in Enschede, Holland. It was awarded an Honorary Mention in the section 'Interactive Art', at Prix Ars Electronica 1992, Linz, Austria.

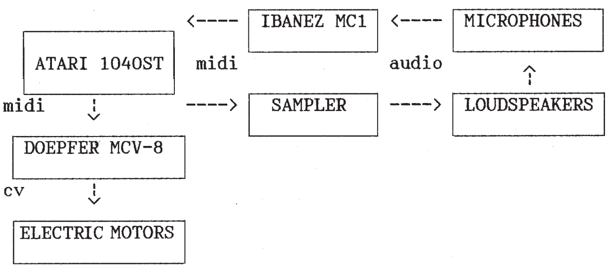


**Figure 4**. Scheme of the two data streams that are present in the *Electric Swaying Orchestra*.

**Figure 5**. *Krachtgever*, TAKTLOS, Dampfzentrale, Bern, Switzerland, 1999.

## 4. KRACHTGEVER

We then moved on to our vibratory projects, in concept closely associated to the *Electric Swaying Orchestra*, but from the start far more sober and abstract in construction. A first version of our vibratory project *Krachtgever* (1994–1997) ('Invigorator') (Bosch and Simons 1998) was also developed within the framework of the TARt Festival In Enschede, in 1993. We started with free-standing towers constructed out of stacked boxes. A second version appeared in 1994 consisting of a wall of vibrating rough wooden transport crates. This leaden, dynamic sculpture, robust of sound and material, exuded some kind of danger that was both audible and visual. The current version consists of seven to fourteen 2.5 metre-high stacks of four wooden boxes each, with a total width of six to twelve metres. The boxes are joined together with metal springs, both horizontally and vertically. One oscillating motor is attached to each stack. These motors are driven by a computer that causes interesting interferences between the stimulated vibratory and resonant frequencies of the construction by varying the speed at which the motors rotate. Depending on the combination of selected motors and frequencies, each box can be vibrated independently, while one complete stack can also be brought into one periodical movement. Combinations of vibrations can be generated to occur simultaneously at different positions within the system. Each box contains different materials. These 'rattles', varying in volume, weight and sound, possess their own resonating characteristics. When stimulated by an oscillating motor, the combined vibrations from all the elements – the springs, the boxes, the various rattles in the boxes, etc. – produce an extraordinarily complex whole. In spite of this complexity, the relationship between all the visual and auditory elements of the installation is unambiguous. The sounds are pure, unamplified and rich in detail. The repertoire of the *Krachtgever* can be best described as stacks of sound varying in strength, timbre and rhythm from the subtle to the powerful, from the ordered to the chaotic. The biggest version was presented for the first time at the O.K. in Linz, Austria, to celebrate the Golden Nica, which was given to the project in the 'Computer Music' category of the Prix Ars Electronica, 1998. At our request, the work had its own space with a closed door, to make it possible to enjoy the wide dynamic range of the piece without being annoyed by other sounds and at the same time avoiding interference with other works at the exhibition. Both the recognition and the form of presentation felt like a double victory due to our firmness: the year before, the festival asked us if it would be possible to make an outdoor version of the work, which we refused, explaining how important the acoustics of the space and a quiet environment were for the piece.

## 5. VIBRATION AND RESONANCE

After the *Krachtgever* we developed several other vibratory projects which both physically and algorithmically have a lot in common with their predecessor. Therefore, it is worthwhile to take a closer look at the physical properties of the *Krachtgever* and at the software that drives the work. The keyword of all vibratory projects is *resonant frequency* (Meirovitch 2000); each box, or any part of the construction has several. Being a three-dimensional form, each box of the *Krachtgever* has three basic resonant frequencies: one (vertical) translation and two rotations around its horizontal symmetrical axes. Other resonant frequencies are multiples of these three (overtones, one would say, in musical terms). This theory can be applied to one box or to combinations of boxes. One can easily imagine that a construction of over two hundred springs and up to fifty-six boxes has thousands of resonant frequencies. Also determinant for the result of excitation by an oscillating motor are the type of springs used. A practical property of springs is that

