Vibration, Volts and Sonic Art: A practice and theory of electromechanical sound

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ABSTRACT
This paper explores the creative appropriation of loudspeakers and other electromechanical devices in sonic arts practice. It is proposed that this is an identifiable area of sonic art worthy of its own historical and theoretical account. A case study of an original work by the author titled *Infinite Spring* is presented within a context of works by other practitioners from the 1960's to present day. The notion of the 'prepared speaker' is explored alongside theories of media archeology, cracked media and acoustic ecology.

Keywords
Electromechanical sonic art, kinetic sound art, prepared speakers, *Infinite Spring.*

1. INTRODUCTION
In 2004 I began experimenting with the physical manipulation of loudspeaker cones in my music and creative sound practice. During a residency at WRAP arts centre, Bergen, in 2005 I built an installation consisting of speakers with torn and broken cones, I used aluminium foil to cover speakers and attached metal objects to speaker cones. In my *Visual Speakers* of 2006 I coupled a speaker cone to an acetate sheet such that it would audibly and visibly vibrate, and used another to act as a vibrating switch contact to flash LED lights. In the *Sonic Marble Run* (2007) and *Infinite Spring* (2010) I used beads, foil cups, springs and other objects to mechanically modify electrically transmitted sound. I use the term 'prepared speaker' for these devices in reference to the prepared piano pieces of John Cage and other examples of 'prepared' instruments where objects are mechanically coupled to traditional musical instruments to alter sonic behavior in some way.

This creative appropriation of the loudspeaker reveals a general interest and focus on electromechanical transduction within sound and sonic arts practice, which I aim to explore in my work. By preparing and extending speakers and other electromechanical devices I hope to identify them as sound sources, and raise questions on the relationship between the mechanical nature of the speaker cone and the electromagnetic nature of the energizing signal driving it. Electricity is ubiquitous as an energy source for all manner of human sonic activity yet the acoustic transmission of sound remains a mechanical phenomenon. The meeting, transduction and interplay between these two forces offers rich creative possibilities which I hope to exploit in my work and explore in the work of others.

This paper provides a context for this approach to creative sound practice offering possible ways to navigate the aesthetic and technical concerns of working in this way. A brief survey of works, techniques and technologies that can be said to exist in this arena is provided along with a case study of my recent piece *Infinite Spring* which makes extensive use of both prepared speakers and motors to create an electromechanical sonic environment (see figs 1- 4).

2. CONTEXT
2.1 Brief Survey of Works
Courting the unique electromechanical qualities of the loudspeaker in sonic art and experimental music is nothing new. It was the notion that 'the loudspeaker should have a voice which was unique and not just an instrument of reproduction but as an instrument unto itself' [7] which inspired David Tudor (1926-1996) to make the installation and performance piece *Rainforest* in various incarnations between 1966 and 1974. The piece, still recreated today, uses cone-less loudspeakers as transducers, to enable an electrical signal to mechanically excite objects such as bedsprings, slinkys and sheet metal. The mechanical activity of each of these objects is then amplified using Piezo electric contact microphones [5]. The piece, in all its guises, is documented by Matt Rogalsky who uses the term 'sculptural speakers' to describe the Tudor devices [5].

In *Music For Solo Performer* (1965), Alvin Lucier directly coupled loudspeakers to percussion instruments such as snare drums and gongs such that they would be mechanically excited by the amplified brainwaves of a performer wearing electrodes. Lucier comments that 'the brainwave piece is as much about resonance as it is about brainwaves' ([8], p. 204). 'I'm trying to make the connection between sympathetic vibration, which is a physical thing, and the next idea is the room as a speaker' ([8], p. 205). Lucier is promoting the idea that the speaker preparations in this piece go beyond the percussion instruments and could be extended to include the influence of the room as an acoustic space.

