MATERIALS SYSTEMS AND AUTONOMY IN ELECTROMECHANICAL SOUND ART

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ABSTRACT

Sound art is a difficult to categorise and broad genre description that draws together modes of creative practice which use sound as a medium or a subject. The field is considered to be critically underrepresented and under-theorised despite an increase of attention and popularity since the 1990s (Licht 2007, 2001, Cox 2009). This is partly as a consequence of an analytical and historical emphasis on textual and conceptual approaches which dominated the arts through the 1970s and 1980s (Cox 2011, 2013). In particular, acknowledgement of the influence of object-based and kinetic sculpture within the field of sound art is found to be inadequate (Chau 2014, Keylin 2015).

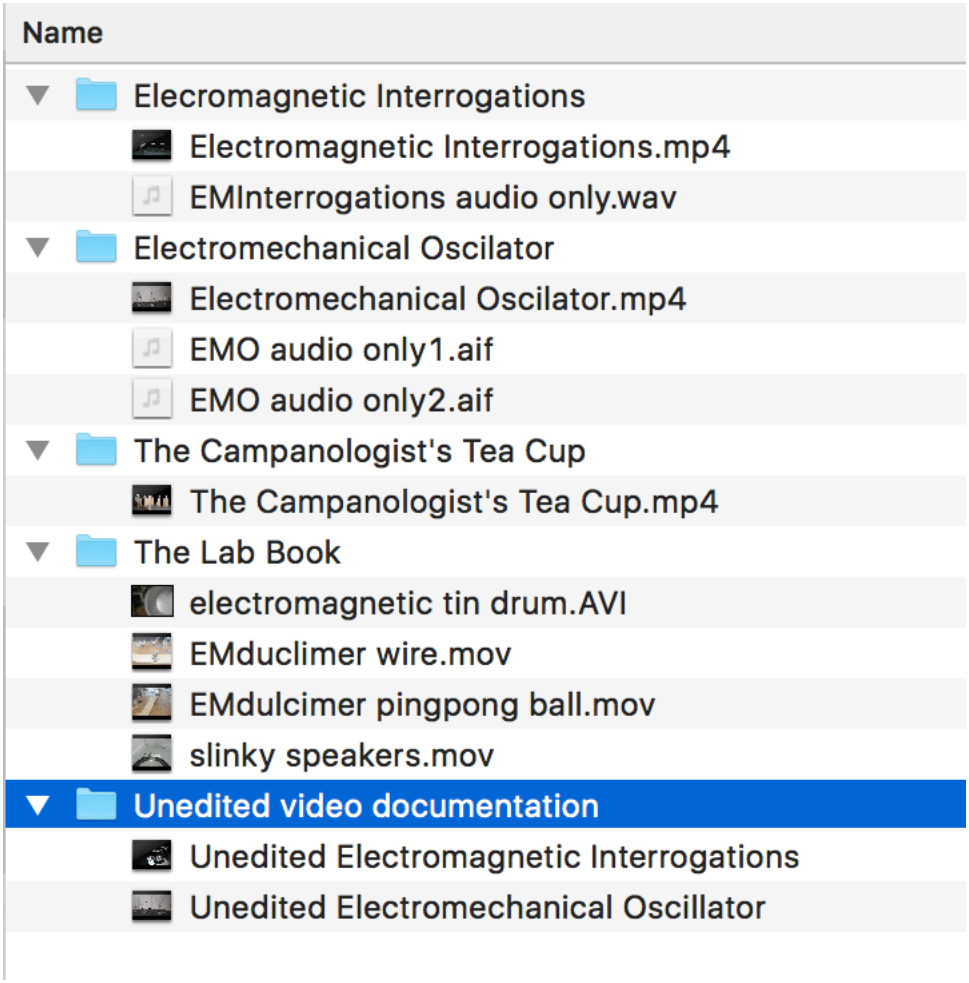
This thesis presents an original body of sound art practice as a means through which to uncover and explore connections between sound art, experimental composition, kinetic art and sculpture. The term ‘electromechanical’ is used to identify this work, highlighting its particular concerns with the use of electrically animated or amplified materials, techniques connecting it to object-based and kinetic sculpture. Through the production, exhibition, critical appraisal and contextualisation of the work new observations and distinctions within the field are presented. These include the identification of a ‘closed system aesthetic’ and the distinction between robotic and process driven approaches to electromechanical sound art. Both these findings relate to the influence of systems art on electromechanical sound art. A further contribution to the field consists of a detailed consideration of sound art emerging from an intersection of experimental music and sculptural practices during the 1960s.

The original works produced for the project, and their production are documented and described in detail alongside existing canonical and contemporary examples of sound art. Analysis of these works is informed by materialist and object-orientated critical positions, and science and technology studies. The method of art practice as research is described and extended in an original way that encompasses and applies a systems approach to creative practice.

CONTENTS

PRACTICAL DOCUMENTATION

Files on accompanying memory stick for discussion in chapter 5:



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1. INTRODUCTION

This project interrogates an area of creative practice identified as electromechanical sound art through core themes that are centred around materials, systems and autonomy. The research contains a documented body of original creative practice, accompanied by contextual, theoretical and methodological discussion. The project grew out of previous work carried out within a master of arts (MA) programme, the outcome of which was the creation and exhibition of *The Sonic Marble Run* (2006). This was a sound sculpture where a rolling marble caused mechanical sound events that were amplified through customised loudspeakers which had been physically altered to change their sonic characteristics. These creative techniques of amplifying mechanical sound events and mechanically intervening in loudspeaker reproduction begin to define the field of electromechanical sound art, particularly through the contrast that such approaches make to software and screen-based creative sound production. The current project has built upon the work developed as part of the MA through research questions that are broad in their scope and for which there has not been an expectation for single or exhaustive answers. Rather, these questions have served as points of departure for an emergent, enquiry based body of work. The questions are:

- How can electromechanical systems be applied and explored through sound art practice?
- What is the artistic context for such an approach to sound art?
- What theoretical frameworks can be used to understand the relationship between electromechanical systems and sound art?

These questions also reflect the interdisciplinary nature of the project, which spans fields such as experimental music, kinetic art and technology through both theory and practice. These are all elements that on first appraisal could seem to belong to separate disciplines. The attempt to accommodate apparently quite different things within a single interdisciplinary enquiry is reflective of both the art practice method used for the research, as well as the topic of electromechanical sound art. Even without the additional technological prefix of ‘electromechanical’, sound art is already

interdisciplinary, spanning the concert hall and art gallery by bringing together art practices such as sculpture and installation with sound and music.

The electromechanical condition (see figure 1.1) can also be thought of as a hybrid assembly, bringing together the different materials of the electrical and the mechanical within a single unit, offering possibilities of energetic transduction and power transfer. Figure 1.1 provides a simple textbook description of the basic electromechanical condition that describes the principle of operation of a motor or a loudspeaker, showing how an electrical current carrying wire will mechanically move when placed within a magnetic field. Also shown is Fleming's 'left hand rule', a useful conceptual model for representing the nature of the relationship between movement, current and magnetic field within the experimental assembly. This shift between material assembly and conceptual understanding reflects another kind of interdisciplinary boundary explored by the project, that which differentiates between materials and systems.

[Image removed for copyright reasons.]

[Image removed for copyright reasons.]

Figure 1.1 (top) Simple electromechanical experiment (below) Fleming's 'left hand rule' describing relationship between field, current and motion (Open University 1971)

The simple experiment in Figure 1.1 also shows how the separate concerns of electrical and mechanical activity are brought together within a magnetic field, and the idea of the ‘field’ recurs throughout this project as the place where elements of different natures and from different disciplines may be brought to bear upon each other, establishing relations, resonances, structures and bringing about possibilities, and effects. The first field that will be established is a historic and contemporary frame for electromechanical sound art. This is achieved by looking at particular examples of experimental music and kinetic art through the themes of materials, systems and autonomy. This forms part of the creative context of the project by exploring precursors, traditions and current activity within the field.

2. CONTEXT

2.1 IDENTIFYING THE FIELD

2.1.1. Sound Art

This project belongs and contributes to the practice and theory of sound art, an area that has enjoyed an exponential increase of attention since the 1990s (Licht 2007: 9, 2001: 3, Cox 2009: 19). It is broadly recognised that there are clear antecedents to sound art in early 1960s intermedia and performance art practice, as well as at the beginning of the 20th century, with Futurism, Dadaism and experimental compositional practices. The term 'sound art' is often cited as emerging in the late 1970s (Licht 2007: 3) though very similar terms have been in use since the 1960s. For example, *The Sonic Arts Union* formed in 1966 by Alvin Lucier, David Behrman, Gordon Mumma and Robert Ashley explored acoustics, electronics, theatre, visual arts and poetry in performances which were 'outside the bounds of what contemporary music generally accepted' (Behrman quoted in Cox 1999: 41 and LaBelle 2006: 124). It is not possible to make a clear delineation between what is meant by the various terms 'sound art', 'sonic art' and music (experimental or otherwise) though Hamilton (2007: ch.2) and Licht (2007, 2001) both provide a useful overview and introduction to the debate which includes such topics as musical tonality and atonality, the development of sound recording technology, musical instrument making of an electronic, acoustic and sculptural nature, and the acousmatic approaches of Musique Concrète. Cox suggests that sound art enjoys a special and close relationship with noise (2009: 19) which helps to define it in relation to speech or music, whilst another distinction is often proposed as being that sound art is generally intended for presentation in gallery or museum spaces rather than the concert hall (Licht 2009, Cox and Warner 2004: 415). Sonic art is often treated as an umbrella term encompassing a breadth of activities that could be said to exist between music and sound art. The term sound art is broadly considered the most appropriate for this project for reasons that include the gallery-based nature of the work considered and produced, and the role that noise plays in some key pieces. Both these themes will be revisited and further explored. However, these various points delineating genre definitions and creative approaches cannot be taken as absolute definitions. Terminologies in creative contexts such as this are often difficult to establish, becoming ongoing topics of debate. Sound Installation pioneer Max Neuhaus observes that 'much of what has been called

sound art has not much to do with either sound or art' maintaining that the term does nothing useful to supplement existing terms such as music or sculpture (Neuhaus quoted in Licht 2007: 10 also in Cox 2009). Neuhaus does, however, support the exploration of what he calls 'fine distinctions' within creative practice and this is a useful premise for this project's specific focus on autonomous, material systems within electromechanical sound art.

> If there is a valid reason for classifying and naming things in culture, certainly it is for the refinement of distinctions. Aesthetic experience lies in the areas of fine distinctions, not the destruction of distinctions for promotion of activities with their least common denominator, in this case sound (Neuhaus quoted in Licht 2007: 10)

2.1.2 Electromechanical Sound Art

'Electromechanical sound art' is not a widely recognised term or genre, and establishing it as such is not a core aim of this project. The term is used here to point to a particular set of concerns within an area of sound art practice that explores the sound making qualities of objects and materials when electrically animated and / or amplified, in work that exists at the intersection of music and sculpture. The Venn diagram in figure 2.1 helps to situate electromechanical sound art in this way. The central overlapping area of the diagram is not exclusively the domain of electromechanical sound art, other sculptural approaches to sound making such as water and wind powered installations and sculptural musical instrument making, for example, could also exist in this area. The finer distinctions between such approaches are further explored as part of the project.

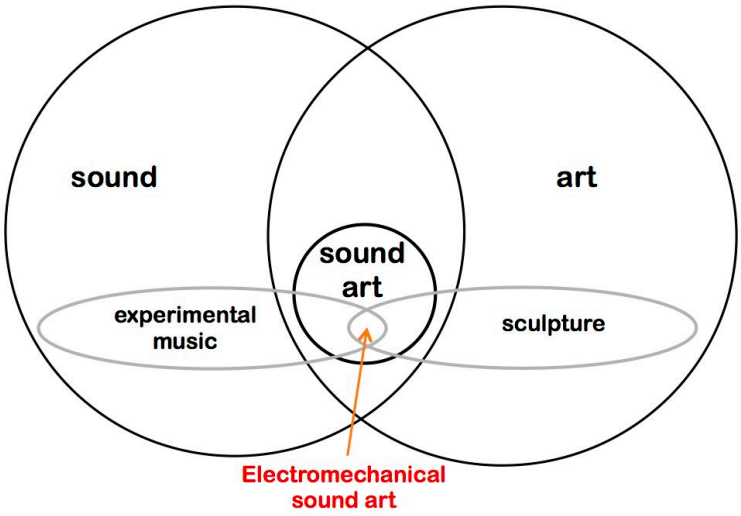

Figure 2.1 Venn diagram to show an initial context for electromechanical sound art

Thinking about electromechanical sound art through the components of sound, art, music and sculpture in this way is useful in developing the creative context for this project. This is partly achieved through a review of creative approaches by practitioners with a musical and compositional background, alongside approaches by practitioners who would typically be framed as material artists, and more specifically kinetic artists. The work of Alvin Lucier, Steve Reich and David Tudor, who belong to the former group, will be considered alongside Jean Tinguely, Len Lye and Takis who have contributed widely to the field of kinetic art. All of these practitioners have produced work that usefully helps unpack the electromechanical condition through themes of materials and systems, and all were active concurrently during the 1960s, when terms such as sonic art began to emerge. This was a time when the boundaries between the fields of music and art were being tested by interdisciplinary creative practice, allowing for the emergence of work that appeared to exist 'in the twilight zone between a concert and an installation' (Collins 2007: 46). This is how Nicholas Collins describes David Tudor's *Rainforest* (1968 onwards), a piece that centres around customised loudspeakers described by Tudor as 'instrumental' or 'sculptural' (Driscoll and Rogalsky 2004: 28). These devices appropriate the electromechanical transduction element of a loudspeaker to resonate objects such as cartwheels, bedsprings and oil drums, among various other objects, in installations and performances realised by Tudor's group *Composers Inside Electronics* throughout the 1970s (see figure 2.2). In *Rainforest* audience members are able to move through the space occupied by the sculptural speakers listening to the resonant characteristics of the objects which may be directly audible, or re-amplified through other loudspeakers.

Occupying a similar territory to *Rainforest* is Alvin Lucier's *Music on a Long Thin Wire* (1977). This is a particularly useful example of an electromechanical approach, as it presents a simple assembly of materials demonstrating the basic electromechanical principle, appropriated for creative sound making. The piece is almost fully described by the textbook diagram in figure 1.1, describing a simple experimental electromechanical set up. In Lucier's piece, however, the wire, various lengths of which have been used from guitar strings to some more than thirty feet long (Lucier 1995: 184), is excited by an alternating current that travels back and forth (a waveform), supplied by a signal generator, rather than just a battery. This causes complex vibration and resonance within the wire, which is then amplified using contact microphones placed at either end.

The piece dates from slightly later than *Rainforest* but belongs to a body of work by Lucier, which began in the mid 1960s exploring scientific phenomena and systems of sound-making through experimental technological arrangements. Like *Rainforest* the piece exists as both a performance and an installation.

Figure 2.2 The sculptural speakers of David Tudors *Rainforest* (Paris 1976, see Driscoll and Rogalsky 2004)

The real time, live animation of materials and objects that forms an important part of these examples of electromechanical sound art and forges connections to kinetic art, is not something that only exists in work form the 1960s or 1970s. Similar themes are present in more recent examples of creative practice such as Peter Bosch and Simone Simons' *Krachtgever* ('invigorator', since1994, figure 2.3). This piece consists of a sprung stack of large wooden shipping crates each filled with different materials. As electric motors excite the lowest crate in each stack, complex resonances are triggered in various parts of the structure, causing the materials inside each crate to vibrate and rattle. Bosch and Simons describe the sound of the piece as 'pure, unamplified and rich in detail' with a repertoire 'varying in strength, timbre and rhythm from the subtle to the powerful, from the ordered to the chaotic' (Bosch and Simons 2005:105). Contemporary artist Zimoun also works with similar themes. Many of Zimoun's current pieces are

sculptural installations consisting of large numbers of small motors with attachments to their shafts that strike materials, causing continuous textured, complex polyrhythmic drone like sounds which are borne of the materials, the movement and the space occupied. *157 Prepared DC Motors, Cotton Balls, Cardboard Boxes 60x20x20cm* (2014) and *361 Prepared DC Motors, Filler Wire 1mm (2010)* are just two of a number of similar examples documented on Zimoun's web site (Zimoun 2014) which exhibit a live and real time dynamism of optical and sonic activity.

Figure 2.3. The large sprung stacks of Peter Bosch and Simone Simons' *Krachtgever* (1994)

2.1.3 Sound Objects and Sound Sculpture

Not all sound art foregrounds visible and live animation of materials in the way that these electromechanical examples do. For example, Michael Brewster's *See Hear Now* exhibition in Los Angeles in 2001, presented empty rooms with hidden loudspeakers probing acoustic dynamics through sound propagation, reflection and standing waves, to create a listening experience for the audience. Interestingly Brewster describes his work as 'sound sculpture' though clearly it does not contain any of the traditional elements of

material sculpture that are present in the more object based approaches described above. Brandon LaBelle describes Brewster's work as 'the interaction of sound in space […] to create sculptural presence', and as central to a redefinition of the form and function of the art object, redefining sculpture in terms of an 'expanded field' (La Belle 2007: 167). Sculpture, says Labelle in regard to Brewster's work, 'in remaining pure wave and sonic resonance exists solely inside and against the humming of the ear canal' (Labelle 2007: 168). Although themes of architectural space, resonance and hence arguably material run through the work, LaBelle's reading emphasising the central role of the listener and the ear canal within the space seems appropriate. This reading highlights an internalised listening experience where sound as a material in itself is the only material forming the work. Other approaches to, and analysis of sound making, which work as a useful contrast to electromechanical approaches, include the work of Pierre Schaeffer whose acousmatic sonic objects ('objet sonore') of Musique Concrète are removed from their source, specifically lacking any real world or hard material context (see Hamilton 2007: ch4, Kane 2007). As with Brewster's use of the term 'sculpture' to describe his purely sound based work, Schaeffer's use of the term 'object' is at odds with how the term may be thought of in relation to electromechanical approaches. Like Brewster's sculptures, Schaeffer's object is a perceptual sonic object, not one that can be seen, felt or sensed in any other way than by the ear. Ethan Rose aligns this 'dislocation of listening from the other senses' (Rose 2014: 66) that is evident in Musique Concrète to a more general modernist scheme of idealised and absolute sound and listening, which was further enabled by sound recording and sound synthesis technologies, particularly in the first half of the twentieth century.

Clearly these types of creative sound making, concerned purely with sound itself and existing solely inside the ear canal, are quite different to the more materially present and object based sound sources of the electromechanical approaches being explored here. Connor (2011) offers a useful contrast between the two approaches that could be described as material or object based on the one hand, and phenomenological or acousmatic on the other:

> 'In both cases there is a commerce between sound and shape whether in the form of a shaping of time, or in the form of a kind of precipitation of sound in form' (Connor 2011: 134).

Vadim Keylin (2015) draws the same conclusion to Connor when he identifies two branches of sound sculpture, one where 'sound itself is being sculpted' and one that represents 'music's undeniable unity with its material source' (Keylin 2015: 188). These useful insights clarify the nature of the two possible approaches, both of which can legitimately appropriate terms such as 'sculpture' and 'object'. Electromechanical sound art fits the second of Connor and Keylin's cases as it appropriates hard materials and objects as organisational agents, sounding bodies and sculptural forms that can be thought of as precipitating the sound that emerges from them. Sound as a material in itself on the other hand, as described through the work of Brewster and Schaeffer above, shapes time, according to Connor's scheme. Of course not all works have to fit neatly or exclusively into one or another of these two categories suggested. Some kinetic and electromechanical approaches could be said to explore a 'shaping of time' through sound, alongside their presentation of materials, objects and their sound producing activity. The two approaches described could be taken as much as critical and analytical positions than as categories or types of artwork.

2.1.4 A note on Autonomy

The theme of autonomy was originally introduced to this project in order to simply discern between the area of electromechanical sound sculpture under investigation here and other closely related areas of creative activity such as electromechanical, sculptural and custom made musical instruments. For example, the Bashet Brothers' *Sculpture Sonores* (since 1952) and composer Harry Partch's instruments (since the 1930s) represent an area of sculptural musical instrument making occasionally described simply as sound sculpture (see Licht 2007: 201). These examples explore the connection between sound and its material source, something that Partch termed the 'corporeality of music' (see Keylin 2015), but they are not electromechanical, they require a good deal of human interaction to make sound, and therefore are not considered autonomous. Thaddius Cahill's late 19th century, industrial sized *Telharmonium* provides a very interesting example of an installation-like electromechanical endeavour but again it was conceived of as a musical instrument and despite the large amount of electrical power required to fire up the industrial sized machine, the control was provided by human interaction.

The distinction between autonomous and non-autonomous examples, however, becomes more difficult with regards to programmable electromechanical musical instruments such as the player piano. Used in a commercial context since the turn of the 20th century (see Bijsterveld 2008: 154) these devices also became a tool of choice for some experimental composers including George Antheil, Percy Granger and Conlon Nancarrow. There are many worthwhile connections to make between this lineage of experimental music making and the more sculptural electromechanical sound art of specific interest here. These connections are evidenced by sound artists including Trimpin, whose *Conlon in Purple* (1997) consists of a large installation of resonant wooden and metal bars excited by an electromechanical mallet system, Felix Thorn who makes modern orchestrion machines as the *Felix's Machines* project, and Godfried-Willem Raes who among many other pieces has over recent years developed the *Robot Orchestra*. All these examples draw out the inherent aesthetic of electromechanical music making machines through a context of gallery installation and performance.

This particular area of practice begins to help identify the more subtle concerns of this project regarding the theme of autonomy. Rather than just describing something that operates of its own accord, the theme also raises questions around the programmability and control of materials in electromechanical sound making installations. The examples discussed above, by Lucier, Tudor, Bosch and Simons, and Zimoun, allow a certain freedom for materials to express their own voice through unpredictable, resonant and at times difficult to control material activity. Player pianos and orchestrions meanwhile share a lineage with other types of automata and programmable machines such as Athanasius Kircher's water organ (1650, figure 2.4) which, following Zielinski (2006), it is possible to situate as part of a history of programmatics and control. This leads directly to approaches in sound and music that speak more of the accuracy of mathematics and computers than the unpredictability of materials. Karen Bijsterveld notes that these mechanical musical instruments 'reduced the expression of music to mathematical systems' (Bijsterveld 2008: 154) and allowed for a level of control that reinforced the position of the 'autocratic and infallible composer creator' (Bijsterveld 2008: 150 quoting Taruskin 1995: 167). The way in which these subtly different approaches to sound making with electromechanical devices parallel, contrast and reflect on each other is explored throughout the project and through the other two core themes – materials and systems.

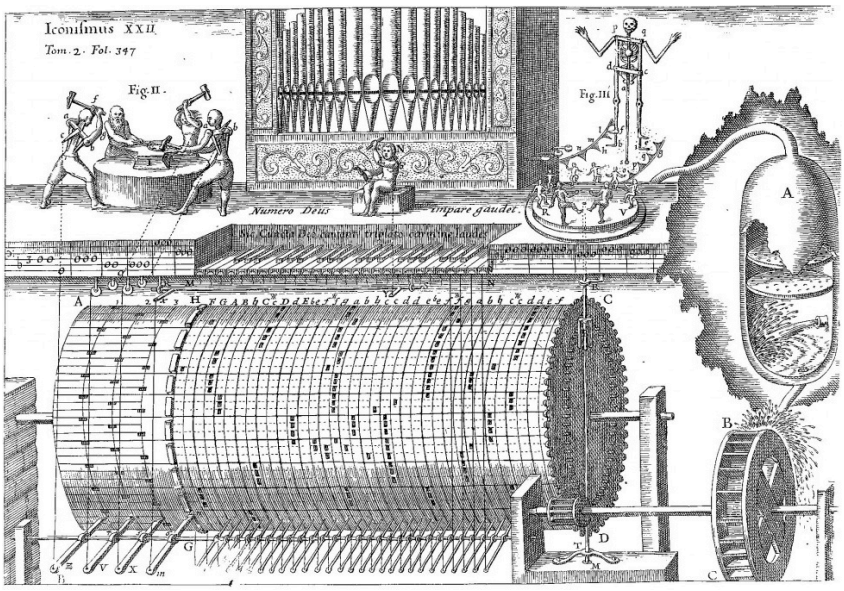

Figure 2.4 Athanasius Kircher's Water Organ of 1650 (see Zielinski 2008: 127) [CC BY]

2.2 MATERIALS AND DEMATERIALISATION IN MUSIC AND ART

2.2.1 Dematerialisation in Art

> The disintegration […] is obviously implicit in the break-up since 1958 or so of traditional media, and in the introduction of electronics, light, sound, and, more important, performance attitudes into painting and sculpture – the so far unrealised intermedia revolution whose prophet is John Cage.
> (*The Dematerialisation of Art,* Lippard, Chandler 1968: 48)

> Over the last ten years rather surprising things have come to be called sculpture: narrow corridors with TV monitors at the ends; large photographs documenting country hikes; mirrors placed at strange angles in ordinary rooms; temporary lines cut into the floor of the desert
> (*Sculpture in the Expanded Field,* Krauss 1979: 30)

Art critics Lucy Lippard, John Chandler and Rosalind Krauss capture the milieu of cultural activity in the art world of the 1960s that gave rise to the interaction between music and art and that allowed for the possibility of sound art. Lippard and Chandler's essay, titled *The Dematerialisation of Art,* pointed to a transition that was happening at that time through the work of practitioners who were moving away from media specific, object based, formalist outcomes and towards 'dematerialised', multimedia and multisensory work involving sound, light, electronics and ideas. It is worthwhile reviewing some of these shifts before comparing them to a different trajectory that can be identified

within some concurrent experimental music practice, in order to further understand the emergence of kinetic and electromechanical sound art.