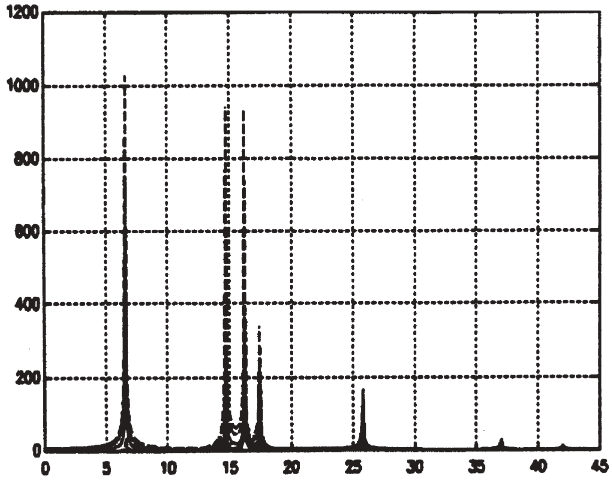


**Figure 6.** Plot with calculated results of an excitation simulation with an oscillating motor.

they can be ordered with specific dimensions and stiffness coefficient (expressed in N/m). During the research period of the *Krachtgever*, students of mechanical engineering plotted some graphics implementing different sizes and weights for the boxes and different stiffness coefficients for the springs. In the figure 6 the horizontal axis displays the rotation speed of an oscillating motor (expressed in rad/sec), and the vertical axis displays the amplification factor of the displacement that takes place in the construction for different oscillation frequencies. This kind of information was very helpful for obtaining insight into the influence of different springs and box dimensions on the results.

Another term from physics that should be mentioned is *damping.* Practically, this determines how much time it takes to build up a resonance and how much time it will take for this resonance to die out. The described physical properties define and restrict for a large part the concept of the software of our vibratory projects.

## 6. SOFTWARE

A computer controls the frequencies of the oscillating motors by sending MIDI information to a MIDI-to-CV converter. The outcoming control voltages go into the invertors to which the motors are connected. The software of the *Krachtgever* does nothing more than gradually direct the oscillating motors from a start to an end speed within different ranges and with different durations. We call the combination of start and end speeds and the slope that defines the duration a *phrase*. Once a motor hits a resonant frequency of an object in the construction by oscillating at exactly the same frequency, this object will start to move. The computer program has a structure divided into a set of 'musical phrases'. It can choose only one phrase at a time. A phrase simply consists of three variables:

(1) which of the seven to fourteen motors take part in the phrase,
(2) the start and end frequencies for each motor used in the phrase, and
(3) the total time taken in going gradually from start to end frequencies.

Combinations of motors are fixed in some phrases, while in others the computer chooses motors at random. The elapsed time of the motor-frequencies can be synchronous or asynchronous, also depending on the chosen phrase. There are a group of preset phrases, in which almost everything is fixed, while others are defined rather freely. They are divided into three categories: quiet, medium and rough (loud) behaviours. The memory of the program does not go back further then one phrase. When it starts a new phrase it will never choose one within the same category as its predecessor. This procedure forms the base of the typical free and dynamic development of the *Krachtgever's* sound at the macro-level. The physically extraordinarily complex properties of the construction itself guarantee an even less predictable texture at the micro-level: also here the future is influenced by the past. A strong resonance of a certain box (or boxes) does not become extinct at once and will therefore influence the outcome of a following phrase. This means that the same phrase can sound completely different next time round. In all our machines, the software is merely an instrument to get the best out of the physical conditions we create. It does not dictate the movement or its sonic consequences, it simply intensifies the inherent properties of complex constructions. Another artistic tool that is used is the adaptation of the work to spatial and acoustical circumstances. We can change both the number and contents of the boxes (the 'rattles') and we may also alter details of the software on the spot. Although the duration of the software is indefinite, the installation itself does not work continuously. We usually use a sensor to switch it on, once someone has entered the space.

## 7. A CASTLE FOR KOBE

*A Castle for Kobe* followed in 1996. Cardboard boxes, springs, oscillating motors, resonance and shake away! The beauty of minimal movement and the energy of sound. The power of this installation lies in its apparent simplicity. Apparent indeed since physically this has been our most complex project to date. Even though, strictly speaking, the *Krachtgever* is three-dimensional in form, because the boxes are stacked as one horizontal plane, its behaviour can mostly be described using two-dimensional models. By