The notion of using space as an extension to the loudspeaker is further explored by Lucier in '*I am sitting in a Room'* (1970). Here he cycles a recording of his own voice through a loudspeaker in a room, recording the result and replaying it back into the same room contiguously until the signal degrades leaving just the sonic resonances of the room / loudspeaker combination exposed. One of Lucier's inspirations for the piece was the testing procedure that loudspeaker manufacturer Bose used for their products to help identify irregularities in frequency response ([8], p. 80). Although, as with much of Lucier's work, there is a theme of interrogating acoustic space, it is clear that this interrogation is electromechanical in its nature and, as we have seen, the loudspeaker and its extensions were a central part of Lucier's vision for the piece.

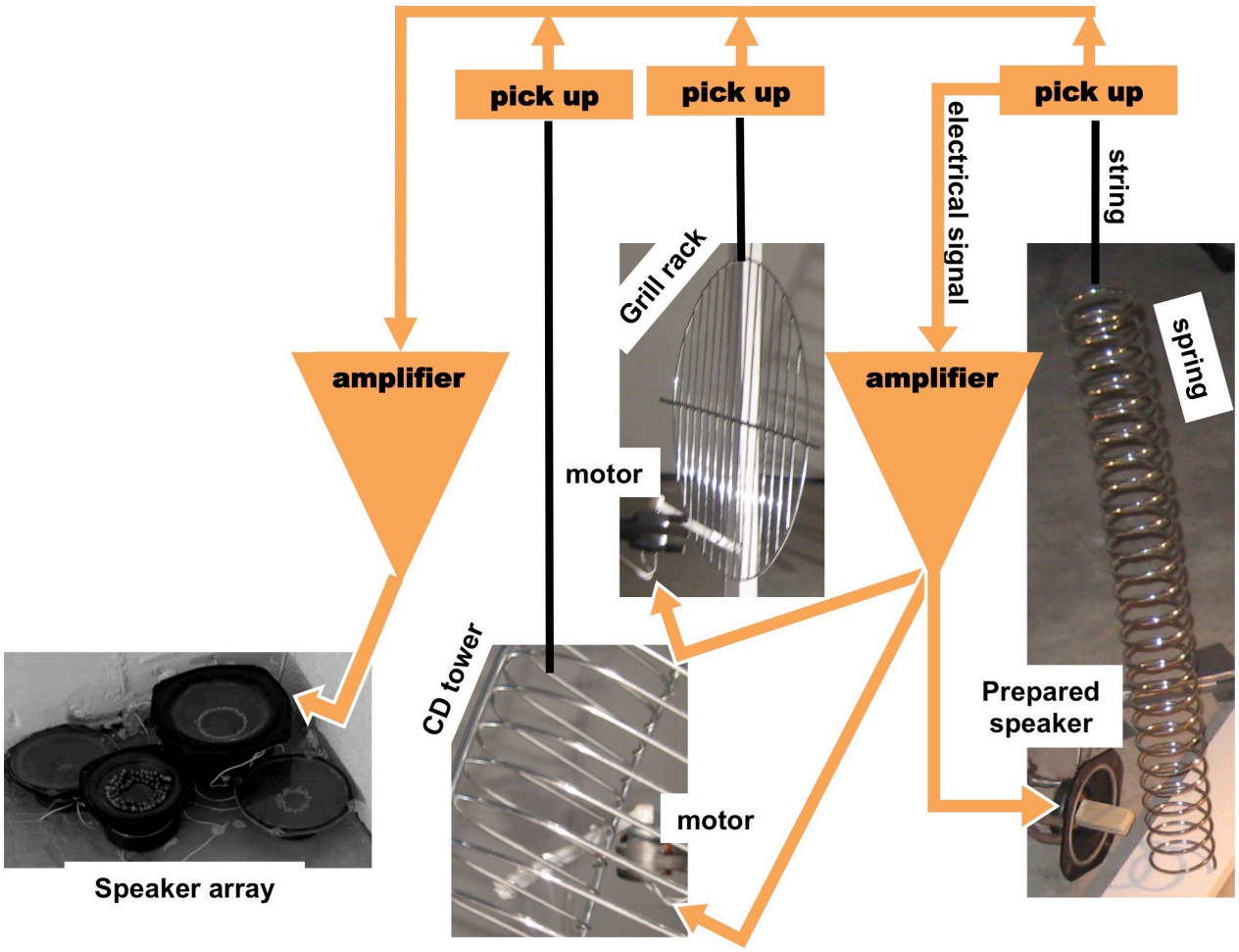

Figure 1. Technical scheme of Infinite Spring

It is this use of loudspeakers in the exploration of sympathetic vibration and resonance that makes this work relevant to my own creative experiments with loudspeakers and other electromechanical devices. Where Lucier has used percussion instruments for his speakers I have experimented with springs, foil, beads and plastic.

Other works of interest, from the same era, include Steve Reich's *Pendulum Music* (1968), which explores the musicality of electromechanical feedback via loudspeakers and swinging microphones. This piece is relevant as the resonant nature of the feedback is defined by the electromechanical system of the speaker and microphone combination, and further modified by the mechanical, swinging of the microphones. *Pendulum Music* is a music born entirely of a dialogue between the electrical and mechanical energies within the system, and their points of transduction. The main source of sound in *Infinite Spring* is also created by an electromechanical feedback system as can be seen in fig 1.

Contemporary sound art practitioners exploring the sonic potential of the electromechanical include Zimoun [15] with pieces such as '*Swarm of Prepared Vibration Motors'* (2008) and '111 Prepared DC Motors' (2010). Prepared electromechanical devices populate much of Zimoun's work, which also includes the use of loudspeakers. Zimoun's web site describes the work as a 'rigorous reductionism of the means used to produce sound' and as exhibiting an 'electric, dynamic sense of disquiet' [15]. The technique of using the DC motor as a loudspeaker or sounding device of sorts is also something I have employed in *Infinite Spring*.