The ‘performance attitudes’ that Lippard and Chandler refer to can be aligned to themes of ‘theatre’ and ‘theatricality’ within the arts, terms whose use Seth Kim-Cohen traces to John Cage in 1957 (Kim-Cohen 2009: 33). This emergence of the idea of theatricality and performance within art provides a convenient lens through which to consider performance based ‘happenings’ and Fluxus events of the 1950s and 1960s, but the terms can also describe the way in which certain gallery-based artworks can extend their reach beyond a plinth or picture frame, interacting with an audience or an environment. This was achieved in a number of ways, for example, through space with the large minimalist form of Carl Andre’s *Lever* (1966) or Robert Morris’ *Untitled* ‘L’ beams (1966), through light, as with Dan Flavin’s fluorescent tube installations (see figure 2.5) or through sound with pieces by Takis, Jean Tinguely and Len Lye (discussed below). The idea of theatricality is also, according to Kim Cohen, almost synonymous with Fluxus artist Dick Higgins’s term ‘intermedia’ (Kim-Cohen 2009: 33), which he defined in a 1965 essay as work that ‘falls between media’ (Higgins and Higgins 2001). The *Intermedia Chart* (figure 2.6) shows a Venn diagram of various art practices including performance, objects, poetry and music among many others, all held within the same intermedia field.

[Image removed for copyright reasons.]

Figure 2.5 Untitled (1964) by Dan Flavin

[Image removed for copyright reasons.]

Figure 2.6 Dick Higgins Intermedia Chart from1995 (Higgins and Higgins 2001)

Krauss' notion of the 'expanded field' of sculpture also points to these same intermedia tendencies of dematerialisation and theatricality while identifying with larger architectural, environmental and land based art. Sculpturally such larger scale approaches can include a sense of place and site specificity rather than just representing an abstract notion of a material construction on a plinth. Krauss observes how this sense of place detracts from the more traditional modernist notion of an artwork's 'autonomy' (Krauss 1979: 34). The term autonomy, in this context, refers to the potential for art to exist and have value and meaning aside from external or environmental factors. Krauss also considers this 'expanded field' as the emergence of postmodernism (Krauss 1979: 44) and certainly it brought about work that was challenging to more traditional modernist values. In his 1967 critique of Minimalist sculpture titled *Art and Objecthood,* Michael Fried considers tendencies towards theatricality as a negative development reflecting the 'degeneration' of art (see Kim-Cohen 2009: 33, Joseph 2007: 46, Fried 1967). Seth Kim-Cohen (2009) and Branden Joseph (2007) highlight how Fried's critique upholds modernist values placing importance on considerations such as a defined material media and the need for the fixed spatial delineation of an artwork.

The trajectory of dematerialised art is presented by Lippard and Chandler as ultimately pointing towards conceptual or 'idea' art, typified by the work of Joseph Kosuth (for example *One and Three Chairs* 1965), where the 'object may become wholly obsolete' (Lippard, Chandler 1968: 46, see also Kim Cohen 2009: 37). Interestingly they align this to a situation in the sciences where mathematicians or scientists may make claims regarding the 'beauty' of an equation (Lippard, Chandler 1968: 48). Parallels may be drawn here with other emerging tendencies of the time such as software and systems art, which was developing within a burgeoning world of computer technology. Christoph Cox (2013) observes how this path to conceptualism favoured a critical program primarily concerned with ideas, discourse and language that dominated visual art through the 1970s and 1980s and that assumed access to real materials was only a fundamentally discursive possibility.

2.2.2. Kinetic Sound Art as a Transitional Form

These transitions and tensions between material-specific plinth-mounted art, and dematerialised expanded art, provided fertile ground for the emergence of a wave of kinetic works that presented sound as a key feature. The work of Jean Tinguely, Len Lye and Takis discussed below concerned itself with the dematerialised and expanded nature of sound (and other energetic forms) as it emerged from a clearly presented material source. The way in which this was achieved was through electromechanical animation, a localised technological theatre, which was active and autonomous.

Tinguely's *Radio Sculptures of* 1962 (titled *Radio Drawing* in Burnham 1968: 246 see figure 2.7) consisted of deconstructed radios resembling biological specimens, emitting sound, which was kinetically and autonomously modified by electromechanical devices fitted to the tuning dials and volume controls. Burnham describes the work as reliefs as well as sculptures in the New York exhibition of 1962 where a number of the radios were exhibited together, seeming to 'communicate with each other – by whisper, hiccup, or a news report, transformed into an eerie howl' (Burnham 1968: 245). One or more of the pieces were also exhibited the same year in Amsterdam (Hulten 1987: 121). Hulten describes the work as taking Tinguely's 'mastery of "immaterial" materials to prodigious heights' (Hulten 1987: 121). Tinguely had been using sound within his kinetic sculpture since the 1950s in works such as his *Sound Reliefs* (1955, part of his *Meta-Matic* reliefs)

which involved the production of sound through the kinetic striking of saucepans, jars, glass funnels and wine glasses by light hammers (Hulten 1987: 28).

[Image removed for copyright reasons.]

Figure 2.7 Tinguely's *Radio Sculptures* (1962)

The Greek artist, Takis, who spent much of the 50s and 60s working in London, Paris and the United States, including a stint as resident artist at MIT from 1967, was also interested in immaterial materials and the 'unseeable energies of nature' (Anderson 1968: 23) such as electricity and magnetism. In 1963 Takis' interests in magnetism, electricity and sound were brought together in a collaboration with composer Earle Brown titled *Sound of the Void* where electromagnetic fields were used to energise a needle to strike a string creating a repetitive musical refrain. This was followed by other electromechanical and electromagnetic sound producing sculptures such as *Magnetic Pendulum Musical* (1965) (Anderson 1968: 30) and *Electro-Musical Relief* (1966) as well as, later, his electro-musicals, which put several needle and string works together, amplifying the string across stretched canvasses (Licht 2007: 201). Anderson (1968: 16) recounts an encounter between Takis and figurative sculptor Giacometti in 1959:

> Takis showed Giacometti a small work of his, a magnet attracting a needle. Giacometti was at first furious that Takis called his work

> sculpture. He said he understood what Takis was doing, but rejected it as art as it made use of energy rather than material. Giacometti proudly admitted to being the last of the figurative sculptors… (Anderson 1968: 16).

The scenario captures perfectly some of the forces at play during this time within sculpture where the modernist world of hard material was giving way to a new approach using softer, invisible and energetic materials.

Len Lye, whose work from this time, like Takis and Tinguely, is broadly recognised as kinetic art, also worked with magnetism and sound, resulting in pieces that were 'half material and half pure energy' (Burnham 1968: 269). Lye's, *The Loop* (1963*,* also titled *Universe,* see figure 2.8)*,* is a twenty-two-foot strip of polished steel formed into a band, which is both tethered and energised by a strong electromagnet inside a plinth. The steel emits tones and harmonics as it rocks and wobbles around on its plinth, occasionally lurching up high enough to strike a ball suspended above it, causing a different set of sonic behaviours. The piece, described by Burnham (1968: 270) 'dances to a weird quavering composition of its own making' and serves as a good example of how Lye's work is controlled by the 'dynamical properties of the materials used' (Burnham 1968: 274).

[Image removed for copyright reasons.]

Figure 2.8 Len Lye's *The Loop* (1963) is controlled by 'dynamical properties of the materials' (Burnham 1968: 274)

The interesting thing to note about these examples apart from their kinetic qualities and their use of sound, electricity and magnetism as materials within sculpture is their comparatively modernist and formalist tendencies. They hold onto the notion of objects, plinths, reliefs and relatively traditional modes of presentation in comparison to some of the more expanded and dematerialised activities described above, such as concept or landscape art. They challenge and question the nature of materiality in art by introducing and foregrounding materials such as magnetism, electricity and sound but they do so in a way that is broadly recognisable, in modernist terms, as sculpture. These examples are exemplary of some of the transitionary events that were at play in the 1960s with regard to the requisition and rethinking of materials for use within art and design. Like the scenario described above with Takis and Giacometti they are the early rumblings of dematerialisation and expansion; plinth mounted or relief presented 'performance' and 'theatre' of unusual materials that quite literally 'fall' between traditional media. Here, electrical fields, magnetic fields and sound appear in the gaps between traditional materials such as metal, wood and ceramics. Far more challenging and expanded art practice was emerging during the 1960s such as the completely non-existent materialities of conceptualism and the ever changing and expansive materials of land art, but the examples described here from Tinguely, Takis and Lye can be viewed as a departure point for such dematerialisation and expansion. A characteristic of the electromechanical approach is that it exists within this transitional place, both in terms of material and energetic shifts between electricity, magnetism, mechanical force and sound, and in terms of its creative context, existing somewhere between material specific and dematerialised or expanded art. In this way it is possible to think of electromechanical transduction as a technical metaphor for some of the cultural shifts that took place around the emergence of sound art.

2.2.3. Materialisation Within Music

In the milieu of activities described above it is possible to see how musical thinking and association was present within activities primarily thought of as belonging to the plastic arts[1]. It is also possible to identify at the same time, an opposite trajectory of object based and material thinking and association emerging from within the field of

[1]The term 'plastic arts' originally referred to art forms that involve the physical manipulation of plastic materials such as clay. The term also is applied more broadly to all visual arts.

experimental music and composition. Through the 1960s composers including David Tudor, Alvin Lucier and Steve Reich, began to consider and forefront the objects, materials and technologies of sound and music making within their creative activities, through compositions that began to appear more like object based installations and kinetic sculpture than traditional musical performance. Ethan Rose (2014) identifies this tendency as a reaction to modernism's rationalisation and separation of the senses. Rose observes that such forms as the 'absolute music' of the romantic era, and later, Musique Concrète promote an 'ideal rationalised "non-place" that focussed attention away from the other senses and into the domain of the ear' (Rose 2014: 65). Steve Reich's *Pendulum Music* (1968, described below) and Lucier's *Music on a Long Thin Wire* are, on the other hand according to Rose, 'sound installations meant to translate the tools of the recording studio into a visible bodily presence' (Rose 2014: 66) bringing about an aesthetic to be experienced through dynamics of space and form as well as sound. The modernist notion of media specificity, when applied to music, implies a purity and isolation of the listening experience. The multimedia and intermedia sensibilities of the 1960s, which allowed sound into the world of sculpture, also allowed physical objects and materials into the musical canon (see Kim Cohen 2009: 39 re media specificity in music).

This emphasis and interest in the material technologies of music making identified by Rose is reflected in a comment from Cage following the production of *Variation V* in 1965: 'one could view composition as activity of a sound system whether made up of electronic components or of comparable components (scales, intervallic controls etc.) in the mind of man' (Nyman 1999: 91). *Variation V* and similar highly technological performance events such as the *Nine Evenings of Theatre and Engineering* event of 1966 offer one possible starting point to explore the 1960s' emergence of composers turning to technologies, objects and materials within compositional practice, while other antecedents such as Cage's *Imaginary Landscape No. 4* (1951) for 12 radios and *Cartridge Music* (1960) also exist. This general area of practice can be partly thought of as 'live electronic music' (see Collins 2007: 46), and it remains a vibrant area of activity today. What is of particular interest here is the way that this approach allowed for the emergence of musical works that became more focussed on sound producing materials, more autonomous and stand alone, requiring less input from performers, and that began to resemble and intersect with modes of practice such as kinetic sculpture.

David Tudor was a key figure in these developments as he set about gaining enough electronics knowledge to build his own audio tools and instruments, believing that 'new object specific, intrinsically electronic, musical material and form would emerge as each instrument took shape' (Collins 2007: 46). Collins notes that this ethos of music implicit in technology served as a paradigm for much American electronic music of the 1970s (Collins 2007: 46). Tudor's first piece of this nature was *Bandoneon!,* performed at the *Nine Evenings of Theatre and Engineering* event of 1966, consisted programmed audio circuits, moving loudspeakers, television and lighting all triggered by a bandoneon concertina, in an elaborate interactive and responsive electronic system. Tudor described the piece as a 'combine' using 'no composing means, since when activated it composes itself out of its own composite instrumental nature' (Tudor quoted in Kuivila 2004: 17). Kuivila points out the term 'combine' is significant as it detracts from the idea of Tudor as a composer, instead presenting him more as a collaborator in an interactive situation, alongside the materials and technologies. After *Bandoneon!* Tudor went on to develop the more overtly sculptural and installation-orientated piece *Rainforest* from 1968 onwards. From his hands on experience with electronics as the materials and tools for sound making, Tudor developed the Rainforest installation, making the relationship between sound and the 'bodily presence' of materials more explicit and visible to an audience who may not be expert users of studio tools (see figure 2.9).

Figure 2.9 Children experiencing the 'bodily presence' of Tudor's sculptural speakers in a 1979 outing of *Rainforest* (Driscoll and Rogalsky 2004)

This more democratic relationship between composer, performer and the musical materials and technologies of sound production can also be identified as a theme in Steve Reich's *Pendulum Music* (1968). Here, performers release microphones, suspended by their cables, such that they swing in a pendular motion above loudspeakers to cause short bursts of audio feedback. These short bursts develop a complex rhythm in relationship to each other, then gradually increase in duration as the microphone pendulums slow down, ultimately arriving at a continuous howling as the pendulums come to rest and the piece is complete. The role of the performer here is reduced to a single energetic impulse to begin the piece giving grounds to the possibility that Pendulum Music is very close to a piece of performing kinetic sculpture. Interestingly in 1969 Reich claimed that 'whether a musical process is realised through live musical performance or electromechanical means is not finally the main issue' (Reich 1969: 305), also stating that when working with electromechanical sound equipment it is natural to think about such musical processes as are used in pendulum music (Reich 1969: 305). This last point provides evidence for Rose's idea that in these works, the tools of the recording studio are appropriated as a 'bodily presence' of performance. Prior to *Pendulum Music* Reich had explored similar musical methods of phased rhythmic relationships in the studio using tape loops in the pieces *Come Out* (1966) and *Its Gonna Rain* (1965).

The best examples of Alvin Lucier's work which illustrate this merging of composition, sounding materials and sculptural installation are a little later than the previous examples, with *Music On a Long Thin Wire* dating from 1977. Lucier had, however, been foregrounding the materials of sound technology since the mid 1960s with pieces such as *Music for Solo Performer* (1965), an elaborate performance system that amplified alpha brain waves and used the resulting signals to energise loudspeakers which were mechanically coupled to percussion instruments. The noteworthy thing about *Music On a Long Thin Wire* in the context of composition merging with sculptural installation, is how the work was initially conceived as a performance piece but in later versions has been presented as a purely autonomous installation. In installation mode the role of any performer selecting pitch and amplitude on an oscillator to explore acoustic properties of the wire, is replaced by the behaviour of the wire itself which is in turn affected by such environmental factors as ambient temperature, humidity, the audience walking on the

floor that the apparatus is standing on, and in one case, rain, all of which contribute to the resulting sound. (Lely and Saunders 2012: 262).

A few years after *Music on A Long Thin Wire* Lucier's score for *Music for Pure Waves, Bass Drums and Acoustic Pendulums (1980)* included the possibility of an autonomous installation version of the work. Here, four bass drums are set up, each with a ping pong ball pendulum resting at the centre of its skin. Loudspeakers placed behind the drum skins emit tones that cause the drum skins to vibrate and hence cause the ping-pong balls to bounce, creating rhythmic patterns. In the performance version of the piece the performer slowly sweeps an oscillator upwards drawing out the various resonances and rhythmic possibilities within the physical system. In the installation version the oscillator is set to a frequency common to all the drums, and the behaviour of the materials takes centre stage, again affected by environmental conditions altering such factors as the tensions of the drumheads, and hence the pendular motion and rhythmic behaviour of the ping pong balls.

Both these works illustrate Lucier's well documented interest in the physical phenomena of sound and its related apparatus of production and transmission. As Cox notes, his work often 'does little more than frame scientific experiments in an artistic context' (Cox 2012: 180) and Lucier himself admits to an interest in the 'poetry of what we used to think of as science' (Lucier 1995: 194). *Music on a Long Thin Wire* began as a collaboration with physicist John Trefny and *Music for Pure Waves, Bass Drums and Acoustic Pendulums* is, according to Lucier, 'simply an orchestration of an experiment discovered in a college textbook' (Cox 2012: 185). With a clear focus on the sonic potential of the materials themselves Lucier is, at times, keen to keep the interfering hand of a performer or composer at bay. In conversation with James Tenney (Lucier 1995: 232) Lucier describes resisting the temptation to alter parameters of the oscillator during a recording of *Music on a Long Thin Wire*, avoiding expressiveness in order to pair things down to their simplest form, exposing the natural phenomena present in the materials and the system.

Lucier explains how *Music on a Long Thin Wire* can be thought of as a deconstructed loudspeaker (Lucier 1995: 186) which, in a similar way to Tudor's *Rainforest*, explores the sonic quality and musicality inherent in a device which in the modernist scheme of

absolute and pure listening described by Rose (2013), would typically be disregarded, hidden away, thought of as sonically transparent and not of aesthetic importance in itself. This disregarding of the loudspeaker is reflective of a hierarchical system within compositional sound organisation, where loudspeakers are thought of as subservient to a higher (typically human) power of compositional control exerted through an electrical signal. But the loudspeaker is a complex assemblage of magnets, electricity, wire and other resonant materials which Lucier foregrounds and explores as a sound-producing device in its own right. Tudor explores the same thing in *Rainforest* which, he said, developed from the basic technical notion that the loudspeaker should have a voice which is not just an instrument of reproduction but an 'instrument unto itself' (Tudor 1988). These works by Tudor, Lucier and Reich that present audio technologies as both instruments and performers, reframe the often hidden materials of an electrically mediated sound culture. In this reframing, exploration and presentation of sounding materials the boundaries between experimental music and sculpture are eroded as described by James Tenney:

> Lucier has always taken great care to design his pieces so that their physical character is not obscured; other elements are made transparent to that physicality. As a result, his music often has a tangible, sculptural quality that is not so apparent in other music (Tenney 1995: 16)

[Image removed for copyright reasons.]

Figure 2.10. The large horseshoe magnet of *Music on a Long Thin Wire* in a 1995 realisation. (Lely and Saunders 2012: 257)

2.2.4. Materials and Dematerialisation Summary

The dematerialisation and expansion of art is a broadly recognised cultural shift, theorised by writers including Lippard, Chandler, Krauss that offers a narrative for the rise of expanded art practice since around 1960 which allowed for the use of light, movement, sounds and concepts as artistic materials. The emergence of musical approaches that foreground materials and objects rather than or as well as, scores, recordings and human performers is an influential area of musical practice which gathered pace with an American wave of activity in the 1960s, centred around Cage, Tudor and the *Sonic Arts Union*[2]. Both developments were a reaction to a previously established modernist desire for media specificity in the arts. Despite the apparently different natures of these trajectories within music and art they were concurrent and intersecting. This intersection happened when the art world woke up to the possibility of sound as a part of the manifestation of more dynamic, kinetic and energetic approaches, and when music acknowledged the importance of materials and objects as key players in sound making activities. In certain cases, the results from these two fields of activity appear remarkably similar. It is this point of intersection that provides one specific context within which electromechanical sound art exists.

2.3 SYSTEMS

2.3.1. Systems Overview

> The system itself is pure abstraction, an assembly of isolable properties studied in terms of their transformations, either alone (closed) or in relation to other systems (open). (Burnham 1968: 318)

The idea of systems, deriving from the general area of systems theory, is another core theme that links kinetic art and experimental composition. There are certain elements of this field worth highlighting in relation to electromechanical sound art whilst accepting that this highly expansive topic that has emerged from the sciences to proliferate a number of genres can not be fully reviewed in detail (see Clarke 2011 for useful general overview). Of specific interest is how systems and processes play out in art and music, something that was explored during the 1960s and beyond, by practitioners already

[2] As described in 2.1.1, the Sonic Arts Union was formed in 1966 by Alvin Lucier, Gordon Mumma, David Behrman and Robert Ashley

identified as important to this project. At the same time as this creative and cultural tendency systems began to replace hardware as a dominant force in computer technology (Alt 2011), providing a specific technical turn useful in contextualising electromechanical sound art. Also, themes of systems engineering, an emphasis on relationships, complexity and the construct of 'black boxing' which will be explored below, emerge as systems related topics which are important for the context, theory and practical undertaking of this project.

The succinct summary above of the idea of a system appears in Jack Burnham's *Beyond Modern Sculpture* (1968) in which the world of twentieth century sculpture is explored in two parts: *Sculpture as Object* including sections on constructivism, formalism and vitalism, and *Sculpture as System*, exploring kinetic, light and cyber art. Burnham traces his ideas connecting systems thinking to art practice and criticism back to the work of Ludwig Von Bertalanffy who since the 1930s had developed systems theory within the field of biology, as an alternative to the previously established and opposing views of the natural world as either a purely mechanistic or purely vitalistic place. Bertalanffy's systems perspective prioritised the notion of relations above individual objects allowing for the study and recognition of the complex and multileveled organisation of those relations: 'we have learned that for an understanding not only the elements but their interrelations as well are required' (Bertalanffy quoted in Skrebowski 2006: 4 also see Burnham 1968: 317). Related areas of development within the sciences accompanied Bertalanffy's theories, including cybernetics, most notably with Norbert Wieners *Cybernetics or Control and Communication in the Animal and the Machine* (1948), information theory, a relevant example of which would be Claude Shannon's model of communication (1948, see figure 2.11), and game theory.

[Image removed for copyright reasons.]

Figure 2.11 Shannon's model of a general communication system as it first appeared in the *Bell System Technical Journal* in 1948 (Shannon 1948)

The development of computing power and programming languages during the 1950s and 1960s were important in the application of these systems orientated approaches. Computers were viewed in this context as 'universal machines theoretically able to solve any problem that could be formulated precisely enough' (Edwards 1989:149). The computer itself, and the increased levels of computing power and complexity that came about in the 1950s and 1960s were also key achievements of a systems approach to technological design. Alt (2011) points to a moment in the 1960s when, with the rise of object orientated programming languages, the computer system became a medium in its own right aside from any hardware media objects or materials such as punch cards or magnetic tape. According to Alt, this is the point at which the system itself becomes the medium; a situation commonly identified today through the general term 'digital media'.

With enthusiastic support from the American military industrial complex, these fields conspired towards a general drive to try and understand and control the world through mathematical formalisation, computing and technology. These tendencies extended to the social, cultural and political realm through systems approaches to areas such as urban planning (see De Monchaux 2011: 299) and defence strategy. This more diffuse field of systems thinking, design, engineering and other systems inspired activities is what Edwards (1989) refers to as a systems discourse:

> This extension of mathematical formalisation into the realm of social problems brought with it a sense of new found power, and hope for a technical control of social processes to equal that achieved in mechanical and electronic systems…Systems discourse included not only the formal techniques and tools of the systems sciences, but also this ideology and language of technical control' (Edwards 1989:149)

And it is possible to situate Burnham's *Beyond Modern Sculpture* in this general ideology and language of technology and control, whilst also recognising the specific connection Burnham makes to Bertalanffy, with whom he shared a publisher (see Skrebowski 2006: 3).