**Figure 7.** *A Castle for Kobe*, Model I, ICMC'96, University of Hong Kong, Hong Kong, 1996.

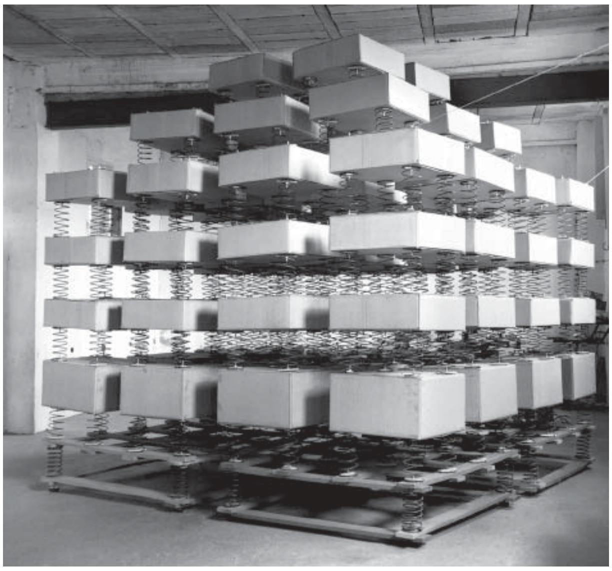

**Figure 8.** *A Castle for Kobe*, Model IV, our workshop, Chelva, 1999.

**Figure 9.** *Cantan un Huevo*, Tschumi Paviljoen, Groningen, 2000.

contrast, *A Castle for Kobe* is truly three-dimensional. It is constructed out of cardboard boxes and springs that can move freely in width, depth and height. The *Krachtgever* was shown in the Nagoya City Art Museum only a few months after the violent earthquake which occurred in Kobe in 1995. Although the *Krachtgever* had absolutely nothing to do with the earthquake – plans for the exhibition had been made over six months previously – for the Japanese public it certainly did. And then we visited Kobe. The construction of *A Castle for Kobe* was simply a necessity. Something we could not not do. A small monument in the spirit of Japan. Not something heavy and monumental, meant for eternity, but something fleeting, portable, lightweight. Its first presentation was in Hong Kong during the ICMC'96 with all the advantages and disadvantages of a public space. The work was placed in a passage where all the delegates and also many students of the university passed, so a large public was guaranteed. We noticed, however, that it was not really an environment that invited spending some time with the piece in order to fathom its deeper significance. Also, the acoustics of the half-open space were not very exciting and, apart from that, the work itself was maybe not as strong as it was meant to be, partly because of the almost 100 per cent humidity, typical for the wet season of the region, that made the cardboard boxes soft and weak. Since then we have made several bigger versions of the work, up to 1999. The last version, Model IV, with a height of over three metres, consisted of seventy-seven boxes.

## 8. CANTAN UN HUEVO

*Cantan un Huevo* (2000/2001) is physically closely related to the *Krachtgever*, but is perhaps more sophisticated. While all elements in the *Krachtgever* are interconnected, *Cantan un Huevo* consists of nine to fifteen independent vibration units, each with a behaviour as complex as a complete *Krachtgever*. Hundreds of metal springs, originally tied together to serve as a mattress, form an extremely complex surface when set into motion. A lightweight oscillating motor causes glass bottles, placed on these mattress springs, to rattle against one another. Only glass is heard. The idea for this work developed from the remarkable recordings we made on the ferry from Kiel to Oslo. The imperceptible vibrations from the ship caused the liquor bottles on the shelves in the tax-free shop to rattle, and the effect was quite hallucinatory. The vibration was a lovely long, slow wave which caused sound to swell out of nothing and to fade back in the same way. Over and over again. The first version of this work with only five shaking-tables was commissioned by the Ives Ensemble, Amsterdam; an airy and subtle celebration of sound, interpreted by four musicians and the installation and premiered at the IJsbreker, Amsterdam, 2000. The second show with nine shaking-tables was in a public space, the Tschumi Paviljoen, a completely transparent glass construction in a small park in Groningen, a town in the north of the Netherlands. Visually perfect, but not a very good place for our purposes. To really hear the bottles the public had to stand below the open grid-type floor of the pavilion. Behind the glass, where most people stayed, much of the subtleties of the sound were not audible. Although many liked the setting, we were not satisfied, because sound is an essential element of the work and this message did not come through. In Metrònom, Barcelona, 2001, the work was shown for the first time in its largest form with a total of fifteen shaking-tables. The sonic output was greatly increased in terms of complexity and dynamics, varying from subtle, almost-silence to massive clouds of high frequencies. At the 29th Competition of Electroacoustic Music and Sonic Art, Bourges, 2002, *Cantan un Huevo* obtained a Mention in the category 'work for installation or environment'. It was shown in Bourges at the Synthese festival of 2003 at Galerie La Box.