Peter Bosch and Simone Simons used oscillating motors driven by 'musical phrases' ([1], p. 106) to excite a large sprung structure of shipping crates in *Krachtgever* (1998). Here, each crate is filled with a different material and the various resonances of the structure are explored by varying the frequency of the signal driving the motors. Much of Bosch and Simons work concerns itself with electromechanically induced vibration and resonant behavior, including '*The Electric Swaying Orchestra'* (1993) which, they claim, has much in common with *Pendulum Music* ([1], p. 104*).*

Another contemporary practitioner worth considering here is Pierre Bastian [10] who has used motors as the driving force of his *Mechanium* mechanical orchestra and other installations since the 1970's. Here we find the electromechanical device in a context of traditional automata, and there are many themes relating this approach to my own, and to the other pieces considered above.

2.2 Music Technology Context

Music technology design has historically made use of electromechanical transfer for sound processing where purely electronic techniques were yet to be developed. Examples include the Leslie rotary speaker cabinet and the Ondes Martineau, which offered a choice of speakers, one of which vibrated a gong, whilst another had twelve strings strung over the front and back of the speaker to induce sympathetic vibration [8]. Early reverberation devices such as the spring and plate reverb used electromechanical transduction and amplification to extract sonorities from material objects, in a

process not dissimilar to that used by Cage in *Cartridge Music* (1960) [8], Stockhausen in *Microphonie* (1964) [8] as well as Tudor in *Rainforest*. Electromechanical user modifications have also appeared in this context, and there is much lively internet debate as to which rock guitarist was the first to purposely damage the speaker cone of their guitar amplifier to achieve a fuzz guitar tone and which recording was the first to feature electromechanical feedback from an electric guitar [4].