An important element in the systems approach is the concept of black boxing. This practical and theoretical construct represents the idea of hiding a complex arrangement of things (materials, objects, ideas) inside a box, which then only presents a simple input and output on its exterior shell for a user, or for fitting into a larger system. A black box

both contains a system, and fits neatly into a larger system as an object. It is clear to see how such a move is necessary if complex relations of an overall system are the main concern, being brought into focus at the expense of any agenda of individual objects or subsidiary elements. Nicholas De Monchaux (2011) gives an illustration of how systems thinking and black boxing played out in the mid 1950s within the U.S air force inter-continental ballistic missile programme. The Western Development Division (WDD), charged with designing the missile, implemented a then radical reorganisation in the way of approaching such a project. Instead of building the technology themselves, WDD produced no physical artefacts, rather, they established themselves as a 'new kind of military contractor, a "systems engineer"' (De Monchaux 2011: 46) integrating and supervising the work of a number of public and private entities. WDD delegated the development of subsystems to contractors, specifying exactly what substance they conveyed to each other, the inputs and outputs, 'fuel, thrust, guidance information, structural support and so on' (De Monchaux 2011: 46). De Monchaux describes the scenario when each component subsystem was ready for testing:

> When teams of engineers from subcontractors gathered to assemble the missile system in prototype form individual components were boxed, often in black emphasising and revealing only their connections to each other (De Monchaux 2011: 46).

It is interesting to note that the organisation of power and communications within WDD with the centralised control of subcontractors as black boxes of the production process, and the technical assembly of the missile itself, both reflect a systems approach, seeking to hide messy internal workings of particular elements.

2.3.2. Systems in Art

These scientific and cultural shifts towards a focus upon relations and energetic transference echo the tendencies of dematerialisation within art practice outlined above, and this serves as a broad context for Burnham's adoption of systems to describe post formalist art. More specifically, Burnham used systems as a way of understanding a breadth of artistic activities in a few different ways. Firstly, by examining conceptual and environmental artworks, performance, happenings and minimalist sculpture, Burnham's systems aesthetics looked to the relations that such practices interrogate between elements such as the artwork, the audience, space, nature and economics. Examples from his two *Art Forum* articles of 1968 and 1969 include pieces such as Dennis

Oppenheim's *September Wheat Project* (which involved growing, buying and selling wheat); Hans Haacke's *Chickens Hatching* (fertilised eggs, incubators, lamps, thermostat, dimensions variable); and Allan *Kaprow's Fluids* (1967), a 'Happening' involving the construction of ice structures. All pieces that are well disposed to reflect relations within both natural and man made systems.

Secondly Burnham discussed artworks that used the burgeoning technologies of interactive electronics and computing highlighting systems aesthetics through systems engineering and technology applied to art practice in early cybernetic, interactive and computer and software based artworks. Beyond Modern Sculpture includes a chapter on *Robot and Cyborg Art* with examples such as Nam June Paik's *Robot-K456* (1965) with radio control, and an account of the *9 Evenings of Theatre and Engineering* event, previously discussed in relation to Tudor's *Bandoneon!* performance. The event was a technologically enabled season of music and performance that was borne out of a collaboration between Bell Laboratories physicist and systems engineer Billy Klüver and artists Robert Rauschenberg and John Cage. Klüver had been introduced to the artists through Jean Tinguely in 1960 (Miller 2001: 552) with whom he had also collaborated. Klüver had also previously worked with Max Matthews (also from Bell Labs) to help realise Cage's *Variations V* in 1965. Such collaborative relationships are an insight to the direct influence systems engineering had on the world of music and art during the 1960s.

A third area of activity that Burnham keenly outlines as systems art is the remote and depersonalised manufacture of artwork, which he illustrates with an example of Robert Morris sending plans to the carpenters of a Chicago museum for the fabrication of an artwork which already existed, such that the work could be remade for less than the cost of shipping the original (the piece was *Untitled*, 1966 exhibited at the 68th American Exhibition). In the context of a systems aesthetic, writes Burnham, 'accurate information takes priority over history and geographical location' (Burnham 1968: 32). A neat end scene to Burnham's late 60s systems aesthetics is his curating of the show *Software* at the Jewish Museum in New York in 1970, which was a combination of computer driven and conceptual artworks (see Shanken 2012: 59). He went on to adopt a general scheme of structuralism and semiology in his writing (Skrebowski 2006:5), and ultimately became very critical of the role of technology in art (Shanken 2012: 60) before disappearing form the art world altogether. Described by Skrebowski (2006) as a

'mercurial' character, Burnham's work has become influential in recent times with regards to the history and theory of digital and interactive arts.

2.3.3. Critiques and Cracks in the System

Burnham's writings on systems aesthetics are considered by some to be problematic. They often prompt criticisms of holding a technologically determinist position, and of being awkward in their attempts to align the language and ideals of systems technologies to the art world (Skrebowski 2006). In 1968 Rosalind Krauss criticised *Beyond Modern Sculpture* on its publication, and later, described it as upholding a 'technocratic' and 'mechanistic' stance (Krauss 1977: 212). Some of these criticisms reflect the perceived shortcomings of systems discourse in general, with its promise of technological solutions to all that is problematic in the natural world, aptly described by De Monchaux:

> Whether body or city, attempts to reduce organic organised complexity to single inputs and outputs fall prey to the same ambition as the militaristic acronyms that permeate such explanations. They flatten multiple complexities to create a world 'atomised and redesigned… spare and letter-sleek (De Monchaux 2011: 310)

Even Bertalanffy himself was wary of the technological appropriations and adaptations of his original systems theory, warning against attempts to create any direct equivalence between biology and technology:

> The humanistic concern of general systems theory as I understand it makes it different to mechanistically orientated system theorists speaking solely in terms of mathematics, feedback and technology and so giving rise to the fear that system theory is indeed the ultimate step towards mechanisation and devaluation of man and towards technocratic society (Bertalanffy quoted in Skrebowski 2006)

Despite these potential pitfalls and the criticism of a wholesale systems theory or systems discourse for art practice in the late 1960s, there are particular points of interest in Burnham's writings, and the thinking that surrounds them. Much of what is valuable in Burnham's work in the exploration of electromechanical sound art comes from the fact that his ideas were developed at the 'crucial intellectual hinge point' between the modernist self contained object and 'postmodernist multifaceted open-endedness' (Skrebowski 2006). This points to a similar transitionary line between media specific

material artworks, and artwork as energy, information or concept, which has been described above. It is valuable to read Burnham through these tensions as his ideas and accounts take in a range of relatively traditional (in a modernist sense) artistic approaches whilst also grappling with more emergent trends within the art world of the late 1960s. These tensions, which can be partly understood as the tensions between object and system, the subheadings of the two sections of *Beyond Modern Sculpture*, are discussed in recent critique of Burnham's work (Skrebowski 2006, Chau 2014) and are particularly illuminating in regards to kinetic art.

The strong intellectual currents towards conceptualism, and the technological drive towards digital media, made Burnham cautious in aligning his systems thinking with something relatively traditional like kinetic art, which had been in existence since at least the 1920s. Burnham describes kinetic art as the 'unrequited art' and at times stresses its ties to the 'methods and attitudes of the first age of machines' (Burnham 1968: 280), associating it with movements such as Futurism and Constructivism. Burnham points out, for example, how kinetic work such as Naum Gabo's *Kinetic Construction* (1920) is simply a formalist exploration of space through the fast rotation of a piece of wire creating a three dimensional form from a line. It is on this basis that Christina Chau (2014) argues that Burnham tries to 'sequester' kinetic art from postmodern aesthetics contributing to the 'flagrant dearth' of current critical and historical discourse on kinetics. Burnham does, however, identify a second wave of 1960s kinetics that he distances from earlier kinetic sculpture, and which he discusses in terms of the 'new tendency' and 'field kinetics' (Burnham 1968: 247), through the work previously discussed by Takis, Lye and Tinguely, among other examples including *18 Superimposed Balls* by Pol Bury (1965) and *Continuel-Mobile Suspended* by Julio Le Parc (1962).

Despite and possibly because of these tensions, *Beyond Modern Sculpture* is a thorough account of its time regarding the issues and concerns surrounding kinetic art, with part two (*Sculpture as System*) taking sculpture and automata, kinetics, light sculpture (including many electromechanical and kinetic optical works) and robot and cyborg art as four separate areas, each warranting their own illustrated chapter length discussion. In this way, through working towards a systems account of the transitions occurring within the art world at the time, Burnham offers useful insights regarding the specific concerns of artists working with electromechanical, as well as other techniques,

to produce effects in movement, light and sound from within a pre-digital world of predominantly hardware materials. For example, Burnham discusses problems associated with the programming of events such that they do not become either repetitive as with mechanistic or robotic automata, or completely random (Burnham 1968: 277, 202). Here he points to the effective use of semi-programme based approaches, which generate long non-repetitive cycles from combined smaller linear cycles reflecting compositional approaches used by Steve Reich with his tape phasing pieces, as well as in *Pendulum Music*. Though Burnham does not discuss Reich's music, he does draw comparisons with music (Burnham 1968: 278) when discussing issues of programming events across time.

Another particularly interesting approach to programming that Burnham identifies is that already discussed with regards to Len Lye's work being controlled by the 'dynamical properties of the materials used' (Burnham 1968: 274), an approach he also highlights regarding Takis' work, quoting him as saying 'I follow the indications of the materials, I do not dominate them' (Takis quoted in Burnham 1968: 271). These sensibilities of Lye and Takis that Burnham makes the effort to present are not simply mechanistic but rather speak of a freedom of materials, reflecting Tudor's idea of *Bandoneon!* as a 'combine', a collaboration between humans and technology. These types of kinetic work allow for the real time apprehension of non-human material activity and behaviour through systems and processes involving materials and technologies.

Other relevant discussions in *Beyond Modern Sculpture* that help to unpack and revise possibilities and problems of working with electromechanical approaches to sound, light and kinetics, include issues regarding artists working with scientific and technical knowledge themselves as well as collaborations with systems engineers in order to realise outcomes (Burnham 1968: 281, 360), and comparisons of different artists visions of an electromechanical future (Burnham 1968: 280) ranging from Tinguely's regrets and fears, to Nicholas Schaffer's more optimistic view.

2.3.4. Material Systems - A Closed System Aesthetic

Although Burnham was keen to align his thinking with the most cutting edge art practices and emerging digital technologies of the time, and, as such was keen to distance it from some aspects of kinetic art, he does offer a thorough account of the then current

electromechanical approaches to systems aware art practice. These accounts help to show how not only work that is concerned with relationships in a conceptual, informatic or global and ecological sense can be thought of as systems, but also other more traditional sculptural approaches such as kinetic art, a form that might usefully be considered as a material system. This emphasis on systems that are explored and presented materially was important to Burnham's close friend and associate, the artist Hans Haacke as described by both Skrebowski (2006) and Chau (2014):

> for Haacke it was essential that the real time processes and conceptual systems that were signified in his art, performed on a material level. As Haacke said, "I was primarily what you might call job-orientated. Even in the 60s I wanted things to function in a very literal, physical sense"' (Chau 2014: 72)

> I believe there are sound reasons for reserving the term 'system' for certain non-static "sculptures", since only in this category does a transformation of energy, material or information occur (Haacke quoted in Skrebowski 2006: 10)

Haacke's work does not provide any particularly electromechanical or sonic examples, however his *Weather Cube* (1965, also *Condensation Cube,* figure 2.12) illustrates an interesting problem when thinking in terms of localised, situated and material systems. Here, a clear Plexiglas cube allows water to evaporate, condense and recollect through various compartments within. This process and the subsequent movement of water within the confines of the cube are visible to the audience. Despite the piece having obvious connotations of environmental thinking and the monumental[3] (Haacke in Jones 2011), Haacke claims that the piece reflects his fascination with the 'nearly magic, self contained quality of objects' (Haacke in Jones 2011), calling it 'unthinkable' without physical separation from its surroundings. This last comment from Haacke, points to the idea of the Plexiglas cube as the outer defining limit of the system, the boundary, conceptually separating it from any other systems, turning it into a single object or a black box with clear sides. In Haacke's view, the work, like a traditional scientific experiment, presents the isolated world inside the cube as a stand-alone system to be observed, but that remains independent and autonomous of any observation, reflecting what he once 'confessed' to Burnham which was that he 'liked the separation and autonomy of art' (Jones 2011: 20).

[3] These are themes which are evident in other work by Haacke from the same time, e.g. the land art influenced *Grass Grows* (1967-1969) and wind pieces such as *Blue Sail* (1964- 1965).

[Image removed for copyright reasons.]

Figure 2.12 Hans Haacke *Condensation Cube* (Also *Weather Cube*) in 1967 (originally made1965)

As Jones (2011) points out this separation is, in practice, not possible as both light and ambient temperature from the environment within which the cube is placed both affect the system within the Plexiglas, as does gravity and a myriad of other factors including the audience passing through the gallery space (all black boxes have at least one input and output). But these facts do not stop Haacke pursuing the aesthetic of the box as a closed system or an object. These problems and tensions of an autonomous (closed) system and of an object, presented against and within a larger system, are problems that material and kinetic systems are particularly well placed to explore, as they present the transformation and transduction of information, energy or materials in real time, within a single situated space. Both the highly relational and object specific nature of elements within the system, and the system as a whole, are presented on equal terms and in equal measure. In Haacke's work the black box is, quite literally, made transparent and the invitation is to try and hold the two worlds of object and system in focus simultaneously.

Haacke's cube is a particularly useful example but similar tensions can be found when thinking through other 'pseudo closed', plinth mounted systems such as have been described with Lye's dancing musical steel loop, Takis' electromagnetic experiments and Reich's pendulums (after their initial –human- energising). Tinguely's radios meanwhile

take a simple single feed from a larger system (the radio broadcast) and treat it as raw material within their medium sized, relief mounted world of mechanical relations and electronic components laid bare. The black box of the radio is opened and its localised, closed set of relations is set against the more open system of electromagnetic waves. Even Lucier's thin wire, although often spoken of in terms its open systems nature regarding the effects of temperature and other environmental factors, first appears resembling a scientific lab experiment disclosing its roots in a scientific collaboration, rather like the inspiration for *Acoustic Pendulums* coming from an experiment in a college textbook. Simple lab book experiments such as these tend to assume a closed system until challenged through their practical realisation, when percentages of error from a myriad of real world systems creep in. The tension between closed material system and open and emergent behaviour, which is present in Haacke's cube, also features in much of the work considered here as electromechanical sound art.

2.3.5. Systems and Process in Music

While systems art may appear as a slightly conscious theoretical effort to bring systems thinking and art together during the 1960s, the emergence of an awareness of systems within music was in many ways an easier occurrence with a much longer history. This is possibly due to the inherently dynamic and real time nature of sound and music, making it an art form dependant on shifting relationships between elements such as pitch, timbre waveform and air pressure. Further to this, since medieval times western art music has had its own form of systems management in the shape of the musical score working as a conceptual schema, overseeing, directing and arranging the musical activity of assembled musicians with instruments. According to Goodall (2001) Guido of Arezzo's development of the musical score during the 11th century allowed for the emergence of composers as the first type of conceptual artist (Goodall 2001: 32), while a more general notion of musical abstraction is often traced back to the Pythagorean concept of music as number (Hamilton 2007: 113). Keylin (2015) and Hamilton (2007: 113) both identify the 18th and 19th centuries as a high water mark in the dominance of the score within western art music. Attitudes emerging from this time assume the musical artwork resides in the score, emphasising the importance and authority of the composer above performers or instruments. In this common practice western art music scenario, musicians with their instrumental skill and musical instruments could be seen as black boxes of a sound making nature who fulfil their role dutifully, outputting the correct tones,

at the correct times, according to their received input from the score authored by the composer. Before the advent of sound recording technology the score was also the first kind of fixed media for music, allowing composition to appear as a 'closed work' (Cox 2004:165), itself operating as a black box or object and in turn enabling other systems of economics, exchange and distribution to take effect (see also Cox 2011: 154). It was this western tradition of thinking of music as a purely abstract art form that Harry Parch aimed to counter with his concept of 'corporeal music' by highlighting the physicality of sound making in both the body of the performers and the body of his sculptural musical instruments (see Keylin 2015: 183).

In the first half of the twentieth century other activities also brought the various established systems of music making into question through atonality, serialism, noise, graphic scores, indeterminacy and early electronic approaches to music making. During the 1950s, such approaches were described and theorised by both John Cage, in a series of lectures later published as the essay *Composition as Process* (See Cage 1958, 1978), and Umberto Eco in *The Poetics of the Open Work* (1959). Cage's notion of process and Eco's ideas regarding openness can be understood within a systems understanding of relationships and complexity in art and music. They also emphasise the experimental, dynamic and unknown nature of working in this way. Eco's definition of the open work states that an 'incomplete knowledge of the system is in fact an essential feature' (Eco 2007: 171) in the formulation of such approaches. This 'incomplete knowledge' reflects the use of such methods as chance composition, for example with Cage's use of the I Ching and the tossing of coins to make compositional decisions in *Music of Changes* (1951- see Nyman 1974: 6, Cage 1958: 178), and indeterminacy with regards to performance as with Morton Feldman's *Intersection 3*, where the score allows performers a certain amount of freedom with regards to pitch and duration of notes played (Cage 1958: 179). In these examples it is the unknown nature of coins or performers that forms the incomplete knowledge of the system; they are both, for the composer, black boxes of an unpredictable nature.

The idea of an incomplete knowledge of a system is also present in Cage's definition of experimental music (Nyman 1974: I). The term 'experimental' for Cage, does not reflect steps taken towards the determination of particular knowledge as in a scientific experiment, but rather an 'act the outcome of which is unknown' (Cage 1955 in Nyman

1974: I). Michael Nyman's attempt to define experimental music outlines practical strategies where this unknown outcome may be explored (Nyman 1974: Ch1). Many of the strategies are described as processes:

> Experimental composers are by and large not concerned with prescribing a defined time-object whose materials, structuring and relationships are calculated and arranged in advance, but are more excited by the prospect of outlining a situation in which sounds may occur, a *process* of generating action (sounding or otherwise), a *field* delineated by certain compositional rules.
> (Nyman 1974: 4, italics in original)

The idea of a 'time-object' here is comparable to the formalist art object, a fixed and unchangeable work of art, in contrast to the unknown outcomes that may emerge from relationships within processes and systems. Nyman's use of the term 'field' is also noteworthy. Eco also uses the term in the context of a 'field of possibilities' and also a 'field of relations' to describe the 'complex interplay of motive forces' within the 'complete dynamism of a structure' (Eco 2007: 170), citing the idea of 'field' as coming from physics (Eco 2007: 170). Field, in this context, conjures notions of a whole, unfathomable, array of possibilities and relationships that a given system could throw up, an indeterminate aliveness waiting to play out in some unknown and unpredictable way. The term is also echoed in Burnham's discussions regarding 'field effects' and 'field structuring' within optical and kinetic art (Burnham 1968:253-262). Here also it is used in regards to fields of relations as well as, interestingly, in relation to Michael Faraday's work with the field effects of electricity and magnetism in the early 1800s.

In this scenario of composition through experimentation with process, the composer is one component part of the system, where all components are 'endowed with equal value and dignity' (Eco 2007: 170). Organisation is no longer necessarily defined by a single author resulting in a fixed blueprint for performance, but allows for a continually emergent structure from a field of possibilities. This is the same working method identified by Burnham in relation to some kinetic artists whose goal is to 'create a "situation" in which things can happen rather than an object per se' (Burnham 1968: 271), reflecting tendencies identified previously with Takis following the 'indication of materials', Lye using the 'dynamical properties of the materials' and Tudor using 'no composing means' for the piece *Bandoneon!* allowing it to emerge from its own 'instrumental' nature. The compositions by Reich and Lucier discussed previously in terms of their

foregrounding of materials also apply this creative method and hence are often primarily recognised as systems or process conscious works. This is especially the case with regards Reich's compositions from the 1960s including *Pendulum Music* and his early tape phase pieces, while more generally his compositions are often situated within an American minimalist tradition which itself owes much to this way of working (see Mertens 1983).

Reich articulated this approach in a 1969 essay *Music as a Gradual Process* (Reich 2007: 304) where he describes setting a process up and letting it run by itself. Importantly Reich draws a distinction between processes which run in the moment of the 'sounding music' such as with *Pendulum Music*, and compositional processes which are not discernable by an audience in their moment of reception, as with Cage's use of the I Ching to determine a score for later performance. A piece of music whose process of composition can be comprehended during the moment of reception can be thought of as exhibiting facture, a term that refers to when 'the way in which something has been produced shows itself in the final product' (Moholy-Nagy quoted in Adamson 2007: 59). This is a similar concern to Haacke wanting things to function in a literal, physical, real time and non-static way in their moment of reception, reflecting a sense of seeing the various activities inside a black box of creative production. With Reich's piece this activity is largely the performer-less stage occupied by the materials and technologies of electromechanical sound. Even without a specialist background in electronic audio systems an audience can appreciate that the swinging microphones of *Pendulum Music* are causing rhythmic bursts of sound, which shift in relation to each other as the swinging slows down.

Similarly, with Lucier's *Music for Pure Waves, Bass Drums and Acoustic Pendulums* the system can be appreciated without specialist knowledge, and even *Music On a Long Thin Wire* exposes the components of its operation such as large magnets, for inspection and discovery even if the electromagnetic forces at play are a little more oblique. Many of Lucier's other compositions particularly from the 1960s also fit firmly the description of systems based approaches, as illustrated by Nyman's discussion of his works as 'electronic systems' (Nyman 1974: 105). *Music for Solo Performer* is one such piece as is *I am Sitting in a Room* (1969) which commits a spoken word performance to tape, then sends it through loudspeaker and room and back onto another tape, again

and again until the resonances of the recording system are all that can be heard. The piece is not particularly electromechanical or kinetic in nature but it does exhibit a theme of facture in that the original spoken word part recorded and recycled through the system is simply a description of the process which is taking place: 'I am sitting in a room […] recording the sound of my speaking voice, and I am going to play it back into the room again and again…' etc. (Nyman 1974: 108).

Tudor's compositional approach can also be usefully viewed in terms of systems and process. Working with systems engineers from Bell laboratories during the *9 Evenings of Theatre and Engineering* event coincided with the beginning of his use of electronics in order to realise his musical ideas. Tudor is a good example of the uncomplicated adoption of systems engineering and systems thinking by the music fraternity through the use of electronics. Characters such as Gordon Mumma, Robert Moog and Raymond Scott provide further examples of this nature. Electronic systems have much to offer the world of creative sound making. The emergence of musical scores that 'may be nothing more nor less than a circuit diagram' (Nyman 1999: 91) makes perfect sense in this context, and that is exactly how Tudors score for *Rainforest* appears (see figure 2.13).

Figure 2.13 Tudor's score for *Rainforest* describes the piece as a 'generalized' electronic system

The word 'generalized' at the top of the score describes the systems nature of the diagram. Each component part, such as amplifier, equaliser and mixer is presented as a black box while the relations between these components, the signal flow and process, are clearly shown. The 'object being transduced' is presented as a slightly more transparent subsystem, showing the voice coil, pick up and a transistor stage (source follower) which were necessary to the operation of the sculptural speakers of *Rainforest*.

Such a systems conscious engagement with the electronics of sound making enabled Tudor to conceive the piece through this score. Importantly though, Tudor also hand made his own audio technologies, soldering and handling the component materials that would process sound. This sensibility is reflected in the larger, sculptural scale of *Rainforest* where large lumps of metal and discarded objects process sound mechanically, just as tiny bits of silicon do electronically.

In this way *Rainforest* is an interesting example through which to explore the connections between materials and systems but also to interrogate the terms ‘system’ and ‘process’. As genre descriptions of some experimental music the terms are often interchangeable, just as they are within art, for example with some of the work of Robert Morris from the 1960s (e.g. *Untitled* 1967 – felt). However, it is worth reflecting on the nuances of the terms in relation to creative method. The score of *Rainforest* presents a system, in itself quite complex, but made comprehensible by describing operational black boxes. This system sets up a field of possibilities in the behaviour of the various resonant objects being transduced (bedsprings, cartwheels etc.), in the different signals generated, and in their possible routing and mixing. This system and its field of possibilities are then enacted, explored and played out through a process, a live assemblage of materials, electricity and sound. Thinking through systems brings about theoretical schemes and plans of energetic transduction, schematic connection, even theoretical and scientific formalism, software and computing. When working or living through processes, on the other hand, things vibrate, get hot and noisy, they excite other things, behave erratically and become too complex to capture fully in software code or mathematical formula. Systems have a cool technological connotation as is evidenced by a particular type of ‘systems music’ which is entirely conceived of and made through complex mathematical and computational procedures (see for example Goings 1991). Processes meanwhile have a dirtier material association of physical bodies moving through space. Processes enact systems through materials. The works by Tudor, Reich and Lucier discussed here provide examples of composition that does this using electrical and mechanical activity in real time, in ways which can be autonomous and in ways that exhibit facture and reveal something about their own operation.