## 9. AGUAS VIVAS

The installation *Aguas Vivas* (2001–2004) also concerns the phenomenon of vibrations, but is, at least mechanically, simpler than ever before: One steel container filled with black oil, one oscillating motor, eight springs. Different to our previous vibratory projects, we started concentrating on the image rather than on the sound. Instead of creating a non-linear system algorithmically, we decided to build it physically. The oil is sent into vibration and the surface starts to undulate, changing constantly. Light reflected onto the surface of the oil is fragmented, instantly. The results are captured with a video camera and projected on a wall. The images are extremely energetic, never constant and very hypnotic. They vary from orderly patterns to chaotic snatches, while the only sounds produced by the construction itself are the sloshing oil and some noise from the oscillating motor and the springs. The first prototype of the work dates back to 1996, and the project has been changed and expanded upon several times since then. At the exhibition Midivisi (2001) in Z33, Hasselt, Belgium, we added electronically processed amplified sound for the first time. The container, light source (a white neon cross), camera and microphones were located in the same space. In an adjacent space, the video image was projected together with amplified, processed sounds that were captured from the moving container, all realised in real time. At ISEA 2002, Nagoya, Japan, we premiered a new set-up with two simultaneous sound-and-image projections. One projection is similar to that described above, the other shows still images captured in real time from the ever-changing original material, revealing an otherwise hidden world. This visual transfiguration is also accompanied by sound, which, once more processed, appears as a kind of 'audio-still'. The relatively static second layer forms a mesmerising counterpoint to the energetic and hypnotising effect of the other projection. In summer 2003 the work was shown at the exhibition 'Del Mono Azul al Cuello Blanco' at the Lonja del Pescado, Alicante, Spain (Bosch and Simons 2003). Here we added a circle to the image of a cross. This does not only alter the emerging light patterns, it also widens the psychological impact of the piece, reminding one of the many images from contemporary crusades of target marks in warfare, or simply of the traditional countdown at the start of a movie.

**Figure 10.** *Aguas Vivas*, ISEA 2002, ArtPort, Nagoya, 2002.

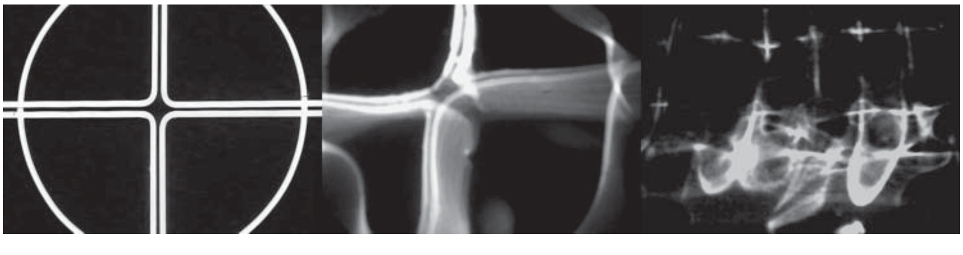

**Figure 11.** *Aguas Vivas*, Metrònom, Barcelona, 2004: three stills from live projections.

**Figure 12.** *Último Esfuerzo Rural*, ENSEMS, La Nau, Valencia, 2004.

**Figure 13.** *Último Esfuerzo Rural*, ENSEMS, La Nau, Valencia, 2004.

## 10. ÚLTIMO ESFUERZO RURAL

*Último Esfuerzo Rural* ('Last Rural Effort') (Bosch and Simons 2004) was premiered in Valencia at the Ensems festival of contemporary music, May 2004. It is composed of two rather different installations. Both produce sounds, big or little, always coarse, sensitive and individual. One part consists of five giant 'zambombas' (lion roars), made of barrels, measuring 1.30 metres and played by pneumatic cylinders. The other part is built up of wooden hayforks which scratch on metal plates, glass or wood. These hayforks are mounted on springs and driven by oscillating motors, as in most of our vibratory projects. Both machines have such a peculiar sound world that its origin cannot be other than the countryside – sounds which come out of the deepest insides, like the braying of a donkey. Whereas the barrels mainly produce extremely low frequencies, even partly below the audible range, the hayforks, on the contrary, emit rather high frequencies, composed of numerous overtones. The hayforks make up a small machine with high-energy radiation, while the barrels comprise a grotesque machine which – at least when not amplified – transmit relatively little energy. The minimum with maximum performance, or the maximum with minimal performance, the result is similar: in this paradox poetry is born. Technically, both machines span and unite the rural, industrial and computerised eras. Knowledge from industry and computer science is fundamental, as in all of our works, but during the development of this work our rural spirit was perhaps even more significant. We do not refer to the romantic myth of rural life but to something like a rural mind: the individual who looks for simple, but creative and playful solutions to the problems that occur in the world surrounding him; a state of mind which is disappearing in our globalised world. Physically, *Último Esfuerzo Rural* continues the vibratory tradition of previous works. However, the origin, the lead and the director of the music it produces is another phenomenon related to vibration: friction. The rural mind and that unpredictable, non-linear phenomenon of friction conform together to produce a powerful combination. This almost natural coupling combines with our interest in creating living machines with a language of their own. When both parts are displayed together, the soundscape of the work is an unusual mixture of extremely low frequencies with atonal scratching. At the ULTIMA Contemporary Music Festival in Oslo, October 2004, the sound changed dramatically: here we opted for a solo performance of the barrels. Each of the five barrels was individually amplified with a built-in microphone and a 120 W bass combo amplifier-speaker, which transformed the space into an impressive ever-changing field of slow vibrations.