2.3 Towards a Theoretical Context

In these examples we find a balance of creative focus (in music, sound art and technological design terms) between the electronic domain of signal manipulation and the mechanical domain of material vibration. This is in contrast to what has become a more common creative approach in technologically mediated music, of focusing almost entirely on the realm of electronic signal manipulation, be it in the analogue or digital domain. It could be argued that the current prevailing model for music technology systems is one that views the loudspeaker as a subservient device, a mechanical 'limb' controlled by an electronic 'brain', whose resonant irregularities are problems to be eradicated wherever possible. Certainly in terms of computer based composition and synthesis, studio recording and production and electronically mediated live performance this is a broadly applicable model. Barry Truax ([13], p. 9) commented in 2001 that "it is significant that that the current emphasis of audio technology is almost entirely on the signal processing aspects and not the actual points of energy transfer". The prepared loudspeaker and other extended electromechanical interfaces seek to redress the balance of creative focus between electrical and mechanical energy in music and music technologies, and in doing so they reassert their power as the final gatekeeper in the signal chain of the electronic music system.

The prepared speaker achieves this through a method and practice that could be aligned to the discourse on *cracked media* as described by Caleb Kelly [9]. Primarily concerned with the breaking, scratching and purposeful creative destruction of sound recording media (vinyl, CDs etc) for sonic effect, the world of *cracked media* concerns itself with the physical user intervention of electric media. Kelly's book presents this partly as a critique of the recording, commercial music and technology industries as well as in the context of modern tactical and creative uses of everyday technologies. Whilst the prepared speaker's means may be radical and involve destructive user modification, we have seen how other technologies such as the Ondes Martineau and the mechanical reverb have achieved an electromechanical balance through the electronic design limitations of their era. An aesthetic and musical focus on electromechanical technology may therefore usefully be aligned to a notion of *media archaeology*. This field proposed by Singfried Zielinsky, among others, proposes that we 'find something new in the old' with regard to media technology, as opposed to accepting the 'continual march of progress' ([14], p. 3) towards new technologies. It sets out to 'destroy the Whig version of technological history' [12]. The loudspeaker is old technology; its basic moving coil design still in use today can be traced back to at least the 1890's ([2], p. 39). Many would argue it is a far from ideal technology with sonic irregularities that we are stuck with until better solutions are sought. The prepared speaker and other appropriations of electromechanical devices may offer new creative possibilities with old technologies in a practice that reflects the values of media archaeology.

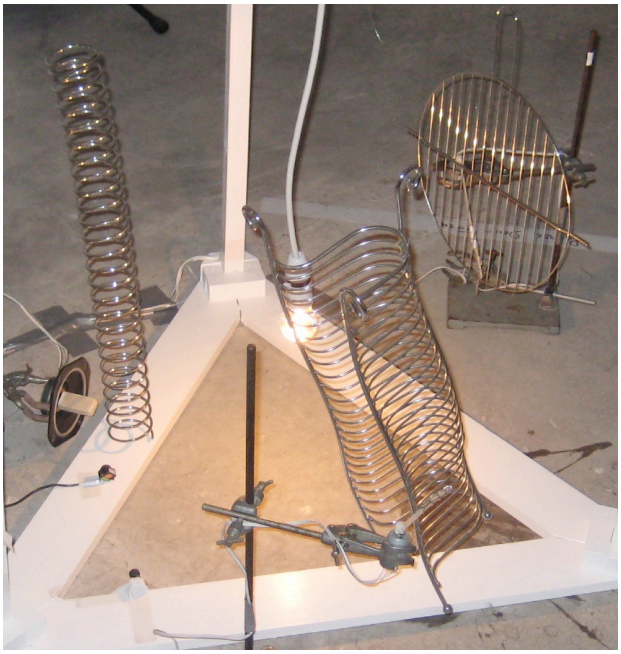

Figure 2. Infinite Spring installation at BV Studios 2010.