2.4 CONTEMPORARY ELECTROMECHANICAL APPROACHES

Many of the key examples and contextual discussion so far has been taken from a canon of creative practice and theory dating from around the 1960s. This has proved a useful era to explore with regard to kinetic art and experimental composition merging to produce a possible historic context for electromechanical sound art. It has also been worthwhile revisiting some narratives and debates which were current during the appearance of key pieces of sound art by practitioners and composers such as Lucier, Tudor and Reich. Also, technologically this era presents a time before widely accessible and advanced computing, a time of open reel tape recording and discreet analogue circuitry, when electromechanical approaches were often an important means to an end in realising a piece of technologically enabled art or music.

As has already been touched upon in reference to more recent works, electromechanical approaches are still current in the contemporary context of gallery based sound art, music performance and composition. Peter Bosch and Simone Simon's large installation based music machines and sound sculptures; Daniel Wilson's 'miraculous agitations' (Wilson 2012) of objects for sonic effect; Andrea Valle's *Rumentarium Project,* described as 'acoustic computer music' (Valle 2013); Ethan Rose's object based sound installations such as *Transference* (2009); Jim Murphy's musical robotics including the 'modular kinetic sound sculpture' *Bacchus* (2012); Martin Riches kinetic talking and music machines such as his 24 Piece Percussion Installation (1988) consisting xylophone bars and electromagnets; Gordon Monahan's works for loudspeakers, kinetic sculpture and piano; Shawn Decker's motorised sound art installations such as *Scratch Studies* (2000); Matt Heckert's sound machines including the *Automatic String Rack* and Zimoun's minimalist kinetic installations are just some of the works from artists using electromechanical approaches who have recently exhibited, released or performed work as well as published written reports in journals such as *Leonardo Music* and *Organised Sound*. The work of other currently active practitioners including Godfried-Willem Raes and the *Logos Foundation's* large mechanical musical theatrics and robotics, Pierre Bastien's kinetic installations and performances such as *Paper Drums* (2004) and *Play Meccano Play* (2010), Max Eastley's *Kinetic Drawings* (2008), and Trimpin's various sound sculptures and installations also represent a longer involvement with electromechanical approaches dating back to at least the 1970s. *Composers Inside Electronics (CIE),* the group set up by Tudor and who performed *Rainforest* throughout

the 1970s, reformed in 1996 and has since made a *Rainforest V* (2009 and 2011). Nicholas Collins, a member of *CIE* and an active practitioner in his own right, has also published the book *Handmade Electronic Music* (Collins 2006) which has done much to revive and keep alive the ethos of the hands on approach to technologically enabled sound making exemplified by Tudor, which has been shown as an important part of electromechanical sound art.

These contemporary artists and writers reference a range of influences on their creative approach including many of the examples already discussed here, as well as the older wave of musical automata and mechanical musical instruments of the 19th and early 20th century such as the player piano. Modernist and Futurist approaches including Luigi Russolo's *Intonarumori* and George Antheil's *Ballet Mechanique* (1926) are also cited as inspiration by some (for example Valle 2013: 243). One thing that clearly makes this body of contemporary electromechanical work seem fresh and relevant is the contrast it makes with the current standard condition of cultural production and exchange in the form of digital media. These works exist outside of, and despite, screen based viewing, music downloading, acousmatic loudspeaker listening and digital sequencing, synthesis, sampling and modelling. In this sense these contemporary works could be read as 'media archaeological' (see Parikka 2012), a theoretical and practical approach to the making of media history and technology that seeks out alternative and non-linear possibilities and narratives. This connection is reflected by Wilson (2012):

> Electro-mechanical means to generate, mutate and process tone may seem a cumbersome retrograde step but it is in fact a logical progression. Equipped with concepts acquired from the analogue/digital electronic domain, the electroacoustic composer can find physical analogues of those electronic "virtual" treatments, and much more, in the real world (Wilson 2012: 39).

Also, a special issue of the journal *Organised Sound* in 2013 on the theme of media archaeology, helps to make and remake connections and differences between modern electronic and digital music making and older approaches including those utilising electromechanical systems.

One clear advantage of working in an electromechanical way today is the potential for producing sounds of an unexpected, rich and complex acoustic timbre in comparison to

more predictable and repeatable tones derived from digital techniques. Both Wilson and Valle identify this, describing chaotic, emergent, non-linear and semi-random acoustic behaviours in their electromechanical systems (see Wilson 2012, Valle 2013). This echoes the process sensibility discussed above where a composer or artist relinquishes some control and gives materials freedom to behave in an unknown way within a piece. Wilson's report on his 'miraculous agitations', which he describes as a mechanical acoustic synthesiser or sound engine (Wilson 2012: 37), reflects this process sensibility, describing how the apparatus relegates the composer to a listener (Wilson 2012: 39). Wilson's approach involves acoustically exciting materials and objects using moving coil transducers (in a similar approach to Tudor's *Rainforest*) fed either from a separate audio source such as an oscillator, or through audio feedback derived from a pick up on the object itself, or both (see Wilson 2012: 36). Resounding objects are then coupled together and physically manipulated to further modify and modulate their sound. Wilson describes running workshops exploring the process of making his physical vibrating systems, and also how recordings of the results of these mechanical endeavours can be edited and used as material in electroacoustic composition. Whilst this last point may seem to introduce a tension between materially driven process and a less autonomous human control over the composition of the final sounding outcome, Wilson is keen to point out that, for him, the creative process is centred upon the physical apparatuses of his 'miraculous agitations'.

It is possible to identify similar tensions between the letting go of materials and the need for organisational control in Valle's *Rumentarium* project. Here, in a similar approach to Wilson, multiple DC motors are connected to a host computer to vibrate and rattle physical objects (often made from discarded materials and junk) to elicit sound, creating 'acoustic computer music' (Valle 2013). The various DC motors are in turn controlled by custom programmed digital interfaces that enable MIDI control, the reading of graphic scores and intelligent computer listening and audience / performer interactivity. In this way the *Rumentarium* project includes many complex systems of per formative, interactive and compositional control alongside the chaotic and non-linear behaviour of the physical materials being excited for acoustic effect.

Control and programmability within contemporary electromechanical approaches is also a theme in Murphy, Kapur and Carnegie's paper *Musical Robotics in a Loudspeaker*

World (2012). Murphy et al, who make robotic sound sculptures and musical instruments, present the loudspeaker listening world as a 'virtual' listening environment which they are keen to forgo in favour of 'mechatronically facilitated actuation techniques capable of truly localised sound' (Murphy et al 2012: 42). The aim of moving beyond the acousmatic and 'virtual' sound world towards 'localised', situated and naturally spatialised sound sources reflects similar concerns to many of the other electromechanical approaches discussed. However, the language of 'robotics' appears in contrast to the idea developed here of material systems and process based creative approaches. Burnham discusses the term 'robot', tracing its emergence to the Czech author Karel Capek and attributing it with notions of 'forced labour' and a 'lack of autonomy and free will' (Burnham 1968: 202). Problematically for this project Murphy et al.'s otherwise quite useful timeline of musical robotics identifies Zimoun's minimalist, kinetic installations as 'robotic installation art' (Murphy et al. 2012: 41). Zimoun's large swarms of identical, small, motor driven sound events such as *361 Prepared DC Motors* (2010) seem to evoke a sense of complex relations and emergent noise rather than a sense of control or forced labour. Also his works mark a strong visual resemblance to some opto-kinetic art from the 1960s (see figure 2.14 and 2.15) such as with Julio Le Parc's *Mobile Blanc Sur Blanc* (1960, see figure 2.14) and Gunther Uecker's *Moving Light* (1960) which Burnham discusses in terms of 'field structuring' and a shifting audience visual perspective (see Burnham 1968: 259). Zimoun's uncompromising minimal electromechanical materialism is also reflected in the titles of his pieces, which offer nothing more than a parts list, the sonic and visual relations and behaviour of the work is allowed to play out on its own accord.

Giving a voice to materials within electromechanical sound installation is also a concern of Ethan Rose, a contemporary sound artist and composer who makes sound installations as well as writing scores for films and releasing albums. Regarding a 2009 collaboration with glass artist Andy Paiko titled *Transference* where glass bowls and goblets are made to sound by rotating them against small pieces of cloth, Rose's website claims that the materiality of the glass itself is a third collaborator in the piece. Bosch and Simons describe similar sensibilities, holding the materials and electromechanical processes of their installations in high regard, describing their work as:

[Image removed for copyright reasons.] [Image removed for copyright reasons.]

Figure 2.14 Zimoun 121 *Prepared DC-Motors, Tension Springs 35mm* 2012 (L)
Zimoun 121 *Prepared dc-motors, Photo Mount Board Elements 8x8cm* 2012 (R)

[Image removed for copyright reasons.]

Figure 2.15 Julio Le Parc *Mobile Blanc Sur Blanc* 1960

> …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 (Bosch and Simons 2005: 103).

Since 1990 the pair have focussed on autonomous installations which they call ‘music machines’. Resonance and unpredictable vibratory behaviour is certainly a theme of many of these pieces such as *Krachtgever* (since 1994, described above) and more recently *Cantan un Huevo* (2000–2001), which explores similar themes to *Krachtgever* through vibrating sprung tables of rattling glass bottles. Bosch and Simons identify an interesting point with regards to the role of computers in their work, which is useful in reflecting more generally on their use within the contemporary wave of electromechanical sound art:

> 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 (Bosch and Simons 2005: 103).

In a piece such as *Krachtgever* with potentially quite violent, industrial scale noise and vibration emerging from the assemblage of sprung shipping crates it is easy to see how the role of the computer driving the motors and creating the initial excitation to the tower is quite literally overpowered. Bosch and Simons describe how the motors are controlled by programmed ‘phrases’ but due to the unpredictable resonant nature of the mechanical system, how those phrases will sound is unknown. They state that:

> 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 (Bosch and Simons 2005: 106)

The use of computers as convenient control or sequencing devices is not taboo in the contemporary wave of electromechanical sound art, reflecting the fact that the artists mentioned here are not merely retro enthusiasts, interested in putting the clock back to a technological time when electromechanics were cutting edge. The important consideration here is the qualitative balance of the type of control the computer exerts over other materials in the system. From highly engineered mechatronic robotics through to highly resonant mechanical systems there is a sliding scale of diminishing predictability and computer enabled human order and control. The theme is similar to

concerns first identified with regard to loudspeakers within Lucier's *Music on a Long Thin Wire* and Tudor's *Rainforest* being allowed their own resonant voice rather than being made to faithfully reproduce some form of fixed electrical media. Contemporary works such as *Krachtgever, Cantan un Huevo,* the *Rumentarium* project and Wilson's miraculous agitations can all be viewed as fitting a similar model to *Music on a Thin Wire* and *Rainforest* as they all mechanically subvert an electrically implemented signal or method of organisation. They all build an important part of their aesthetic from the introduction of hard material noise into a soft electrical signal path. The degree of autonomy in these examples may vary from purely stand-alone machines as with Bosch and Simons to potentially more performative tools as with *Rumentarium,* but always the hard and complex real world of matter is purposefully placed in the signal path foregrounding an unknown material behaviour over human intention.

Having established that computers can play a legitimate role in contemporary electromechanical sound art it is worth outlining one final piece that is very purist in its use of electromechanical systems, not employing computers in any way. The work of Norwegian artist Atle Selnes Nielsen is described on his web site simply as kinetic sculpture though he clearly has a primary concern for the sonic. In *Capstan* (versions I – iV, 2004 – 2014, figure 2.16) Nielsen drives an analogue magnetic tape recording and playback mechanism from a dripping tap (version iV) and from the flow of gas as it is fuels a flame (version iii). In these pieces the tape loop also records and plays back the sound of the mechanical activity that is driving it. In the case of the tap a hydrophone picks up the sound of the dripping water for recording as it drives a small water wheel, and with the gas system a whistling sound created by the currents of the flowing gas is captured. These constantly renewed recordings are audible over loudspeakers and of course sound very noisy not least due to the high levels of wow and flutter present in the tape system's mechanics. The piece is reflective of many themes fitting with the idea of material systems, it is also autonomous, with the artist appearing in the video documentation of the work as a lab technician setting up and tending the system. *Capstan* draws attention to the energy sources that are driving it (flowing water or gas) and also their transduction from material to kinetic energy, to sound. This reflects a systems aesthetic of input, output and energetic transduction. While the energy sources are natural they are presented in a way that could be construed as a pseudo closed systems aesthetic, discussed above with regard to Hans Haacke, appearing less about

monumental and global issues of gas or water and more as a lab based scientific sound experiment, the outcome of which is unknown and ever changing. That the materiality of the mechanical system is also the audio content of the recorded electrical media makes a further case for this piece as a closed material system.

[Image removed for copyright reasons.]

Figure 2.16 Atle Selnes Nielsen *Capstan iV* (2006-2014)

There are many other contemporary artists working in ways that usefully illustrate themes of autonomy, materiality and systems within electromechanical sound art. The selection presented here provides a sample of current activity which shows that many themes identified in the 1960s wave of electromechanical sound art are still relevant and significant to artists working today. Open and closed systems, hard and soft materials, energetic transduction, processes and fields of possibility, relationships and complexity, electrical control signals and hard material resonances, degrees of autonomy and robotics are all themes and tensions that continue to circulate through contemporary sound art. In an observation characteristic of media archaeology, it is possible to identify how these themes have not been neatly resolved by creative or scientific work in the past, allowing for a linear progression of technology and sound arts practice. Rather, they are recurring throughout technological and cultural paradigm shifts, as equally relevant and fertile for creative endeavour in todays digital era as they were in the 1960s and no doubt in times before that too.

3. THEORETICAL FRAMEWORKS

3.1 SONIC MATERIALISM

> Sound is not a world apart, a unique domain of non-signification and non-representation. Rather, sound and the sonic arts are firmly rooted in the material world and the powers, forces, intensities, and becomings of which it is composed. If we proceed from sound, we will be less inclined to think in terms of representation and signification, and to draw distinctions between culture and nature, human and nonhuman, mind and matter, the symbolic and the real, the textual and the physical, the meaningful and the meaningless. Instead, we might begin to treat artistic productions not as complexes of signs or representations but complexes of forces materially inflected by other forces and force-complexes. (Cox 2011: 157)

This excerpt above summarises a core part of Christoph Cox's position in the paper *Beyond Representation and Signification: Toward a Sonic Materialism* (2011) in which he outlines a materialist aesthetic theory of sound art. Cox describes how much aesthetic theory over the last few decades has been dominated by critical positions such as semiotics and poststructualism that construe culture as a 'field or system of signs that operate in complex relation' (Cox 2011: 146) to each other. Such positions, Cox describes, emerged from a 'linguistic turn' and have a deep suspicion of the material world, which they consider 'extra-symbolic' and 'extra-discursive', inaccessible or even non-existent (Cox 2011: 146). This situation, he points out, follows from a dualistic Kantian view of the world as either phenomenal (knowable and part of human discourse) or 'noumenal', 'belonging to the domain of nature and materiality and excluding knowledge and intelligible discourse' (Cox 2011: 147). Cox's proposed way forward from this intellectual impasse, illustrated by the above quote, is to explore artistic sound productions from the point of view of a complex of materials and forces of both a human and non-human nature, a position that he locates in a broader contemporary philosophical context of materialist, object-orientated and post-humanist thought (Cox 2011: 146,158). In the paper Cox is not speaking specifically about approaches to sound making that involve objects, materials or electromechanics, but a full breadth of practices including such approaches as phonography and acousmatic music. But it is clear to see how such a theoretical approach resonates with the electromechanical sound art that is being considered here. The aesthetic stance regarding sound art proposed by Cox

provides a context from within which to draw out particular points from the broader range of materialist theoretical positions to which he refers, with the aim of further exploring electromechanical sound art.

It is beyond the scope of this project to provide a full review of all the various positions that go to make up the theoretical territory that may broadly be considered as materialist or object-orientated. Even summing together the different positions represented by, for example, object-orientated ontology (OOO) (see Harman 2009), Jane Bennett's *Vibrant Matter* (2010), Ian Bogost's *Alien Phenomenology* (2012) and the approaches of actor -network theory (ANT) associated with Bruno Latour and John Law (Law 2004) in a single group is problematic although they could all be said to contribute to recent developments in post-human or materialist thought. Bogost (2012) does provide a highly accessible and broad view of current debates within this theoretical field in the first chapter of *Alien Phenomenology or What it's Like to be a Thing*. John Law's paper *Actor Network Theory and Material Semiotics* (2009) is also a useful summary of the actor-network approaches associated with the work of Bruno Latour, which are often cited as informing much of the more recent wave of theoretical debate around objects, materials and their interactions and relations. Apart from providing a general theoretical basis from which to consider the materials and objects of electromechanical sound art, that does not render them unknowable in the realm of language, two areas of interest from this field are worth highlighting here. Firstly, theories of objects and their relations as elucidated by writers such as Bogost, Latour, Law and Harman among others have significance to and resonance with points raised already with regard to material systems within electromechanical sound art. And secondly following Jussi Parikka's claim that much materialist debate stems from an interest in 'mediatic' phenomena (Parikka 2011b: 1), materialist media theories will be shown to reflect usefully on electromechanical sound art practice. Other related points from the theoretical field being explored have also informed the methodological approach of this project (particularly from Law 2004) and these are developed further in chapter 4.

3.2 OOOs, ANTs AND OTHER THEORIES OF MATERIAL SYSTEMS

John Law lists five common sense, empirical and positivist assumptions about reality (Law 2004: 23), which he describes as Euro-American. Briefly, these assumptions are that reality is 'out there' (external to us), independent of us (our perceptions and actions),

it precedes us, it is definite (accurate knowledge of it can be ascertained), and it is singular (that knowledge applies universally). It is interesting to contrast these points from Law, characterising empirical, positivist thought, with Cox's characterisation of semiotic and post-structural thinking with regard to aesthetics, described above, where the material world is seen as inaccessible, non-existent and 'excluding knowledge and intelligible discourse'. These same two opposing epistemological positions are also described by Bogost (2012: 13) as scientific naturalism on the one hand assuming that the fundamental nature of objects can be discovered and known, and social or cultural relativism on the other, where all discoveries or truths are to be viewed as existing within a constructed human context of culture and language. According to Bogost, these are the two polar opposite theoretical positions that materialist and object-orientated thinking tries to overcome and weave a path between, avoiding veering too close to either.

Drawing on the work of Bruno Latour who carried out ethnographic research in science laboratories such as the Salk Institute in San Diego, Law goes on to subtly undermine the five assumptions he outlines with regards to scientific positivism, but without assuming a simple position of cultural relativism. Following Latour's findings from within a science lab, where hard facts and truths about the hard material world are produced, Law shows how it is possible to construe these truths as being contingent and dependant on potentially shifting relations between other truths and other materials. Law, after Latour, does not claim that the real world is merely a construction of the human mind, of culture or of language, rather he claims that reality is constructed in scientific *practices* and *processes* (Law 2004: 19), which are borne out of enacted, relational networks of materials and humans. These networks include a myriad of different heterogeneous things such as, for example, lab rats, chemical compounds, measurement devices and tools, financial funding, computers, software, books, people's careers, published papers and much more besides, all of which exert some affect on the outcomes and findings through their complex web of relations. Furthermore, each of these relational parts is a black box, itself containing a whole other network of material relations within. For example, the technologies and tools used for measuring and extracting data from material experiments within the laboratory, described by Law as 'inscription devices' (see Law 2004: 29), are previously established technological black boxes presenting sets of previously established 'arrangements for converting relations from non-trace-like to trace-like form', and for 'shifting material modalities' (Law 2004:

29). ‘Material modalities’ such as voltage, heat, chemical presence, mechanical properties of materials or animal behaviour etc. are converted into other material modalities such as graphical data and numbers (on a screen or pieces of paper for example) through relational systems of materials and human understanding, neatly folded into a technological black box, or as Law also describes it, a ‘routinized hinterland’ (Law 2004: 32). ‘Hinterland’ in this context can be thought of as all that has gone into a black box and since become accepted, unquestioned and inaccessible. This last point is helpful in understanding how such a situation can lead to a sense of fixed and stable reality; some black boxes of relations are pre-made and already fixed, and it would be too difficult, costly and time consuming to remake or undo them. Law quotes Latour and Woolgar:

> Once a large number of arguments have become incorporated into a black box, the cost of raising alternatives to them becomes prohibitive. It is unlikely, for example, that anyone will contest the wiring of the computer (Latour and Woolgar 1986: 242 quoted in Law 2002: 34)

Hence findings about reality become fixed and standardised, unchanging in a world where the means of observing, measuring and sampling the world is fixed and standardised:

> [R]ealities are made. They are *effects of the apparatuses of inscription*. At the same time, since there are such apparatuses already in place, we also live in and experience a real world filled with real and more or less stable objects. (Law 2004: 32)

This small extract from Law (2004) reflecting an approach that has become thought of as actor-network theory (ANT) gives a sense of how such thinking prioritises relationality, materiality and process in what appears to some, a radical view of the world (see also Law 2009: 146 and Dusek 2006: 208 regarding ANT’s relationship with ‘process philosophy’). From the ANT stance the standard scientific method deletes much of the unexpected, messy materiality of process and practice in what is ultimately produced and circulated as data and text in published papers (see Law 2004: 20). What is interesting about the ANT sensibility for this project is that *materials* within the context of processes and relations are given an equal place, a voice, and a chance to talk back. Although occasionally misconstrued as simple cultural constructivism, in fact ANT begins to allow for an agency of non-human materials, a theme that has been more recently developed by writers such as Bennett (2010), Barad (2007), Bogost (2012) and Harman (2009).

But for some of these more recent writers, the actor-network stance has too many relations and not enough objects in it. The more object-orientated positions associated with Harman (2009) among others, whilst paying their dues to Latour, take issue with the fact that there is no attempt to distinguish between objects and relations in his thinking. As Harman puts it, there is 'no mysterious residue in the things hiding behind their relations with other things' (Harman 2009: 158). Bogost (2012) develops the theme, taking issue with the fact that in actor-networks things 'remain in motion far more than they do at rest' (Bogost 2012: 7) and hence objects become de-emphasised in favour of their couplings and relations. Bogost quotes Latour claiming that 'actors do not stand still long enough to take a group photo' (Bogost 2012: 7) and then retorts in a characteristically specific and poetic way, claiming that in fact they do: 'the scoria cone and the green chilli remain, even as they partake of systems of plate tectonics, enchiladas, tourism, or digestion' (ibid). Bogost's world of 'alien phenomenology' speculates about the closed off, odd, mysterious and alien world of things of all natures (material and abstract), speculating about how those things may experience each other as well as how humans may experience them. As the 'object' in object-orientated ontology suggests, this theoretical territory allows for a harder shell to things, whilst also acknowledging the importance of relations, practice and process. Interestingly, Bogost cites his experience as a computer programmer and engineer as a prompt for arriving at his particular metaphysical position (Bogost 2012: 9), wondering about the computer's 'tiny, private universe […] behind its glass and aluminium exoskeleton' (Bogost 2012: 9). This acknowledgement of the computer as an object, in a kind of closed system state is reflected in Bogost's discussion of 'unit operations', the terminology he chooses to consider the themes of systems and black boxing:

> Counter-intuitively, a system and a unit represent three things at once: for one, a unit is isolated and unique. For another a unit encloses a system – an entire universes worth. For yet another, a unit becomes part of another system – often many other systems – as it jostles about (Bogost 2012: 25).