## 11. PUBLIC OR PRIVATE SPACE?

Over the years we have shown our work on several occasions in the public arena. Although it has been received positively in general, we ourselves sometimes had doubts about whether it was worth sacrificing part of the impact in order to reach a new public. We see our work as an alternative method of music production, which needs as much time and concentration as other forms of contemporary music, especially because of the often slow and subtle processes that take place, which are not so easy to discover in the volatile atmosphere of a public space. We do not deny that installation work offers new exposure possibilities outside of the traditional contexts of a gallery or concert hall, but on the other hand public space also has its restrictions: high sound volumes are rarely tolerated, while subtle noises get easily lost in the melting pot of sounds typical in a public space. However, organisers of larger events like an ICMC or the Ars Electronica Festival quite often see sound sculpture in a public space as the perfect tool for reaching people who normally would not come into contact with 'contemporary music'. Many see the provocative side of our work as an extra reason for presenting it. We do not deny that this is an aspect which is present in our work, but it certainly is not a main topic. Often we try to encourage a host to search for a 'private space' when the demand for public art crops up – not necessarily a gallery or a museum, but at least a space that gives the public a free choice to go to the exhibition. This way our work can function as a stopping place in our hurried and hasty lives, offering an environment in which to come to one's senses. In a public space this is rarely possible. The free choice to go to an exhibition or a concert implies an inherent motivation: one expects to receive some kind of artistic product. In public spaces, however, our daily worries predominate. This usually does not help us to approach an artwork with an open and impartial mind.

We end this article with a brief examination of some of our own experiences with works presented in a public space. The one and only work that has been shown in a typically 100 per cent public space is the *Electric Swaying Orchestra*. During the ISEA '96 it was placed on the outdoor stairs of the entrance of the Exchange Building in Rotterdam, right in the centre of town, competing with street noise, flashy shops, etc. One can argue about whether this was really an environment in which it was possible to enjoy the piece to its fullest, but it was still satisfactory and interesting. In contrast with almost all our other projects, this machine uses a sampler and loudspeakers for its sonic output, which allows us to adapt the colour and volume of the sounds to the circumstances. What also makes this work more appropriate to a public space than others is that the structure and concept of its music is of much more importance than subtle changes in timbres and dynamics. Also in this respect it forms an exception within our oeuvre. Last but not least, its rather grotesque gestures definitely help it to survive in the jungle of city life. The other confrontations of our work with public spaces have been generally less inspiring. As we already stated, high sound volumes are often not accepted in spaces like the central halls of, for instance, a university or in cultural buildings like a concert hall, library or theatre, a restriction which automatically disqualifies most of our machines. We already mentioned the rather problematic performance of *A Castle for Kobe* at the ICMC'96 in Hong Kong. Looking back at this experience, we think that the main reason why the work did not convince was not its sound level but rather the informal setting; the passage where it was placed apparently made it difficult for many of the visitors to imagine that the work was meant to be anything more than a joke. Recently, at an opening of a group exhibition in Valencia, November 2004, where we showed *Último Esfuerzo Rural* in the modest form of only two 'zambombas', we noticed that the extremely low frequencies produced by the barrels were in a completely different audio range than the other sounds present (mainly people talking). We therefore think that this work might be successful in a public space, simply because you can hear it if you want to, while it hardly interferes with the other sounds of daily life. When the opportunity presents itself, we will probably accept the invitation to show this machine in a public space.

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