3. INFINITE SPRING

3.1 Technical Description

At the centre of my piece *Infinite Spring* is a prepared speaker system that has been developed to operate as an electromechanical oscillator (see fig 1). It is built from a large steel spring suspended such that its lowest coil touches a piece of wood that is glued to the centre of a loudspeaker (see fig 3). The top of the spring is coupled to a Piezo ceramic pick up which is used to transduce any movement or vibrations present into an electrical signal. The signal from the Piezo pick up is amplified and fed back to the loudspeaker whose cone is mechanically coupled to the bottom of the spring as described above. The vibration of the speaker sets the spring vibrating which, via a feedback chain of transduction and amplification, causes the speaker to vibrate (see fig 1). The whole electromechanical system oscillates when power is applied to the amplifier and it is possible to set the parameters so that it produces an audible, harmonically rich sound without causing uncontrollable feedback.

The signal from this spring / speaker oscillator is also used to drive two small DC motors. The DC motors here are essentially being regarded as rotary loudspeakers in a technique described both by Nick Collins [3] and the 'Electronic Peasant' [6]. With an AC audio signal driving them, the motors twitch and vibrate rather than rotate fully in their usual manner. The motors have armatures attached to their rotors that strike other metal objects in the installation (a metal CD storage tower and a grill tray – see figs 1 and 2), and the sound from these objects is also picked up using Piezo ceramic transducers, and amplified. The signals from the spring, the CD tower and the grill tray are amplified and routed out to a combination of three loudspeakers, one of which is prepared with beads, whilst another has the paper cone removed and replaced with a small tin cup (fig 4). The electromechanical sounds generated by the spring are modified by the electromechanical system of the motors, the CD tower and grill rack. All these sounds are further modified by the prepared speakers that broadcast the final mix in the room, and of course by the room itself. Figure 1 shows the full technical scheme for the piece and figure 2 shows an overview of how it was realised in its first public

exhibition at the BV open studios event in Bristol, UK, in 2010. Film documentation of the piece at this exhibition is viewable at www.sonicmarbles.co.uk.

Figure 3. Prepared speaker vibrating spring

3.2 Sonic Behaviour

Infinite Spring is a simple, dynamic system that produces a controlled but diverse and unpredictable music that is timbrally rich, always changing and never ending. The spring itself produces very deep tones, which would be inaudible without the contact microphone and amplifier system used to capture them. When this tone is used to drive the motors they twitch and vibrate sporadically creating a percussive element to the piece as the armatures strike the other metal objects. When the spring's tone is heard through the foil cup speaker it is diminished to a small tinny rattle.

Truax states that '…the electroacoustic process is not merely a simple extension of the capabilities of sound, but rather a fundamental transformation of how it works...it permits totally new concepts to operate' ([13], p. 124). At each point of transduction in *Infinite Spring* these 'new concepts' are able to operate. The amplification of the normally inaudible low frequencies of the vibrating spring, and the transference of those vibrations to other materials and objects, in such a way as *they* are made to sound in a form of mechanical synthesis, constitute Truax's transformations in this context. Even causing objects to sound continuously over long periods of time is a difficult thing to achieve in the purely mechanical world, yet easily achievable in the electromechanical one. The spring in this piece will vibrate continuously, or until someone switches the power off. Both Truax [13] and R. M. Schaffer [11] consider the dynamic behaviors of mechanical sound compared to the fixed waveform behaviors and immortality of electrical sounds. Infinite Spring creates a balanced dialogue between those two behaviors in a sonic and kinetic installation that draws attention to the physical cause and effect of sound as it is transmitted mechanically and electrically. This is achieved through the appropriation and modification of existing technologies, and through a design technique that uses nothing more complicated than would be found in an electrically amplified gramophone.

4. CONCLUSIONS

This paper has shown the context in which my piece *Infinite Spring* sits both in practical and theoretical terms, and in doing so has begun to set out an arena of the creative application of electromechanical transduction within the sonic arts.

Figure 4. Foil cup prepared speaker

It has exposed many themes and techniques that are worthy of continued exploration within creative sound and music practice, both in my own work and the work of others. This exploration will need to involve further surveys and analysis of works, practices and technologies, as well as practical experimentation. *Infinite Spring* is worthy of further practical development, particularly with regard to maximising the visual impact of the piece in any future exhibition scenario.

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