This brief overview of ANT and more object-orientated thinking is relevant to the investigation into electromechanical sound art in two ways. Firstly, the emphasis on materials and relations clearly serves as a useful theoretical underpinning of the idea of the 'material system' within electromechanical sound art. Importantly, ANT emphasises

practice, enactment and process of material systems within both scientific and cultural practices, using such an emphasis to forge connections between the two domains. This emphasis reflects the same thinking uncovered with regards to experimental process based music and art making, explored above through Burnham, Cage and Eco's writing, and through the creative work of Lucier, Reich, Tinguely, Lye and others. In electromechanical sound art as in ANT the material system provides a way of thinking about objects and materials in a way that does not either reduce them to scientific formalism or exclude them from consideration through cultural relativism. The different influence of the cultural and scientific disciplines however does make itself evident through the two epistemological positions described at the beginning of this section where, as Bogost puts it human 'culture is allowed to be multifarious and complex, but the natural or material world is only ever permitted to be singular' (Bogost 2012: 4). In music and art there is an acceptance of the unknown and ever changing nature of the outcomes from these enactments of potentially changing material relations and this is actually an important reason for working in this experimental way. Whilst in science, according to ANT, there exists an attempt to fix and secure outcomes and findings, making them repeatable and universal.

The second main point of relevance for electromechanical sound art, which emerges from this general theoretical territory, is the tension between the highly relation-orientated thinking of ANT and the more object-orientated thinking of OOO. This resonates with the tensions between thinking of art as object or art as system. These tensions have been identified in Burnham's writing, and particularly in regard to Burnham's associate Hans Haacke's continued tendency to pursue the making of art objects whilst working with a theme of systems. Bogost's counterintuitive three things from two, in the quote above, reflects this tension of inner relations, object, and outer relations. Haacke's pseudo closed Plexiglas weather cube system invites a temporary suspension of the third thing, the other, bigger system outside of the cube whilst presenting the inner system and the object. Tinguely's dismantled radios, mechanically scanning the airwaves, reveal their inner 'tiny private universe', as relief mounted art objects whilst pointing to one specific isolated aspect of the larger system – the world of broadcast radio waves. Other aspects of the larger universal system are not important to the aesthetic experience of Tinguely's *Radio Sculptures*, such as the supply of electricity powering the electronics, the life cycle of electric motors and the exchange value of

artworks for example. The work represents a highly selective version of the universal system within which it exists (the radio broadcast) whilst foregrounding and objectifying the inner, 'tiny private universe' of the radios. Similar 'relation versus object' based analysis of works by Lucier, Lye and Reich have been explored in terms of 'pseudo closed' systems and in particular through the connections that some of Lucier's pieces such as *Music for Pure Waves, Bass Drums and Acoustic Pendulums* make with simple textbook-based scientific experiments.

3.3 MATERIALIST MEDIA AS THEORY AND PRACTICE

Themes usefully connecting theoretical approaches to material systems and electromechanical sound art also emerge from the field of media archaeology and related traditions that might usefully be thought of as 'materialist media theory'. Jussi Parikka, who has done much to define the field of media archaeology in recent years, points out its connections to the work of Latour, as well as a to a line of media theorists including Marshall McLuhan, Walter Benjamin and Fredric Kittler who have focussed on the effects of technologies and hardware within a media context which is more typically associated with a cultural world of signs, messages and meanings. Parikka identifies that this 'turn' to materiality through attention paid to the hardware and the wiring of media networks at all levels can be seen as a response to the 'perceived immateriality brought by digital culture, and by what postmodern theories flagged as the abstraction and immaterialisation of cultural reality' (Parikka 2012: 84). In an attempt to balance this glossy, malleable, digitised version of culture, the materialist media sensibility highlights the wax cylinders, the glass plates, the copper, the gutta-percha, the silicon, the transistors and the microprocessors of media tools throughout history, drawing attention to the particular pull that each exerts on a complex web of media relations. There is much more that could be said regarding the specific approaches and methods of media archaeology, which also has a particular interest in seeking out lost and forgotten possibilities and narratives within a material history of media, but two points from the more general field are worth highlighting with regards electromechanical sound art. These are the notions of 'decent', and of 'material noise' both of which owe much to media theorist Friedrich Kittler (1999).

'Decent' in this context can be understood simply as a theoretical and practical disassembly of the media machine, an investigation of its inner hardware workings and a

recognition of how they may relate to the 'higher' and softer levels and workings of signals, signs and meanings resulting from human interaction with such a machine in use. Following Kittler (1995), the computer is a rich example through which to test the idea of 'decent' where an apparently disembodied stream of images and sounds presents a rich flow of cultural experience, meaning, information and communication. All of this, however, is deeply embedded in hardware contexts such as the high speed shifting of voltage differentials, semiconductor logic gates, server rooms, capacitors and bits of silicon, the specific arrangement and nature of which defines the symbols and meanings being thrown up to the user level. Parikka connects such an approach with Kittler as well as with Michael Foucault's ideas relating to the archive of knowledge (see Parikka 2011: 3, 2012: 81, 83, 89 and ch4).

The idea of decent is particularly relevant to pieces of electromechanical sound art such as Lucier's *Music on a Long Thin Wire* and Tudor's *Rainforest* where the opening up, disassembly and reworking of the loudspeaker in hardware terms is akin to an investigation and questioning of the material relations within a standard piece of sound technology. Also, Tudor's sustained interest and practice relating to handmade electronic audio devices, since the mid 60s, for works such as *Rainforest* can be understood in terms of decent. The soldering composer's approach reflects a similar sensibility to that which Parikka (2012) explores in regards to circuit bending, the creative practice of rewiring and hacking pre-existing commercially available technologies for new and interesting results. Whilst circuit bending in 2012 may carry a more overtly political tone relating to mass produced and non-serviceable consumer electronic technologies, Tudor and other soldering composers since the 1960s intuitively recognised that the cultural practice of creative sound making is, in part, hard wired into technology. They took this as a call to pick up a soldering iron, descend inside technology and partake in electronics practice as part of their music making. Once inside the electronics, Tudor exhibits further materialist tendencies. John Driscoll (2004) describes Tudor's fascination with electronic components taking on their own personalities and suggesting musical direction (Driscoll and Rogalsky 2004: 29), while elsewhere he is quoted describing electronic components as his 'friends', who he chooses not to control but allows to 'release what's there' (Tudor quoted in Kuivila 2004: 21). As Jane Bennett (2010) points out, this anthropomorphising is valuable in avoiding a human centred position because 'oddly enough it works against anthropocentrism: a chord is struck between human and

thing and [people] are no longer above or outside a nonhuman “environment”’ (Bennett 2010: 120).

The idea of ‘material noise’ also owes much to Kittler’s brand of media theory (see Parikka 2011a: ch12, Cox 2011: 154, Henriques 2003 and Kittler 1999). A good way to understand the proposition is to consider Shannon’s model of communication (see figure 2.11, chapter 2) where an information source is transmitted to a received destination by way of a communication channel represented in this original version of the model by the smaller empty square in the centre. This channel through which the information passes belongs to the real, material world. In terms of sound this could be the air through which sound waves travel or the copper and electronic components through which an electrical analogue of a sound wave is conducted. It is during this materially embedded part of the journey that noise can infiltrate a signal, and the information being communicated. Whether it be a conversation on a windy day, a telephone line with a poor connection or a gramophone record with a crackly surface, noise can be introduced through real world material influence, bringing with it non-signifying, audible artefacts.

In *Gramophone, Film Typewriter* (1999) this thinking prompted Kittler to specially align audio recording with a status of ‘the real’ where, unlike the symbolic, written account of language, afforded by the typewriter, the whole audible spectrum is captured including non-signifying elements such as coughs, stutters, pops, hiss, hum, crackle and even the mechanical noise of the recording equipment itself. The theory reflects usefully on a range of sound art activities from Luigi Russolo’s *Art of Noises* (1913) to activities including the purposeful cracking, scratching and bending of various types of physical media such as vinyl and compact discs for creative effect (see Kelly 2009). Noise, as Cox (2009) points out has a long and intimate connection with twentieth century experimental music and sonic art. The idea of the insertion of noisy material into a clean signal path however is particularly well illustrated by the electromechanical approaches described here that subvert the operation of the loudspeaker by adding materials to its mechanism. Tudor’s sculptural speakers of Rainforest are the key example here but also, as has been shown, other more recent works such as the *Rumentarium* project, Wilson’s miraculous agitations and Bosch and Simons’ *Krachtgever* can all be viewed as fitting a similar model. Choosing to specifically work with customised complexes of hard resonant materials as the only means through which soft electrical signals, software and

information technology can exert its will upon the world is a creative practice that speaks of material noise being introduced to a signal path.

3.4 SUMMARY

The theoretical positions considered have reflected usefully on electromechanical sound art in various closely related ways, which will be briefly summarised. Firstly, the mysterious and closed world of objects is, in part, made accessible and perceptible through the sounding qualities brought about by the kinetic interactions and processes of electromechanical sound art; sound is one way of appreciating and gaining access to objects and their material make up. Interactions, relations and processes (kinetic or otherwise), however, can also be seen as actually constituting what makes those objects, bringing them into being through sounding, relational, material networks. These positions, underpinned by OOO and ANT respectively, reflect the tensions already identified between what has been termed here a 'closed system aesthetic' and a more open systems sensibility. Secondly, following Law (2010) in particular and the ANT stance in general it is possible to uncover a view of scientific practice that presents it as remarkably similar to some process-orientated experimental music and art practices in terms of a reliance on materials, process and relations. The difference is that in science there exists an expectation that outcomes will be fixed and repeatable (reflecting Laws empiricist assumptions on reality) whilst in experimental music and art there is an acceptance that outcomes will be unpredictable and ever changing. These differences in expectation reflect the different epistemological positions described by Cox and Bogost: cultural relativism on the one hand and scientific naturalism on the other. Seeking out a theoretical territory that avoids these two theoretical polar opposites seems especially appropriate for a sound art that directly appropriates scientific experiments, material objects and engineering technologies as its raw materials for creative and cultural endeavour.

Meanwhile these concerns are found to exist within media technologies, where sound, objects, materials and relations are already at play. It follows that disassembling, reassembling and descending inside these media technologies has been a fruitful starting point for creative endeavour since at least the 1960s, and continues to be so today. One particular electromechanical technique of this nature follows a model of reworking the loudspeaker, introducing material noise into the signal path in a very direct

and literal way. This type of creative approach intuitively recognises that even in electrified and digitised contexts, cultural and aesthetic experience emerges from a hardware level of materials. These various positions have been presented under the guise of theory although it becomes evident that within them there exists an emphasis on practice and process alongside themes of relations, systems and materiality. This establishes a useful context from which to consider the practice based research method of this project, in the following chapter.

4. METHOD

4.1 ART PRACTICE AS RESEARCH METHOD.

Broadly speaking this project and its methods can be described as art practice as research (also referred to here as artistic research), an approach where artistic practice forms a core part of the research process and outcome. Henk Borgdorff considers that one key feature of this kind of artistic research is that 'artistic practice occupies the subject, method, context and outcome of the research' (Borgdorff 2011: 46). This is not the same as claiming that a piece of artwork in itself constitutes research of this nature, though it is true that all artwork in whatever media does require research of some kind for its production. For example, the auditioning of sounds, testing of colour palettes, drawing, listening, reading and planning are all activities that could constitute the research phase of a creative project. However, this is not necessarily the same as a fully articulated research project where context, critical frameworks, methods and findings are presented and explored alongside, in and through the production of artistic outcomes. Christopher Frayling's paper *Research in Art and Design* (1993) is an early attempt to tease out some of these nuances regarding research in art and design within a broader context of research that includes the sciences, humanities and the institutional and political context of funding bodies and degree awards. Borgdorff (2006, 2011) uses a framework proposed by Frayling as a basis for his trichotomy between research ***on*** the arts (which maintains a theoretical distance as with musicology or aesthetics), research ***for*** the arts (which seeks to develop new techniques and technologies in the service of the production of artworks) and research ***in*** the arts, which is the type of research presented here where creative outcomes, contexts and methods are closely intertwined at each stage of the research process representing 'no fundamental separation […] between theory and practice' (Borgdorff 2006: 7).

4.2 METHOD ASSEMBLAGE AND PLURALISM.

The close and inter-dependant relationships between constructs such as practice, theory and method that exist within artistic research of this kind are also explored from within other disciplinary contexts by John Law in the book *After Method* (2004). Here, the idea of method as something active, creative and open emerges in a form befitting Law's actor network sensibility, introduced in chapter 3. Through a series of case studies including the fields of science, social science, technology, society and ethnology, Law

presents a case for method as a creative tool for crafting, resonating with and amplifying findings which are capable of re-working and re-bundling new versions of the world (see Law 2004: 143,144, 14 and ch8) in a process-orientated, rather than objective or end-orientated approach to research (see Law 2004: 152). In this way Law warns against thinking of method as a neat, pre-packaged black box of procedures and instruments that can be chosen appropriately in order to carry out particular research. Instead he draws attention to the possibilities of method as an evolving process within a large complex system of heterogeneous elements potentially including such diverse elements as questionnaires, laboratory rats, statistical data analysis software, communication systems and economic agendas to name just a few. The term Law uses to refer to this conception of a method whose 'boundaries are porous and extend outwards in every direction' (Law 2004: 41) is 'method assemblage' (ibid), defining the idea of an assemblage as:

> […] like an episteme with technologies added but that connotes the ad hoc contingency of a collage in its capacity to embrace a wide variety of incompatible components. It also has the virtue of connoting active and evolving practices rather than a passive and static structure. (Watson-Verran and Turnbull 1995: 117 in Law 2004: 41)

These ideas from Law, considered alongside the notion of art practice as research, show how it is possible to see research method as something creative, open to continued development and requiring assembly from a wide range of possible components and sub-assemblies of a practical or theoretical nature.

From a disciplinary context not specifically related to the arts, Law also calls for more research outcomes that are not merely text or written statements of single immutable facts but outcomes that can include materials, processes, artworks, 'bodies, devices, theatre, apprehensions, buildings' (Law 2004: 153) and poetry and fiction (Law 2004:148). This call for a more inclusive research agenda reflects Law's concern that in purely textural and graphical research findings the 'materiality of the process gets deleted' (Law 2004: 20). This 'materiality of the process' has been shown in chapter 3 to include the lively and shifting relationships between tools, instruments, technologies and media within research and creative practice. From this position where instruments, tools

and other methodological black boxes can be opened, tinkered with, remade and reimagined, a further useful observation comes from Law:

> It is not possible to separate out (a) the making of particular realities, (b) the making of particular statements about those realities, and (c) the creation of instrumental, technical and human configurations and practices, the inscription devices that produce these realities and statements. Instead all are produced together. (Law 2004: 31)

It is interesting to take this statement as a departure point for making similar claims regarding artistic research. For example, it is not possible to separate out the making of particular artworks, the making of statements about those artworks and their context, and the development of tools, processes, techniques and critical frameworks necessary for the production and critique of those artworks, instead all are produced together as creative practice infiltrates each stage of the research process. Borgdorff (2011) further supports this by acknowledging that his first two defined areas of research relating to the arts (research ***on*** and ***for*** the arts) feature in the third category of artistic research (research ***in*** the arts). Art criticism, social or political theory, material and instrumental knowledge are all 'partially constitutive of artistic practices and products' (Borgdorff 2011: 46) and hence have a part to play in art practice as research, which can draw on approaches deriving from the humanities, social sciences and science and technology among a myriad of other fields. The term Borgdorff uses to refer to the interdisciplinary nature of this type of research is 'methodological pluralism' (ibid).

Clive Caseaux (2008) contributes to this theme of 'pluralism' in a literature review of four book length studies into art practice as research, titled *Inherently Interdisciplinary*. As the title of the review reflects, a common thread of interdisciplinarity runs through each of the books reviewed, and Caseaux suggests that artistic research is uniquely placed to generate new perspectives and knowledge through interdisciplinary practice and theory (see Caseaux 2008: 110, 127). Caseaux (2015) also suggests that theories of metaphor from Harman (2005) and Bogost (2012) help to explain how novel and significant findings can emerge from this pluralism and assemblage.

4.3 METHOD IN PROCESS.

Interdisciplinarity and methodological pluralism have been put to work within this project by assembling approaches and methods from areas such as the aesthetics of music,

musicology, the history and theory of sculpture and kinetic sculpture, the history and theory of sound art, the scientific theory of electromagnetism, electromechanics and electronics, science and technology studies, media archaeology and object orientated ontology among others. These seemingly diverse fields have been brought together and assimilated through cycles of activity that include the practical experimentation with electromechanical systems to create original pieces of sound art. Critical and reflective listening to and exhibition of these sound based artworks has been informed by the histories, theories and current contributions to the field, described here in previous chapters as the context and theoretical framework of the project.

This process of researching through the making and reflective and critical evaluation of electromechanical sound art can be seen as fitting schemes such as the Kolb cycle of experiential learning (see Kolb 1984, Race 1998, Fry, Ketteridge, Marshall 1999) a cyclical model consisting stages of experience, observation, conceptualisation and experimentation, or more simply put – 'think, do, review'. As Race (1998) points out these various points of experiencing, reflecting or conceptualising, however, do not necessarily happen discreetly but often simultaneously, impacting on each other in ways more complex than a simple cycle suggests. Robin Nelson (2013) also presents a comparable model to Kolb in *Practice as Research in the Arts* where the terms 'know how', 'know that' and 'know what' could be mapped to doing, thinking and reflecting respectively (see Nelson 2013: 37)

Lawrence Halprin sets out similar territory in the book *RSVP Cycles* (1969) through creative themes that relate to this project in useful ways. Halprin, an environmental designer and planner, describes how the book began as an exploration of scores of all kinds, within the various fields of art. Halprin defines scores as 'symbolisations of processes' (Halprin 2014: 40), which he aims to use to enable him to design environments whose 'essential nature is complexity and whose purpose is diversity' (Halprin 2014: 40). Halprin goes on to describe, however, that the book actually became an exploration of the creative process, in an admission that is reflective of other projects that blur the boundaries between systems and process, such as have been discussed through work by David Tudor and Steve Reich above (see Chapter 2). Halprin's RSVP cycle refers to resources, scores, valuation and performance as procedures inherent in the creative process. The abstract systems nature of creative design (Kolb's

‘conceptualisation’) is represented by the ‘scores’ part of the cycle while enacted process is covered within ‘performance’. The stages of observation or review are represented by Halprin’s ‘valuation’ part of the cycle and, usefully for this project’s particular focus on materials, Halprin’s ‘resources’ include ‘human and physical resources, and their motivation and aims’ (Halprin 2014: 42). As an environmental and urban designer Halprin saw his own practice, which both informed and was informed by the RSVP cycles, as ‘process orientated rather than simply result orientated’ (Halprin 2014: 40) and he saw the creative process he described as relevant to all other arts where elements of time, and activity over time were key (Halprin 2014: 40). Just as it has been suggested that Kolb’s learning cycle may not simply be thought of as a single ordered cycle, Halprin points out that there is a ‘multidimensional and moving interconnectedness’ (Halprin 2014: 42) between all the elements of the RSVP cycle which can be viewed as operating in any order and any direction.

With reference to these ideas regarding the creative process and experiential learning this project can be viewed as processing theory and practice together, through planning, designing, making and evaluating electromechanical sound art. The experience of listening to and viewing existing and original artworks has been unpicked through engaging with narratives and theories from within the field or context of the project. Also, ideas and theories from the field have suggested creative practical endeavours that have been realised as small-scale electromechanical experiments, which could be understood as sketches or studies. Where successful and where these experiments have uncovered or elucidated core values and themes of the project they have been developed into fully exhibit-able works. A process of ‘open studio’ exhibition has formed an important part of this process where public audiences are invited to view artworks in the context of artists’ working studio spaces. Other more formalised exhibition opportunities and small commissions have also shaped the project’s cycle of practice and theory. In this way the project has not only involved enacting Borgdorff’s description of artistic research as ‘the articulation of the unreflective, non-conceptual content enclosed in aesthetic experiences, enacted in creative practices and embodied in artistic products’ (Borgdorff 2011: 47); it also has involved the reciprocal process of enacting and embodying conceptual content in creative practice and through the making of artistic products.

4.4 MAKING

Artefacts and the making of objects as an opportunity for embodying, exploring and developing ideas and theory is something that Bogost (2012) also discusses as part of a process which he terms ‘carpentry’. Like Law and Borgdorff, Bogost, a philosopher and computer programmer, questions the primary position that texts hold in academic research, suggesting that artefacts and their construction can play a role in ‘philosophical practice’ (Bogost 2012: 92) and form ‘earnest entries into philosophical discourse’ (Bogost 2012: 93). Bogost’s ‘carpentry’ is not just about woodcraft but includes all manner of making (including computer programming) and incorporates the notion that things (human and non-human) fashion one another and the world around them; it is ‘making things that explain how things make their world’ (Bogost 2012: 93), a sentiment that recalls the theme of facture discussed in section 2.3.6. The idea also has resonance with Law’s notion of methods ‘crafting’ new versions of the world as well as with artworks previously considered that deconstruct and rework media technologies such as loudspeakers. As discussed, this type of technologically mediated artwork serves well as a practical exploration of certain areas of media theory, by descending inside the daily tools of sound making and communication technologies. Art practice as media critique is an important theme within the field of media archaeology (see Parikka 2012: ch7) and this fits well with Bogost’s idea of ‘carpentry’ as a practice where things are made in order to reveal how they fashion the world. Other connections also emerge from the field of media archaeology where the idea of text and writing is presented as just one possible form of practice among many. Parikka points out ‘we need to understand the various modalities of our tools for thought – such tools are not only about text and writing’ (Parikka 2012: 156).

Making things, whether from wood or electronic components and magnets, also brings with it an entirely new set of concerns and methods. As Bogost notes ‘[w]hether it is a cabinet, a software program or a motorcycle, getting something to work at the most basic level is nearly impossible’ (Bogost 2012: 92) and Parikka asks the question ‘do we have to become engineers to say and do anything interesting and accurate about current media culture?’ (Parikka 2012: 155). It is interesting to consider these points in regard to Burnham’s discussions of kinetic artists of the 1960s needing to up-skill in their use of technology as well as collaborate with systems engineers such as Billy Klüver (Burnham 1968: 281, 360) in order to realise work. The artefacts and practical work in this project

have drawn on a range of making skills from within the fields of electronics, digital fabrication (the use of laser cutting and computer controlled routing for example), woodwork, metalwork and the reverse engineering, appropriation and 'hacking' of existing technologies. All of these activities have been supported by an open source culture of makers and technologists sharing information on the internet, through books and at events such as maker fares, through organisations such as Hackspace and facilities such as Fab Lab, the MIT endorsed international network of fabrication laboratories aimed at enabling people of all ages and skill levels to make things. This current culture can be viewed as belonging to a lineage of creative activity shared by Tudor's *Composers Inside Electronics* and other 'soldering composers' such as Nick Collins where hands on making and intervention in technology forms a core part of creative practice.

An overview of the current 'maker movement' as it is sometimes referred to, as well as the implications of open source approaches, digital fabrication and the impact of easily available user programmable microprocessors such as the *Arduino* platform is given by Chris Anderson (2012) in the book *Makers: The New Industrial Revolution*. This project has drawn on practical circuit designs, CAD software, data sheets, tips for extracting useful parts from discarded technology, microprocessor programming guides and reference pages, electromechanical techniques and more, from a community of enthusiastic creatives and technologists who make such resources freely available. Practical developments and experiments carried out as part of this project have been documented and made available online to contribute to this culture (see Pigott 2016). Making facilities and workshop resources at *Cardiff School of Art and Design*, part of *Cardiff Metropolitan University* and home of *Cardiff Fab Lab* has also supported the practical side of the project. Figures 4.1, 4.2 and 4.3 depict something of the systems thinking and materials involved in this process and the following chapter describes the outcomes of some of this practical endeavour.

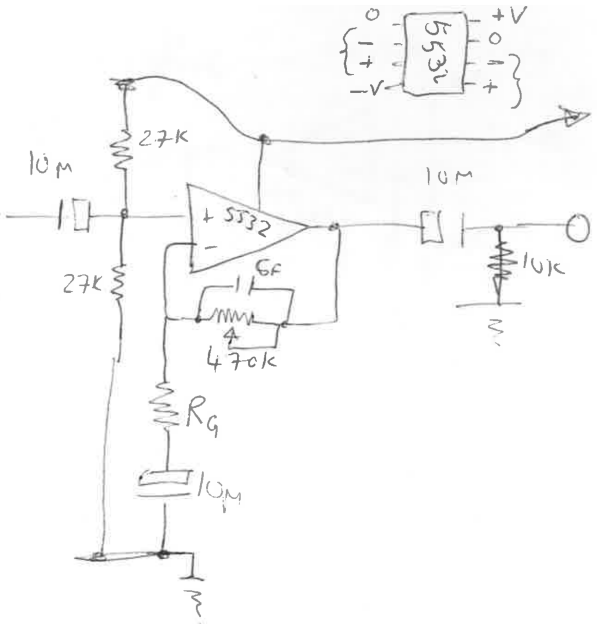

Figure 4.1. Extract from project notebook showing schematic for amplifier circuit developed for practical outcomes.

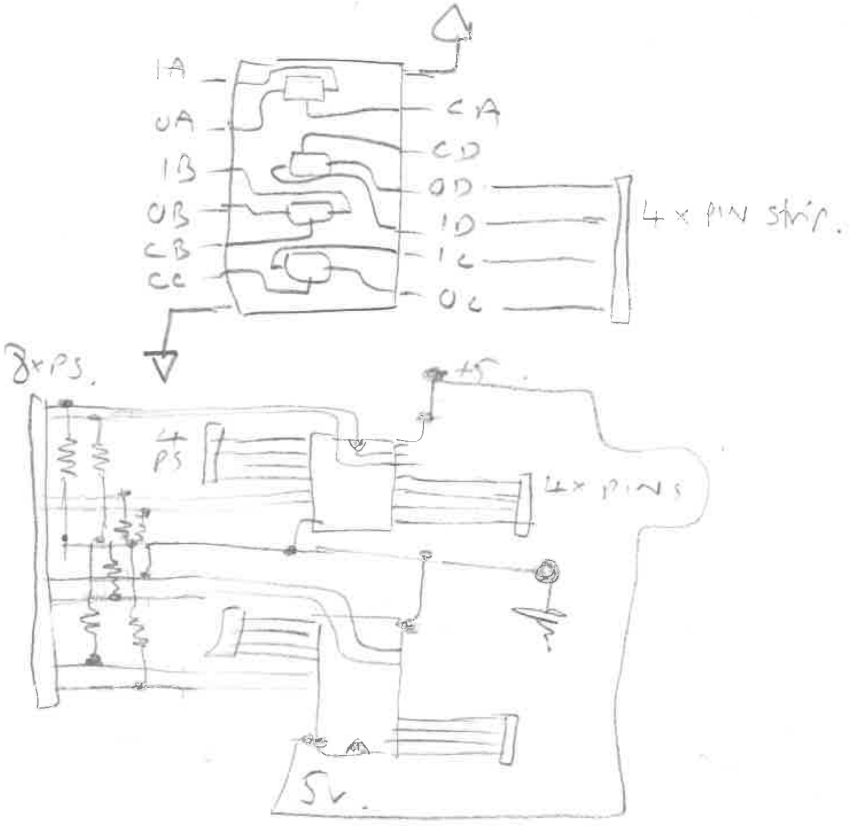

Figure 4.2. Extract from project notebook showing schematic for switching circuit developed for practical outcomes

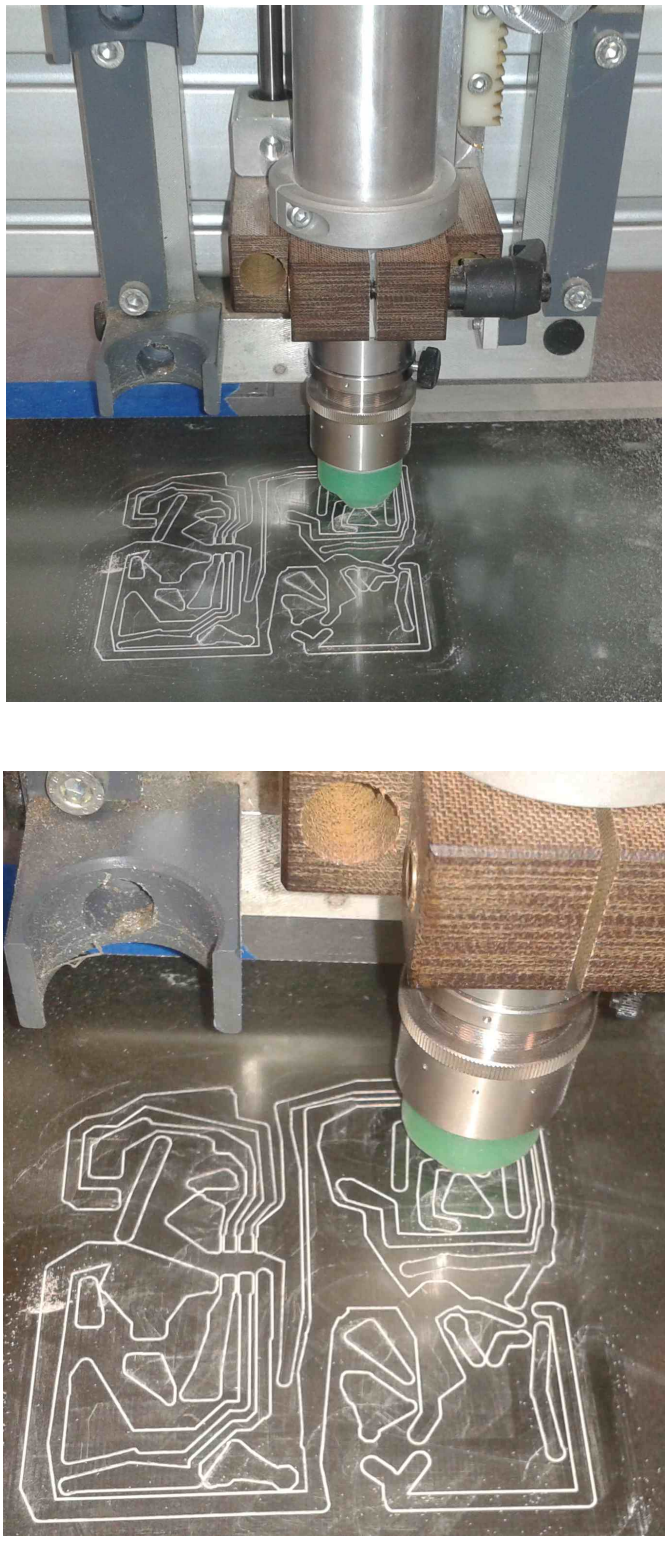

Figure 4.3. Fabrication of the amplifier circuit shown in fig 4.1 using computer numeric controlled (CNC) routing of copper clad board.

5. PRACTICE

5.1 INTRODUCTION

Having discussed the interrelated nature of practice and theory in this project, this chapter will describe the practical work whilst continuing to make connections to the context, the theoretical framework and the method. Three complete individual pieces will be discussed alongside a fourth body of practical work which is presented as an 'open lab book'. This open lab book contains less complete experimental endeavours that serve as evidence of the iterative and reflective cycles of practice and theory that formed part of the method of the project. The pieces are discussed broadly in chronological order. The practical element of this project began by experimenting with some very simple and primary electromechanical systems with the aim of creating autonomous sound pieces. This is the context in which the first piece discussed, *Electromechanical Oscillator* (2010 – 2015), emerged concurrent with the three lab book experiments titled *Electromagnetic Tin Drum*, *Electromagnetic Dulcimer* and *Slinky Speakers*. Following this a commission to partake in an exhibition in 2011 led to the development of work that later became *Electromagnetic Interrogations* (2011 - 2015). Finally, the fourth piece discussed, *The Campanologist's Tea Cup* (2015), conceived, built and exhibited during 2015 was made collaboratively with ceramicist Ingrid Murphy. This piece is included as an example of applying the project's aesthetic concerns to a collaboration and a public exhibition schedule. All of the discussion of the practical work is supported by film and audio documentation on the accompanying memory stick. Any time references to the documentation made in the discussion below relates to the edited videos of the work in the folders which carry the titles of the pieces. In addition to this, unedited audio and video documentation is provided for *Electromagnetic Interrogations* and *Electromechanical Oscillator* to give further insight into how the pieces may be received in an exhibition scenario. The unedited video documentation is in a separate folder for clarity of navigation and includes occasional unintended camera tripod noise.

5.2 ELECTROMECHANICAL OSCILLATOR

The *Electromechanical Oscillator* uses modified loudspeakers and small motors as electromechanical transducer elements to mechanically excite and elicit sound from suspended metallic objects. The sound produced by the objects is picked up by

piezoelectric contact microphones, amplified and output to standard loudspeakers as well as being fed back to the input of the modified loudspeakers and motors, which are exciting the objects. Where the signal from a resonating object is fed back to the electromechanical device that is exciting that same object, the result is a continuous oscillation similar in principle to a microphone or amplified instrument feeding back through a loudspeaker, causing a continuous howling sound, sometimes referred to as 'howl round'. In reference to the generalised technical diagram of the piece in figure 5.1, the top 'object being transduced' of the column of three, is held in continuous oscillation in this way, with the output of its piezo pickup being fed back to the voice coil exciting it. Figure 5.2 shows the spring-like steel object that is placed in this part of the system in the first 1'30" of the example film documentation. The modified or prepared loudspeaker that forms the voice coil used to mechanically excite the spring can also be seen with its paper cone removed and a piece of wood attached to its centre such that it can strike the object mechanically whilst producing virtually no audible sound itself. All audible sound from the piece is provided by the two separate, standard loudspeakers, which produce a balance of the output of all three piezo pick-ups (these speakers are shown on the right hand side of figure 5.1). Because of the mechanically complex system of the metal spring placed in the feedback loop between the output of the prepared loudspeaker and the signal driving it, the resulting sound is more variable and unpredictable than the usual howling feedback typically caused by a loudspeaker and microphone combination. The wood attached to the cone of the modified loudspeaker causes percussive impulses, which become longer resonances as they disperse vibrations through the material of the spring. Depending on the position of the spring, which is hanging freely and swinging very slightly, sometimes the resonances are allowed to fully disperse through the spring and die away to silence, and sometimes they are interrupted by another impact from the loudspeaker's wooden appendage. The limiting amplifier shown at the very top of figure 5.1 is necessary to make sure the overall signal level of this electromechanical feedback system does not get too large, causing a continuous howl and damaged speaker coils or amplifiers.

The signal produced by the electromechanically oscillating system that centres around the top 'object being transduced' in figure 5.1 is also used to drive the other electromechanical components of the lower two objects being transduced. In the film documentation of the piece these are small direct current (DC) motors that vibrate and

twitch erratically in response to the alternating current of the audio signal connected to their input. These electromechanical components could also be prepared loudspeakers similar to the one shown in figure 5.2 (and this type of configuration has been tested) but by using the DC motors with a wire armature connected to their rotor (see figure 5.3) a more erratic, percussive sound is elicited with lots of high frequency harmonics to complement the lower drone like sound of the oscillating spring.

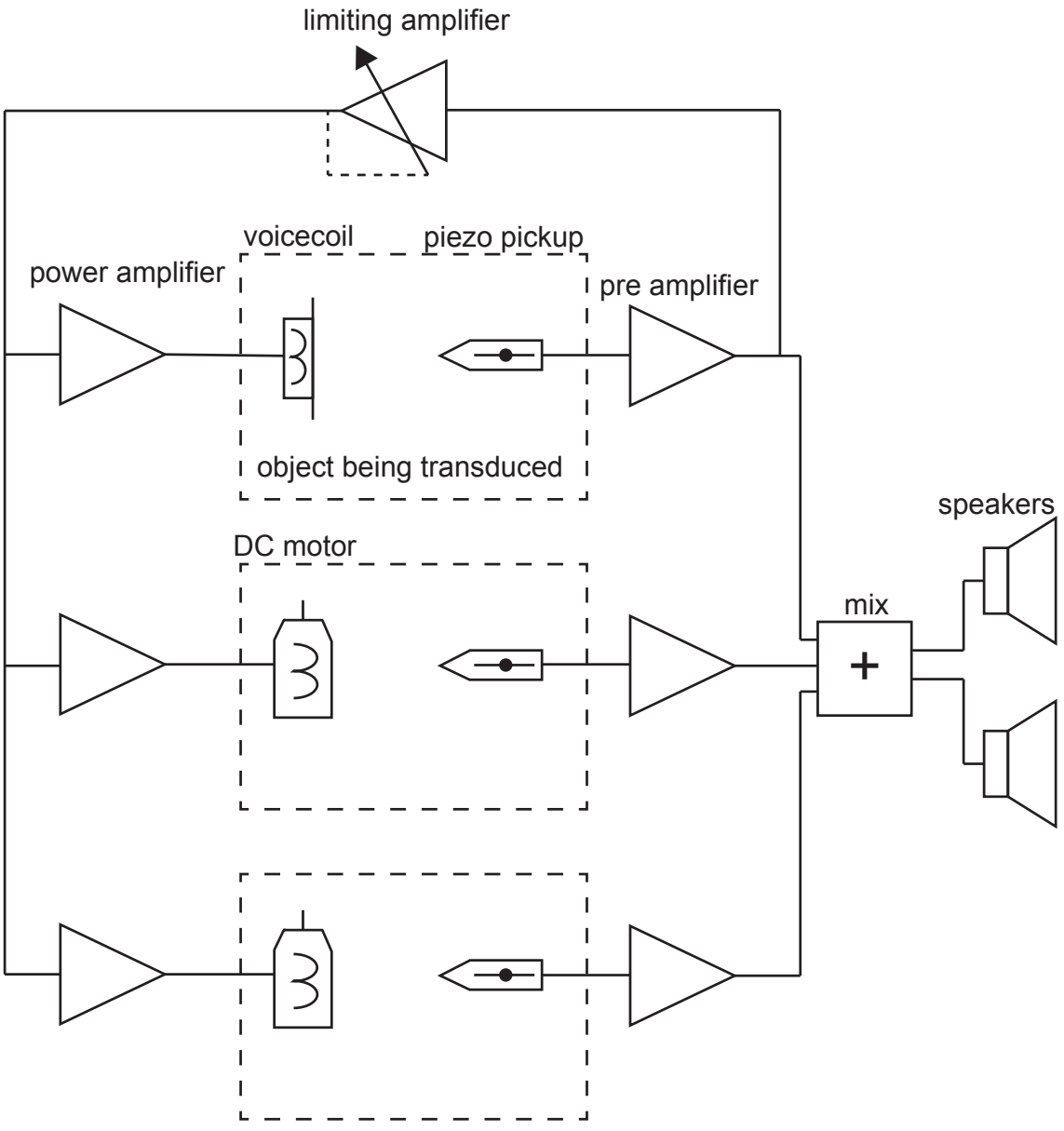

Figure 5.1 *Electromechanical Oscillator* generalised system diagram

Figure 5.2 *Electromechanical Oscillator* prepared speaker transducer and 'object being transduced'

Figure 5.3 *Electromechanical Oscillator* DC motor transducer

Sometimes these wire armatures swing and rotate away from the suspended metallic objects that they are intended to strike rendering that particular component of the system silent for a period. At other times the armatures trap themselves in the swinging metal objects and the vibrations are translated effectively from the top, oscillating object being transduced, via the DC motor and into the secondary metallic objects (the middle and bottom 'objects being transduced' in the generalised schematic in figure 5.1). In the first 1'50" of the film documentation these secondary objects are a domestic compact disc storage unit and a grill tray, both made from a welded metal wire with a chrome plating, not dissimilar in their material make up to the spring. In the second part of the film documentation (from 1'50" onwards) the objects being transduced are swapped, with the core, oscillating component now a rusty flat steel bar, formed in a shape that suggests it was once part of a fence or gate (see figure 5.4). This object produces a very bell-like sound when it is made to oscillate in the system. The steel spring in this second version of the piece is now relegated to being one of the secondary sounding objects, and with the wire motor armature striking it, its high frequency resonances become more audible. This second part of the film documentation, showing the different arrangement of objects, illustrates how the piece *Electromechanical Oscillator* is conceived as an electromechanical system whose sounding nature will change according to the material characteristics of the chosen objects being resonated and transduced.

Figure 5.4 *Electromechanical Oscillator.* One of any number of possible arrangements of objects.

Electromechanical Oscillator is a continuous sound piece with no defined beginning or end. It is intended for installation in a gallery space where the overall system may be understood through the kinetic and sculptural nature of the objects, the electromechanical components, and the resulting sound. It is an autonomous material system that is apparently closed, in that there is no clear or highlighted interaction or active relationship with the audience or environment within which it is placed. The system's behaviour is derived entirely from its own electromechanical components, in as much as that is possible in a practical sense. Exactly how much an audience member may grasp the technicality of the system obviously varies depending on people's knowledge of sound technologies. Some people understand exactly how the piece works technically just from observation, others perhaps just that the objects are responsible for the sounds. Either level of engagement is entirely appropriate; whilst exposed technological activity is a theme of the piece it is not intended to be a lesson in sound technology, rather an aesthetic experience.

Clearly the piece is working with themes that are very closely aligned to Tudor's *Rainforest,* which also uses the re-amplified mechanical resonances of objects or 'sculptural speakers' as a core part of its aesthetic. The main point of difference between *Electromechanical Oscillator* and *Rainforest* is that *Electromechanical Oscillator* has no performers or pre-recorded audio being fed through the system; it is a 'no input' version of *Rainforest*, with an exploration of further electromechanical signal routing possibilities to the secondary objects. The approach of using electromechanical feedback also features in other examples of experimental music and sound art. Nyman (1999: 100) describes David Behrman's *Wave Train* (1967), which uses contact microphones to amplify a piano to the point of feedback but with the aim of avoiding 'uncontrolled howling' and creating more delicate sounds from the sympathetically vibrating piano strings. Max Neuhaus took a similar approach in his version of Cage's *Fontana Mix* (around 1965 see Nyman 1999: 100) when he placed contact microphones on the skins of two timpani drums, amplifying them to the point of feedback; and Reich's *Pendulum Music* also uses loudspeaker feedback modulated by the mechanical swinging of the pendulum microphones.

Other sources relevant to *Electromechanical Oscillator* come from Nicolas Collins (2006: 39) who describes the technique of oscillating a plastic sheet material by using a piezo

element as both a contact microphone and a mechanical driver (the simple devices work as transducers in either direction) with the output of one connected to the input of the other. Collins also provides good technical detail on Tudor's *Rainforest,* with information on the original Rolen-Star cone-less speaker transducers that Tudor used, as well detail on hand made equivalents, similar to those used in *Electromechanical Oscillator*. Collins makes the connection also between these electromechanical techniques and spring and plate reverberation devices that were commonly used to create artificial reverberation in the recording studio before digital techniques were commonplace. There are many do-it-yourself guides to making these mechanical reverb units on the internet using techniques similar to those used in *Electromechanical Oscillator*, including the well documented endeavours of the *Electronic Peasant* who clearly shows the use of modified speakers and DC motors as electromechanical transducers in his projects.

The initial series of experiments that led to the development of *Electromechanical Oscillator* drew on sources such as Collins, Tudor and the Electronic Peasant as well as first hand practical experimentation with modified loudspeakers, piezoelectric transducers and other apparatus to hone the piece. Figure 5.5 shows an early experimental set up with a modified loudspeaker and piezo transducer as part of the system designed to keep the steel spring in continuous oscillation. Figure 5.6 shows an extension of this set up where the signal produced by the oscillating spring is made audible through a small prepared speaker made from a foil food container. This configuration, alongside the use of DC motors to excite other objects was taken forward to a public presentation in an 'open studio' context. These events allow members of the public into artists' studios to view artworks in the space where they have been made, possibly also viewing incomplete and developmental pieces. This presents an opportunity for artists to test how complete or exhibitable an artwork may be, whilst gauging audience responses and gaining their own fresh perspectives on work. Figure 5.7 shows how the piece looked at the open studio event in 2010 when it was exhibited under the title *Infinite Spring*. A contextual review of the piece with documentation of the open studio event was published at this stage of the project at the New Interfaces for Musical Expression (NIME) conference in Oslo, 2011 (Pigott 2011).

Figure 5.5 Early experimental set up of *Electromechanical Oscillator*

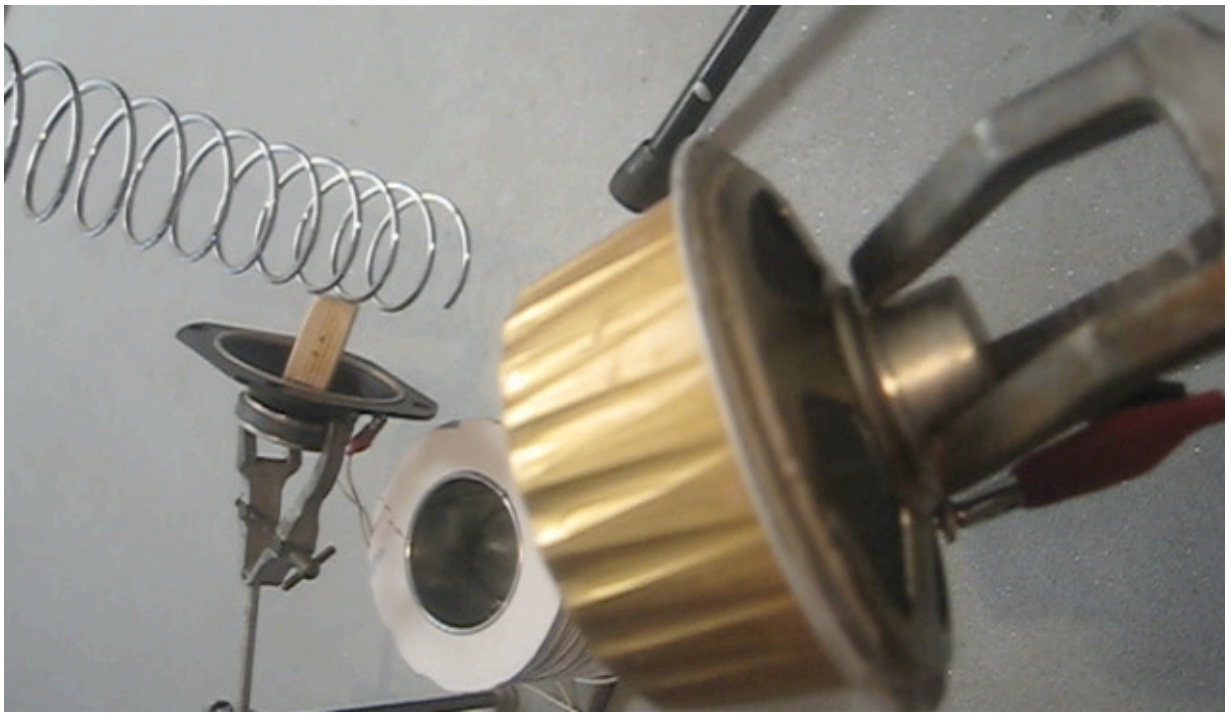

Figure 5.6 Early experimental set up of *Electromechanical Oscillator* with additional prepared speaker

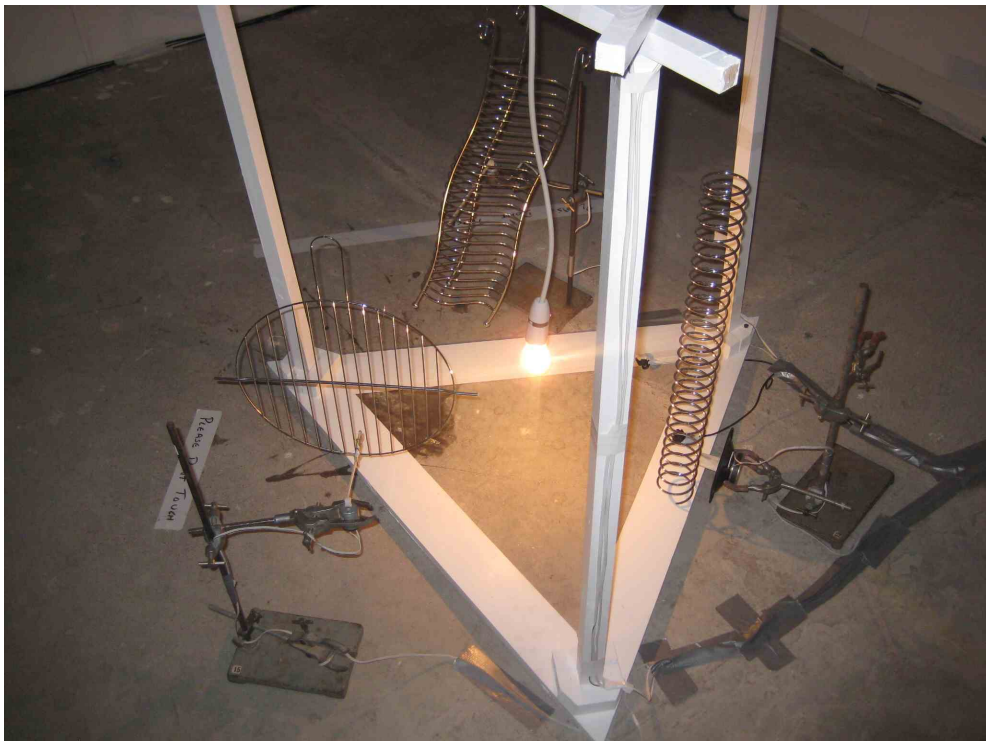

Figure 5.7 *Infinite Spring*

Reviewing the NIME paper highlights how the context and practical work relating to Electromechanical Oscillator has developed. The additional prepared speakers such as the one shown in figure 5.6 that formed a part of the work at the stage of the open studio, do not feature in the final version of *Electromechanical Oscillator.* As interesting a departure as these extra, prepared speakers are, the final version presents a clearer construct of a material system where objects are causing other objects to sound via electromechanical transduction. In the final version the standard loudspeakers (depicted in the far right of Figure 5.1) are better placed to present this. Throughout its development *Electromechanical Oscillator* has remained technologically purist in its arrangement of components that include nothing more complex than amplification, signal routing and electromechanical transduction. The materials and objects chosen for use in the system define the sound palette and organisation of sounding events within the piece. Despite the occurrence of regular patterns of behaviour, overall the resulting sound of the piece is unpredictable and non-linear within the limits of the assemblage and characteristics of the materials used. In this way it is an evolving and process-driven piece. The two excerpts in the film documentation and the unedited audio excerpt

illustrate this, as well as the effect of different materials on the system. In the first 1'50" of the documentation the piece has a low piano-like drone, with occasional and unpredictable interjections of percussive high frequency events. In the second section it has a more periodic bell-like sound accompanied by more continuous clouds of metallic high frequency.

One final theme to identify in the piece, which connects to some of the theoretical positions explored within this project, is that of 'material noise', discussed in reference to theorists such as Friedrich Kittler and Jussi Parikka, among others, in chapter 3. In a similar way to Lucier's *Music on a Long Thin Wire* and Tudor's *Rainforest*, *Electromechanical Oscillator* draws attention to the mechanical and material nature of the loudspeaker as well as other technologies that make up the electronically mediated world of creative sound making and modern communication. As is indicated in Claude Shannon's system of general communication (Shannon 1948), all information passes through a material channel where noise can be introduced. *Electromechanical Oscillator* increases the influence of the noisy materials of this channel by preparing loudspeakers and physically coupling objects to their voice coil, then taking the resulting sound of those materials and connecting it back to the 'information source', the input to the speaker. A theoretical scheme of the piece could be described using Shannon's system as a basis, and adding one feedback loop from the channel to the information source as shown in figure 5.8.

[Image removed for copyright reasons.]

Figure 5.8 Shannon's model of communication adapted to describe *Electromechanical Oscillator*

5.3 THE LAB BOOK

Emerging from the same, early phase of practical electromechanical sound experimentation as *Electromechanical Oscillator* are the three documented experiments presented here as an open lab book. Although not as complete as the other practical work discussed, these investigations form an important part of the reflective cycle of practical and theoretical work that constituted the research method of the project. The lab book experiments were carried out in a studio environment that allowed for the relatively quick, ad hoc setup of materials for testing, listening and documentation in order to inform idea development and further planning. In the case of *Electromagnetic Tin Drum* and *Electromagnetic Dulcimer* these experiments are documented on the test bench in the studio, surrounded by the tools and equipment needed for their design and construction. The third lab book piece, titled *Slinky Speakers*, is slightly more developed, and is presented in the context of an open studios event that it was shown at in 2011.

Electromagnetic Tin Drum is a simple set up of an electromagnet made from a copper coil placed around a steel tube, driven from a signal generator via a power amplifier. The resulting oscillating magnetic field from this assembly causes a steel guitar string to vibrate and knock against a small foil cup, creating a metallic resonant drumming whose rhythmic behaviour is defined partly by the frequency setting of the signal generator and partly by the mechanical characteristics of the wire. The film documentation, which is an uninterrupted two minutes of footage of the experiment, shows the full experimental set up and the effects of manually adjusting the frequency of the signal generator. The piece is an exploration of the basic electromechanical principle in a similar way to Takis' *Magnetic Pendulum Musical*. It is also a small-scale investigation of the mechanical or material subversion of an electrical signal, a theme identified in *Lucier's Music on a Long Thin Wire* and Tudor's *Rainforest*. The simple, uniform rhythmic pulses produced by the signal generator become more nuanced and complex when heard through the non linear mechanical behaviour of the guitar string as it strikes the tin cup in slightly different places, creating ghost beats, missed beats and a range of timbres. From the experiment it is possible to imagine how multiples of the simple electromechanical system might create an interesting swarm of shifting rhythmic and timbral relationships in a manner akin to some of Zimoun's work.

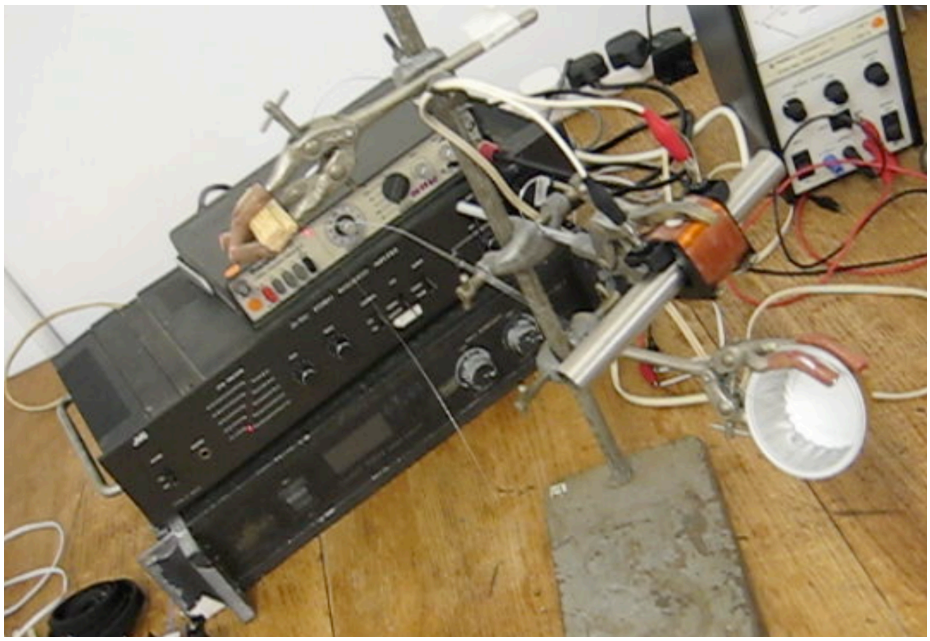

Figure 5.9 the experimental set up for *Electromagnetic Tin Drum* showing signal generator, amplifier, coil and steel bar.

The Electromagnetic Dulcimer is an experimental set up that is based on Lucier's *Music on a Long Thin Wire*. Scaled down to table top size, the piece is made from some neodymium magnets salvaged from old computer hard drives, a signal generator, some steel guitar strings, piezo contact microphones and amplification, in exactly the same configuration as Lucier's piece. The difference between *The Electromagnetic Dulcimer* and *Music on a Long Thin Wire,* apart from scale, is that it is designed to have other objects and materials placed onto the resonating wire in order to modify the sound produced, creating something that could be described as 'music on a long thin prepared wire'. To this end there are actually three wires in parallel to allow for this; two are each driven by their own signal generator and magnet combination, while a third, lower wire, is passive, potentially allowing for sympathetic vibration to be transmitted from the other two. A single piezo pick up amplifies the sound of all the wires, and the aim is that they be tuned to the same note or a perhaps an octave or a fifth apart. In practice this is difficult to achieve with the experimental set up, as it currently exists, due to the tension of the wires proving quite high for the ad hoc wooden substructure. A steel frame structure would be worth exploring in this regard, though issues of electrical insulation would need considering as the vibrating guitar strings are also current carrying and would need electrically isolating from each other and hence any metal frame.

The distance between the wires in the existing set up is designed to allow a ping-pong ball to rest on them securely whilst they vibrate, and the effects of this particular material intervention into Lucier's idea are shown in the 'ping pong ball performance' documentation of the piece. The 'wire and plastic performance' film relies on a more manual intervention or preparation, with a very thin piece of copper wire and a part of a plastic fork handle being held in contact with the vibrating guitar strings. In both examples of the piece the effects of the materials added to the vibrating strings creates a harmonic filtering as the materials are moved up and down their length, highlighting different harmonic activity in different places. This is not unlike the electronic audio effect known as phasing. The ping pong balls have a more radical effect on the sound of the guitar strings, creating, at times, a quite industrial machine like sound palette and at other times stopping all vibration altogether. The handheld thin piece of wire creates far more subtle effects that seem to move between the timbral, the pitched and the rhythmic, particularly when it is manually swept across the two active guitar strings. When the plastic fork handle is rested on the strings it creates a sounding behaviour that is somewhere between the ping-pong ball and the small wire intervention. The main factors that seem to effect these sonic outcomes are the weight and material make up of the various additional objects used as preparations. It is possible to imagine how these experiments could be developed into fully autonomous pieces with materials sweeping across the resonating strings driven by motors, or with the ping-pong balls being batted up and down the wires mechanically, or possibly encouraged to roll up and down through a mechanical tilting of the whole structure.

Slinky Speakers is a prototype piece that specifically tests the idea of autonomy within electromechanical systems. It is an electromechanical oscillator though of a different nature to the type described previously. Here the system is based on nothing more than a loudspeaker and an electrical power source and it operates on the same principle as the simple electric bell shown in figure 5.10, but with a loudspeaker replacing the iron core and solenoid assembly. Often ascribed to computer scientist and musician John Bowers (see Collins 2006: 19) this 'Victorian synthesiser' as it is also sometimes known, uses the mechanical deflection of a speaker cone when connected to a DC power source to make and break the electrical connection that is driving it. The resulting behaviour is one where the electrical connection causes the speaker cone to pop in, this in turn breaks the electrical connection causing the speaker cone to relax forward

making the electrical connection again, and hence the cycle repeats (see figure 5.11). The resulting sound is a popping square wave whose frequency can be affected by the physical distance and nature of the electrical contacts that are partly formed by the speaker cone itself.

Figure 5.10 Traditional electromechanical bell push system (Open University 1971)

Figure 5.11 Victorian synthesiser (from Collins 2006)

As can be seen from figure 5.12 there are two main points of difference with *Slinky Speakers* and the basic system described above. Firstly, the electrical connection between the copper and silver contact on the centre of the speakers and the DC power source is made via a long hanging slinky spring with a ball weight on the end. This causes the system to oscillate according to the mechanical characteristics of the spring and ball combination, producing a metallic shooting sound that resonates along the metal spring, and which is acoustically amplified by the large plastic cones above. Secondly, the DC power source to the system is provided by modified wind up torches, connected to large capacitors which are visible to the back of the white plinths in figure 5.12. Depending on how vigorously the torches are wound and hence the resulting charge on the capacitors, the balls and slinky springs either bounce quite high, causing single percussive impulses with up to around a one second interval, or with slow and gentle winding, the balls can be made to rattle continuously on the speaker cone, creating a more continuous sound. Other intermediate states can also be achieved with different amounts of winding of the torches. The resulting sound from the piece is a combination of percussive popping and rattling caused predominantly by the speaker cones hitting the balls at the bottom of the springs, and metallic, shooting sounds caused by the springs themselves. This metallic sound is reminiscent of an audio spring reverb device being overdriven or physically hit, or perhaps the sound of a distant train approaching when heard through the rails on which it is travelling. Another important factor in the sound of the piece is the relational nature of the four oscillating speaker assemblages, which occurs as the different periodic impulses of each system bring about complex rhythmic patterns. These constantly shift in relation to each other depending on the mechanical characteristics of the springs and the level of electrical charge being held by each of the capacitors, which is in turn dictated by the winding of the torches.

One of the key elements in the design and development of *Slinky Speakers* is that it is an electromechanical sound piece that does not require mains electricity or batteries. The idea that electromechanical sound art and other types of kinetic sculpture can somehow be autonomous or closed systems, requires a suspension of belief that the national electricity grid that powers them is a large and very open system. Bennett (2010) describes the national grid as:

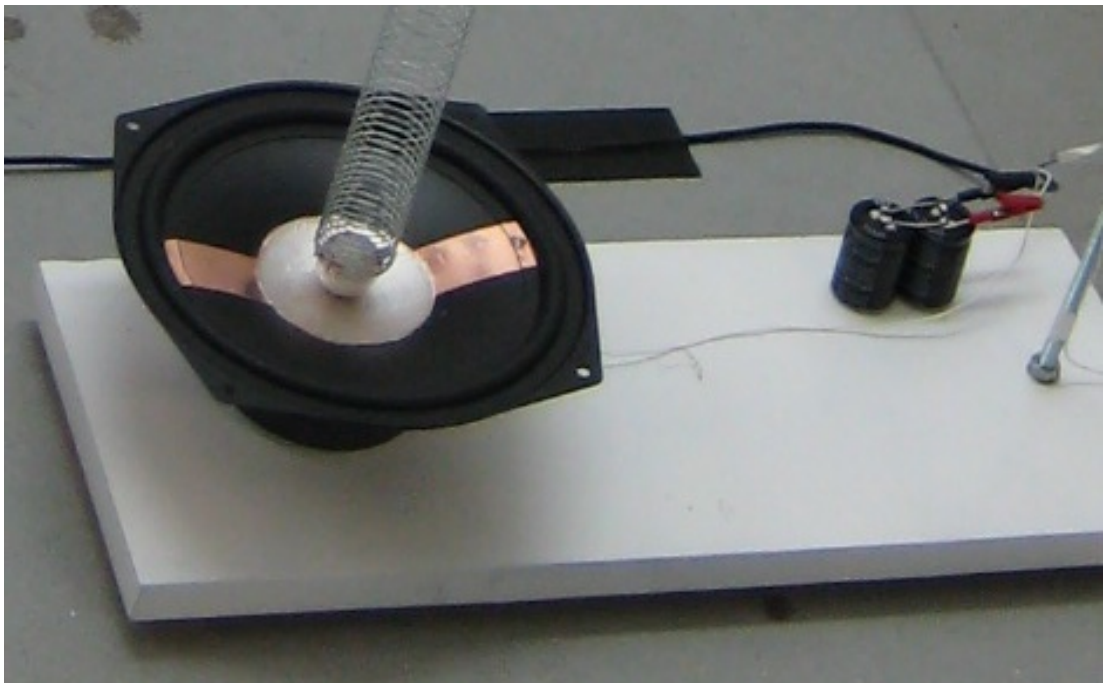

Figure 5.12a, b *Slinky Speakers* and detail showing conductive speaker cone and capacitors

> a volatile mix of coal, sweat, electromagnetic fields, computer programmes, electron streams, profit motives, heat, lifestyles, plastic, fantasies of mastery, static, legislation, water, economic theory, wire and wood – to name just some of the actants…
> (Bennett 2010: 25).

When this view is taken into consideration it is clear that anything using mains power is actually far from autonomous. This highlights a problem similar to that identified with Hans Haacke's *Weather Cube,* which he conceived of as a closed environmental system, but which is actually affected considerably by the environment within which it is placed (see 2.3.4). However, by making *Slinky Speakers* a more localised system and 'off grid', a further issue emerges with regards to the idea of autonomy in that the piece becomes audience interactive. Each of the four speaker and spring systems has its own wind up torch for members of the audience to provide the power source for the piece, inserting themselves into the system whilst exploring the different dynamics possible through the operation of the torches. The piece, in this way, becomes more a type of musical instrument and less of an autonomous sound sculpture. During open studio exhibition it was clear that there was a good deal of value in the piece being audience interactive, with up to four people working together to create different sounding arrangements from the four speaker and spring assemblages. Also by putting people energetically in the electromechanical system (or perhaps, in this case the bio-chemical electromechanical system) the audience are drawn into the specific dynamics of what is happening as the torch is wound, the ball is bounced, the capacitors charged and discharged etc.

Slinky Speakers proved a very useful prototype piece for testing these notions of autonomy, closed systems and interactivity. It has not been developed into a fully resolved piece at this stage because its interactive nature detracts from the idea of autonomous electromechanical sound art. It is, however, a valuable way of thinking through the theme of autonomy and as such serves as a boundary test piece for the project. It is also a successful functioning prototype of a piece that could easily be further resolved for gallery exhibition.

5.4 ELECTROMAGNETIC INTERROGATIONS

Electromagnetic Interrogations (2011 - 2014) is an autonomous system that has been fully realised for gallery installation. It has electromechanical and kinetic elements and its exploration of materials delves into the dematerialised and unseen nature of

electromagnetism. It does this by interrogating the electromagnetic radiation given off by three dismantled but still operative compact disc (CD) players, mounted upon three plinths (see figure 5.13). Coil microphones, which work as electromagnetic pick-ups, are suspended in a pendulum configuration such that they can swing above the various interior parts of the players, including the circuit boards, the motors, the transformers and the display units. The coil microphones, sold commercially as telephone bugs or pickups, are basically a long piece of copper wire wound around a metal core. These devices transduce the electromagnetic energy that surrounds the various electronic components into an electrical signal, which is then amplified and made audible through loudspeakers. The sound is affected by both the operation of the CD players and the movement of the coil microphones, which are swung by servo motors at timed intervals that allow them to periodically come to rest for a short time, before being made to swing again. Depending on how energetically the pendulum microphones are swinging, their movement modulates the sound in different ways, ranging from short rhythmic bursts to a more undulating variation as an electromagnetic field is interrogated in a very localised way. Two of the dismantled CD players have two pendulum coil microphones swinging above them and the third CD player has a single pendulum. This is due to the architecture of the various units' internal components and the associated electromagnetic activity. The cycle of when each respective plinth's pendulums are swung is unsynchronised, such that the relationship between the motion and hence the resulting sound of the pendulums is always changing and emergent. Similarly, the cycle of operation of functions of the CD players such as play, pause, eject, track skip etc. is not synchronised and also constantly shifts. Both the servo motors that swing the pendulums, and the operation of the CD player's functions are controlled by Arduino microprocessor boards, one inside the plinth of each dismantled CD player. Each coil microphone is amplified individually and has its own loudspeaker associated with it, hence the piece has five loudspeakers; a broad selection of single domestic hi-fi loudspeakers ranging from small computer desktop types, to larger and older ones. This motley selection of speakers both adds further individual sonic character to the sounds produced by each of the coil microphones, and also reflects the theme of outmoded and slightly decrepit domestic hi-fi equipment that is present in the dismantled CD players.

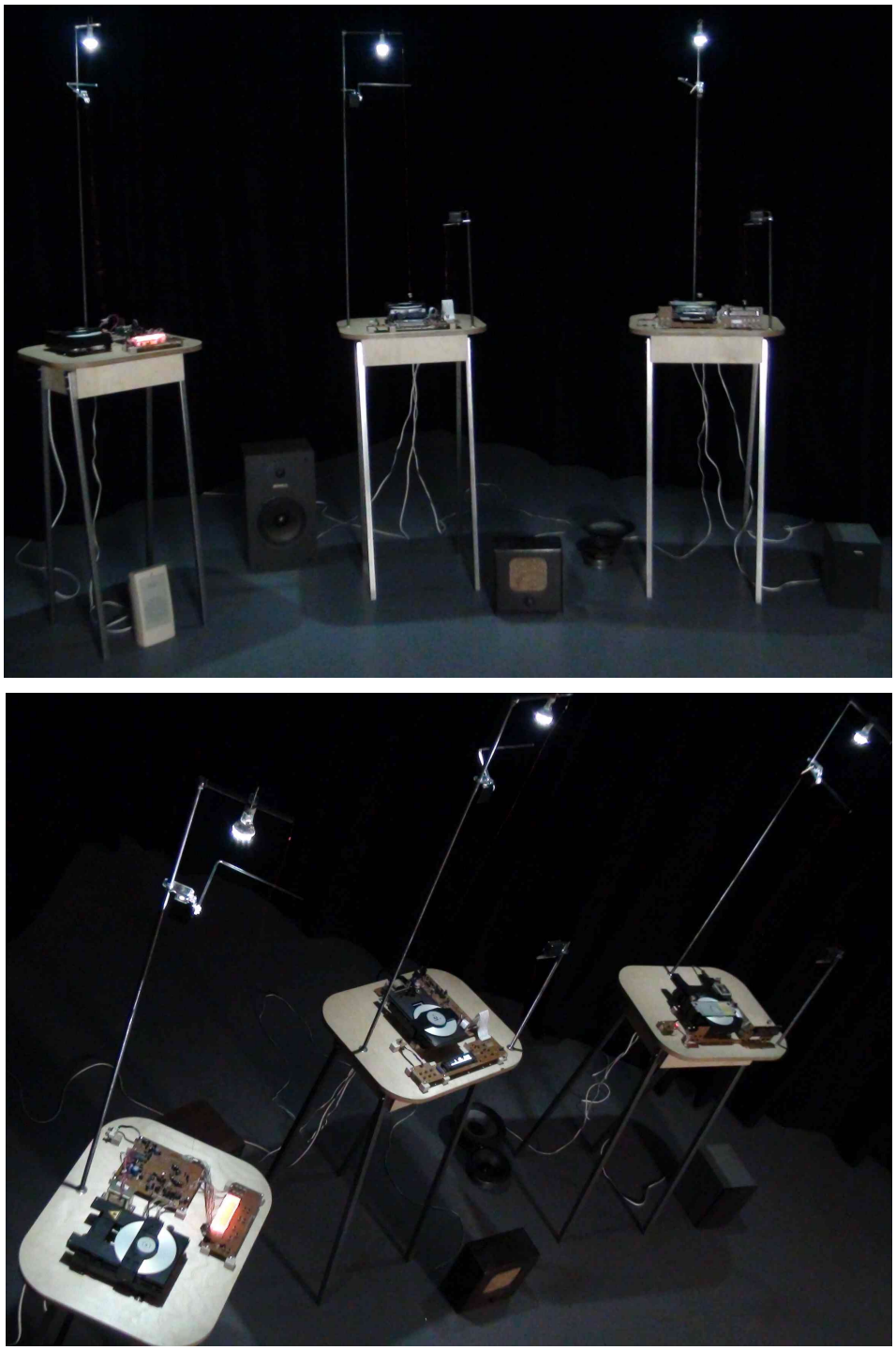

Figure 5.13a, b *Electromagnetic Interrogations*

The film documentation of *Electromagnetic Interrogations* gives an overall sense of the different moods that can emerge from this process driven piece. A central sonic feature is the low frequency drone given off by the mains transformers of the CD players whose main harmonic components are defined by the frequency of the national grid at 50Hz,

though harmonics of this frequency, especially 100hz, are also present. These low frequency tones are either rhythmically modulated into short bursts by the energetically swinging microphones, or more continuously audible where the microphones are slowing down and coming to rest. Sometimes both of these situations are audible simultaneously from a combination of different plinths, for example at 0'35" – 0'44" of the film documentation. Relationally shifting rhythmic patterns of short bursts between the different pendulum microphones are evident at 2'04" – 2'12" of the documentation. Another possible state is the thick layering of a more continuous transformer noise (the piece is approaching this state in the opening few seconds of the film). The motors of the CD players emit a range of higher frequency sounds including a kind of laboured nasal whine (CD drawer movement at 2"00') to a whistling sound, ascending in frequency, reminiscent perhaps of a sound effect for a small space craft taking off (CD spindle motor spinning, immediately following the drawer movement at 2'00", also a good example at 0'12"). The optical lasers of the players present a good deal of electromagnetic noise as they track the CD media. This ranges from a broadband white noise present when the CD is playing and lots of data is being read (this is noticeable throughout much of the film documentation, often rhythmically modulated through the pendulum microphones into a whooshing sound), to the chirrups that occur as the laser is searching for a particular track (e.g. 1'49" – 1'53") or the rhythmic ticking caused during the fast forward or reverse function. The fluorescent display units of the CD players and their associated signal paths and ribbon cables emit a characteristic high frequency whine. The two CD players that have this type of display unit have shorter pendulum microphones directly above them in order to localise the interrogation of this. These shorter pendulums have a faster periodic swing creating a rhythmic phasing effect within the context of a single plinth system as well as adding to the overall sound across all three plinths as can be seen in the documentation between 1'21" and 1'33".

Whilst it is interesting to make the associations between particular sound events and electro mechanical events within the CD players it is of course not possible to know exactly what causes every sound that may occur. Many of the sources of electromagnetic radiation are hidden away in the electronics of the circuit boards and integrated circuits of the devices, and the exact nature and cause of the activity at this level is not really knowable in practical terms. Listening to the mysterious inner workings of the units in this way adds to the process nature of the piece. It is also interesting to

note that even similar functions can sound quite different between the different makes, models and electronic architectures of the particular CD players. The operation of these domestic hi-fi units has been black boxed by each manufacturer in a slightly different way, creating a slightly different electromagnetic field and sound.

Electromagnetism has featured as a key material in a number of sound artworks including Lucier's *Sferics* (1981) which takes the idea of listening to electromagnetic waves to a cosmic scale using large antenna set up away from urban interference, trained on the sky and fed through very sensitive amplifiers in order to record naturally occurring atmospheric electromagnetic activity (see Lucier 1995: 456-465). On a more human scale Christina Kubisch's *Electrical Walks* (since 2004) equips listeners with electromagnetic listening devices, letting them walk freely and explore the electromagnetic fields of the urban environment. Compared to *Electromagnetic Interrogations* and considered through the themes of this project, however, both these examples work on a relatively large scale and with very open systems of cosmic and socio-geographical-technical activities. Closer in scale to *Electromagnetic Interrogations* are some of the efforts of *Studio Algorhythmics*, a 'studio lab' founded by Shintaro Miyazaki (see Studio Algorhythmics and Parikka 2012: 151) which defines 'Algorhythms' as something that occur when 'real matter is controlled by symbolic structures like instructions written as code' (Algorhythmics quoted in Parikka 2012: 151). The website shows documentation of a coil microphone like the one used in *Electromagnetic Interrogations* being used to harvest the electromagnetic radiation of digital technologies such as mobile phones. Collins (2006: 12) provides an overview of the creative use of coil mics within electronic music, and more broadly, in the book *Hertzian Tales* (1999), Anthony Dunne explores the topic of electromagnetism across a range of creative activities with a focus on electronic artefacts and critical design. Dunne's term for electromagnetic radiation is 'hertzian space'.

Examples of works more closely aligned to the themes of *Electromagnetic Interrogations* and the context of this project include some of Takis' magnetic sculptures from the 1960s such as *Magnetic Ballet* (1961) and *Magnetic Pendulum Musical* (1965). Both these pieces use a combination of electromagnetism and pendular motion to create a localised kinetic system that combines matter, energy and sound in a sculptural context. As can be seen in figure 5.14 Takis uses the same bobbin wound wire and metal core

configuration that forms the coil pickup microphones in *Electromagnetic Interrogations*. In Takis' pieces however the device is used in the reverse mode, as an electromagnet, periodically setting up magnetic fields, which then attract and repel other magnetic forces causing kinetic activity and creating sound events mechanically. *Electromagnetic Interrogations,* on the other hand, uses these devices to detect and transduce latent magnetic fields that surround electrical activity whilst the kinetic motion of the pendulums is driven by servo motors. Both Takis' works and *Electromagnetic Interrogations* do, however, draw attention to electromagnetism as a dematerialised material, through a kinetic, pseudo-closed system and through sound.

[Image removed for copyright reasons.]

Figure 5.14 Takis' *Magnetic Pendulum Musical* detail showing coil electromagnet (centre)

Another piece, which cannot go unreferenced with regard to the creative application of pendulums, is Reich's *Pendulum Music*, and one of the key systems qualities of *Electromagnetic Interrogations* is provided by the shifting periodic relationships between the various pendulums within the work, which is also a key element of Reich piece. The autonomous nature of *Electromagnetic Interrogations* does however create a specific point of difference with *Pendulum Music*; the performers who swing the microphones at the beginning of Reich's piece have been replaced by servo motors. Bosch and Simons (1996: 116) make a similar observation in comparing Reich's piece with elements of their own *Electric Swaying Orchestra* (1992) which uses motor driven parametric pendulums with both speakers and microphones attached to them as part of an unpredictable

recording and playback system. The element of feedback between microphone and loudspeaker, present in both Reich's and Bosch and Simons' pieces, however, is not a feature of *Electromagnetic Interrogations.*

An early iteration of the piece was first developed for the exhibition *Telenesia* (2011) and was presented there in a single CD player configuration under the title *Unfixed Media* (see figure 5.15). This version had one rotating and one pendular coil microphone above a CD payer that was still housed in its original casing but with the top removed and replaced by clear Perspex. The operation of the player's functions was achieved by way of electromechanical solenoid actuators physically pushing the buttons on the front panel. This added an additional mechanical 'clunk' to the sound of the piece alongside the electromagnetic noise. However, in its standalone state the single CD player did not provide the sonic depth or emergent, process driven qualities hoped for. As an initial solution to this for the exhibition, the CD itself was used as an audio source playing back a field recording of the sea alongside the electromagnetic noise of the player. The sound of the field recording was practically indistinguishable from the electromagnetic noise of the player and the two sources merged effortlessly to create an interesting soundscape borne of the natural and technical worlds. The fact that part of the sound was coming from the recorded media as it was controlled by, and heard alongside the electromechanical assemblage, informed the original title, *Unfixed Media*. Through further development *Electromagnetic Interrogations* was made as a group of three players (more could be added), fully removed from their casing and laid bare in a manner reminiscent of Tinguely's *Radio Sculptures.* The solenoid control of the player's functions was deemed unnecessary when simple electronic switch closures served the same purpose and the result is a physically and conceptually more elegant piece where nothing other than the original players and their interrogating microphones are seen or heard.

One of the key ideas of Bogost's book *Alien Phenomenology* is that of gaining an insight into how objects may possibly interact in or experience their world. One example Bogost uses to illustrate this idea is how different types of camera components such as photocell sensors and optics, cause cameras to 'see' the world in different ways (Bogost 2012: 72). This relates more broadly to his notion of 'carpentry' as a creative act of 'making things that explain how things make their world' (Bogost 2012: 93).

Figure 5.15 *Unfixed Media* (2011)

Electromagnetic Interrogations illustrates how things experience and make their world in two ways. Firstly, the swinging electromagnetic microphones create a sound that is borne of both their ability to 'hear' electromagnetism and their kinetic motion through electromagnetic fields. The aesthetic experience of hearing the sound that a swinging microphone hears is also something that can be appreciated in Reich's *Pendulum Music*. Secondly *Electromagnetic Interrogations* allows for a descent into the inner workings of domestic digital audio players, entering and interrogating their electromagnetic or 'hertzian' space.

The piece does not describe every single detail of the inner technicalities of these machines, but it does provide a window into how these machines create their world. It is an audible and visual peeling back of the outer layer of the technological black box to reveal the multitude of other black boxes and interactions that reside within. This draws attention to the materiality of the audio media system of CD players through a media technological 'descent' which has been associated with theorists such as Kittler (1995,

see chapter 3). And unsurprisingly with a shift of focus towards the materials of media technology the resulting sounds of hum, hiss, pop and click are suitably categorised as noise.

5.5 THE CAMPANOLOGIST'S TEA CUP

The final piece of practical work to be discussed, titled The *Campanologist's Tea Cup,* was developed in collaboration with ceramicist Ingrid Murphy and commissioned for an exhibition titled *The Sensorial Object* in Cardiff in 2015, It has also been exhibited in *Oriel Q* gallery in Wales, and was selected for the British Ceramics Biennial and exhibited as part of that event in Stoke-On-Trent during October and November 2015. It is included as part of this project as an example of some of the core aesthetic concerns applied through a collaborative piece of work which has enjoyed a busy exhibition schedule.

The piece appropriates a simple electromechanical system to interrogate materials and facture through sound. One initial inspiration for the work came from the common practice of tapping a piece of ceramics and listening to the resulting sound in order to ascertain the inherent quality, value and material integrity of the object. This is a very practical application of the relationship between sound and material. As can be seen in figure 5.16 and in the film documentation, this relationship between ceramic material and sound is explored in the piece through four ceramic gramophone horn forms on plinths, each with a rubber ball suspended inside its throat. Positioned on a fifth plinth is a small bone china tea cup that the audience are invited to tap or 'ping'. With this simple, single interaction the four suspended rubber balls start to rotate eccentrically, driven by four small DC motors from which they are hung. With this eccentric rotating motion the balls bounce around the inside of the ceramic horns causing them to ring at a pitch which is defined by their thickness, their surface glaze and the temperature at which they were fired during production. There is a non-linearity to the nature of movement of the balls as they swing and bounce off the surface of the horns, and hence the tonal percussive sounds that are produced build a complex relational sonic arrangement across the four plinths. The overall sound is a soothing almost wind chime-like or bell-like effect that is entirely recognisable as being borne of a ceramic form. Small contact microphones are attached to each of the ceramic horns in order to reinforce the natural resonant sound through standard speakers (hidden inside the two end plinths).

Figure 5.16a *The Campanologist's Tea Cup* in the *Sensorial Object* exhibition Cardiff (2015)

Figure 5.16 b *The Campanologist's Tea Cup* in the *Sensorial Object* exhibition Cardiff (2015)

Figure 5.16c, d *The Campanologist's Tea Cup* showing detail of rubber ball in horn and motor assembly

The electromechanical nature of the piece is simply in the kinetic, motor driven behaviour that excites the unpredictable nature of the bouncy balls. An Arduino microprocessor board, running three possible set sequences, controls the timing and switching of the motors' activity, but the exact nature of the resulting electromechanical activity and sound is unpredictable. The small interaction of pinging the teacup, required to trigger the kinetic and sonic activity, reflects the initial inspiration for the piece of checking the material integrity of ceramic tableware through sound. It is also a practical solution to the problem of kinetic sound pieces running continuously in open gallery spaces where audiences may be moving around an entire show of different artworks, and invigilators may be stationed in the space for long periods of time. Having a kinetic piece triggered in this way also helps with the longevity of work that may suffer from extended periods of operation, requiring maintenance. Contemporary documentation of Tinguely's work often shows the pieces being button activated for a timed period.

There are useful connections to make between the ceramics practice that forms an important element of *The Campanologist's Teacup,* and the themes of this project. Ceramics, and more broadly material or craft based art practice, obviously has a strong lineage of engaging with materials. The field also holds the notion of process in high

regard, something that has already been identified as a theme linking materials with systems. Process from this stance of material arts is the working, firing, turning, forming and general processing of materials that happens before the final static form of an artwork is produced. Glen Adamson (2007: 58) explores this emphasis on process within material art through the process art of Robert Morris (*Untitled* 1967), Eva Hesse (*Right After* 1969) and Richard Serra (*Catching Lead* 1969). In these examples the materials and their natural behaviour during processing are considered an important contributing factor to the final artwork. Adamson also identifies the facture of the work, the evidence of the making process in a final outcome, as an important theme, and one that he explores through Morris' piece *Box with the Sound of its Own Making* (1960), a small wooden box that contained the pre recorded sounds of the sawing, banging, sanding etc. that went into its making.

The difference, however, between this kind of process art and kinetic sound art, is that with kinetic pieces the process (of creating the sound and movement) is happening in real time and in the moment of reception by an audience. This is the same difference that Reich observes in regard to his *Pendulum Music* being different to compositional processes that are not discernable by an audience in their moment of reception (Reich 2007, see 2.3.6). However, the connections between real time kinetic sound processes, previously completed material processes, material art and sound art are made elsewhere too. For example, with Ethan Rose's kinetic object based sound installation *Transference* (2009), made in collaboration with a glass artist Andy Paiko, (see 2.4) that explores the sounding nature of glass bowls. Also the British Crafts Council sponsored tour *Sound Matters* (since 2013) features a range of artists working with sound such as Max Eastley, Keith Harrison and Owl Project who have created sound pieces through an engagement with craft processes, using materials such as wood, textiles and clay. In the *Campanologist's Tea Cup*, the real time kinetic process of the rotating, bouncing balls reveals something of the previously completed material processes of slip cast clay, kiln firing and glazing, which all contribute to the resulting sound of the work in some way. The sound presents a facture of the objects and a window into their internal material make up which has been formed by a previously completed making process.

5.6 SUMMARY

The three complete pieces and one set of experiments presented here as practice condense the theoretical, contextual and methodological elements of this project into material systems and assemblages that seek to communicate and embody the core ideas being explored in this project. In accordance with the method of the project, the ideas being explored also concurrently seek to understand this practical work. The two elements have evolved simultaneously and these descriptions of the exact nature of the practice have further illustrated how that evolution has happened.

Each of the pieces presented deal with the themes of materials, systems and autonomy in different ways and to varying degrees. *Electromechanical Oscillator* is a purist and autonomous electromechanical system that allows interchangeable materials to effect the sounding outcome. The first two lab book experiments are similar explorations of electromechanical systems. *Slinky Speakers* is an electromechanical system that tests the boundaries of autonomy both in regard to the national electricity grid and the audience interaction. *Electromagnetic Interrogations* exhibits its systems nature through the shifting phased relationships of swinging pendulum microphones, and the electronic activity of complex exposed circuitry. It also tests the theme of materials by foregrounding electromagnetism as an invisible, dematerialised sounding material, straying into the territory of Takis' work and recalling Lippard and Chandler's 'dematerialisation of art'. Finally, *The Campanologist's Tea Cup* represents a return to a more solid materiality, but one that even in its apparently very simple form of clay, can represent a black box of processes and make up that can also be interrogated through sound. Through the common themes of materials, systems and autonomy, these pieces, which use a breadth of materials and technologies and produce a wide range of sounds, become a coherent body of work.

6. CONCLUSIONS

6.1 QUESTIONS AND CONCLUSIONS

Three questions served as a starting point for this project and will be used to structure a discussion of conclusions and findings:

- How can electromechanical systems be applied and explored through sound art practice?
- What is the artistic context for such an approach to sound art?
- What theoretical frameworks can be used to understand the relationship between electromechanical systems and sound art?

These broad questions have been explored through work of a practical, theoretical and reflective nature where a field of enquiry has been established through drawing together materials from various disciplines. The findings presented below can be understood as particular themes, resonances and possibilities that have been identified within this field through a reflective process of making, reading and writing. Responses to the three questions overlap and conclusions that emerge from answering one question also speak to other questions as context, theory, practice and method all emerge from the process of art practice as research.

Particular original insights and contributions emerge primarily from the identification and discussion of a closed system aesthetic, as well as from discerning between process driven approaches and programmable robotic approaches to making electromechanical sound art. The method developed for this project can also be summarised in terms of the particular nuances and originalities that it develops within art practice as research. A further original observation is made regarding the context for electromechanical sound art as existing at an intersection between the ‘dematerialisation’ of art practices and the ‘materialisation’ of compositional practice. All of the findings and contextual observations are shown to be embodied within, informing, and informed by the core artistic practical work for the project. The brief discussion of context and theoretical frameworks towards the end of the conclusion, serves as a reminder of where and why there exists a gap in

knowledge regarding practices such as electromechanical sound art. It also identifies how current critical traditions such as media archaeology and science and technology studies exist as possible frameworks to help fill that gap.

6.2 ELECTROMECHANICAL SYSTEMS APPLIED AND EXPLORED THROUGH SOUND ART

'How can electromechanical systems be applied and explored through sound art practice?' is actually two closely related questions, one concerning the artistic application of electromechanical systems to sound art, the other a more method oriented question of how such systems can be explored. Two core findings relate to the first part of the question. Firstly, the contrasting of programmable robotic approaches to electromechanical sound art with a more process conscious approach that allows for a greater freedom of material behaviours, and secondly the identification of a closed system aesthetic. The findings relating to the more methodological question of how electromechanical systems can be explored through sound art are discussed in detail in chapter 4 (methodology), but one core contribution is highlighted here which is the development of a process orientated approach to art practice as research.

6.2.1 Process Driven Versus Programmable Robotic Approaches

Electromechanical systems can be applied to sound art practice in two ways that contrast each other. On the one hand systems can highlight the freedom and agency of non-human material activity in creative approaches presented throughout this project for their emphasis on unpredictable processes. On the other hand, electromechanical systems can support human authorship and highlight the effective mastery of programmable technology by humans through approaches which have been described as more robotic. These distinctions between process driven and robotic have been identified through artistic practical experimentation, critical review of existing electromechanical and kinetic works and associated literature, and through applying ideas from Burnham (1968) on kinetic art, and Bijsterveld (2008) and Zielinski (2006) on autonomous programmable instruments, to sound art practice.

From the very initial stages of studio based practical experimentation for this project the emphasis was on creating autonomous electromechanical systems that could be set in motion to allow for an unfolding of sounding events that would be dynamic,

unpredictable and emergent. These were initial, intuitive experiments with the approach that would become clearly identified as process driven. Early experiments for *Electromechanical Oscillator* and its development, and the three experiments presented as the open lab book (*Electromagnetic Tin Drum*, *Electromagnetic Dulcimer* and *Slinky Speakers*) all clearly show this in some way. The unpredictable behaviour of metallic objects, electrical and magnetic fields and mechanical forces within these pieces gave these early experiments a dynamism and a drama of natural emergent phenomena. This experimental phase of the practical work was important in identifying these qualities without the pressure of producing an exhibition ready piece. The fine balance between creating work which is reliable in that the system runs effectively over the course of a public exhibition, but also presents this dynamic and unpredictable behaviour, was something to be developed separately. The open lab book and the early experiments for *Electromechanical Oscillator* represent the initial, intuitive phase of practice as research into a process driven electromechanical sound art.

With this particular focus developed through early practical outcomes, it has been possible to critically align other particular examples of sound art and kinetic art, and related ideas concerning creative practice and technology. Some of the key relevant examples of sound art considered are canonical, belonging to genres of music and art that developed directly out of a context of 1960s experimentalism. David Tudor's *Rainforest*, Steve Reich's *Pendulum Music* and Alvin Lucier's *Music on a Long Thin Wire* along with Jean Tinguely's *Radio Sculptures*, Len Lye's *The Loop* and a number of Takis' musical magnetic sculptures from the mid 1960s have all been shown to form a key part of the history and tradition of process driven electromechanical sound art. From a more contemporary context similar concerns have been shown to be present in Peter Bosch and Simone Simons' *Krachtgever*, Daniel Wilsons 'miraculous agitations' and Atle Selnes Nielsen's *Capstan*. All of these pieces use electromechanical technologies in a process driven way where the work could be described as creating a 'situation in which things can happen rather than an object per se' (Burnham 1968: 271), or as 'outlining a situation in which sounds may occur' rather than prescribing a defined time-object (Nyman 1974: 4), and where outcomes are controlled by the 'dynamical properties of the materials used' (Burnham 1968: 274) and an 'incomplete knowledge of the system […] is an essential feature' (Eco 2007: 171). These are all apt descriptions of the way in which

electromechanical systems are applied in the original practice of this project and in other core examples discussed.

Another contrasting way in which autonomous electromechanical systems can be applied to sound art practice has been identified as exhibiting a concern with more robotic and programmable systems. This approach, reflected in various pieces by Trimpin including *Conlon in Purple* (1997), and by the Logos Foundation, including their Robot Orchestra, as well as in Felix Thorn's orchestrion machines, explore, remake and update old programmable electromechanical music technologies such as the player piano and the orchestrion. These devices belong to a tradition of programmable sound technologies which, in an era before effective sound recording or synthesis, allowed for a level of control that reinforced the position of the 'autocratic and infallible composer creator' (Bijsterveld 2008: 150 quoting Taruskin 1995: 167). This tradition also includes the music boxes and musical automata which were particularly popular in the 1700s and 1800s and which Burnham (1968: 185) considers indicative of a 'new age of precisionism' reflecting evolving classical musical forms of the time (Burnham 1968: 196). The paper 'Musical Robotics in a Loudspeaker World' (Murphy Kapur and Carnegie 2012) also covers this trajectory through a contextual history of musical robotics as well as through identifying the contrast that such 'live' technologies make with the 'hidden' sound sources of standard loudspeaker based sound production. However, despite including a section on 'mechatronic sound sculpture' (Murphy et al 2012: 43), Murphy et al's paper, does not discern between programmable robotic approaches, and the more process orientated electromechanical approaches described previously. Problematically, Murphy et al merge the two areas.

All the practical work developed for this project is process driven. The early lab experiments helped to clarify this creative focus when, for example, with *Electromagnetic Tin Drum* it was observed that the unpredictable mechanical qualities of the moving steel wire and the tin membrane that it struck created the real aesthetic value of the system. Considering the way in which these unpredictable material behaviours changed the more uniform behaviour of the electronic oscillator further extended the theme. Such experiments and observations also developed from making interventions into existing loudspeaker technology. Disassembled or prepared speakers present important possibilities for how electromechanical systems may be applied to sound art in a way

which allows for a freedom of materials. Even in today's highly controllable and digitised world of sound production, the loudspeaker serves as the final electromechanical gatekeeper in a long chain of more malleable and refined technologies. David Tudor's *Rainforest*, Alvin Lucier's *Music on a Long Thin Wire*, Daniel Wilson's 'miraculous agitations', Andrea Valle's *Rumentarium Project* and Peter Bosch and Simone Simons' *Krachtgever* have all been shown to reflect in some way the creative potential of the loudspeaker as a material system, the exact sounding nature of which cannot be known prior to hearing it. Much of the original practical work developed for this project stems from a consideration of and reflection on the loudspeaker. *Electromechanical Oscillator* and *Slinky Speakers* are the two most obvious examples of this, where prepared loudspeakers form a core part of the system under creative exploration. These pieces do not force the loudspeaker to exercise the will of a human composer by transparently reproducing a finely honed electrical signal. Rather they allow for and develop the idea of loudspeakers sounding their own resonant voice in unexpected and non-linear ways, reflective of the process driven approach.

The distinction between creative methods which are programmable robotic on the one hand and process driven on the other is a new and original distinction made within the field of contemporary electromechanical sound art. The two approaches are recognised by Burnham (1968), within the context of kinetic art of the 1960s, and they are reflected in a more general discussion of the topic of systems, where themes of mechanistic and technocratic control infiltrated the original sentiments of systems thinking which came from scientists such as Ludwig von Bertalanffy. Discovering these historic distinctions in other fields, and applying them to sound art practice is worthwhile as it prevents quite different creative works being considered as qualitatively equivalent just because they appropriate electromechanical technologies. The identification of differences between process driven and programmable robotic approaches also leads to a possible distinction between the terms 'system' and 'process' with regards to creative practice. Whilst often used interchangeably as genre descriptions with regards to the work of, for example, Steve Reich's early compositions and Robert Morris' artworks of the 1960s such as *Untitled* (1967, felt), it is possible to assign a 'dirtier', less predictable material association to the idea of process art or music, whilst a systems approach could also include conceptual, software based or cybernetic approaches, where modes of control can be manifest in a multitude of ways, sometimes predictable, sometimes not.

6.2.2. A Closed System Aesthetic

Loudspeakers are not the only device that can be appropriated to forefront the activities and agencies of materials within electromechanical sound art; magnets, microphones, pendulums, motors, electronic components, copper wire and many other things besides can feature in material systems that play out in their own way within the field of possibilities afforded by their assembly. Electromechanical systems can be applied to sound art practice in such a way that the activity of these materials in terms of their movement, their surrounding energetic fields, their interactions and relationships, their energetic transduction, their inputs and outputs, their resonances and patterns of behaviour are exposed and clearly presented. This reflects important aspects of the systems aesthetic and it can be achieved effectively through presenting a localised material system described in this project as both a plinth mounted performance of materials and a closed system aesthetic. This creative approach is identifiable in the work of the first wave of systems conscious kinetic artists such as Hans Haacke's *Whether Cube*, Jean Tinguely's *Radio Sculptures*, Len Lye's *The Loop* and Takis' magnetic sculptures. It is also reflected in Steve Reich's *Pendulum Music*, Alvin Lucier's *Music on a Long Thin Wire* and David Tudor's *Rainforest* as well as in the original work made for this project.

The way in which these examples expose materials and their interactions highlights connections and tensions between the idea of a system and the idea of an object. Materials such as wire, magnets, springs and metal loops appear in these pieces as both separate, closed objects and as part of the larger relational, real time system in action. The behaviours and interactions of these objects draws attention to their own internal make up as well as to the arrangement of the system that they sit within. These systems that the objects sit within, however, do not explicitly point to any other larger systems or objects outside of themselves such as the gallery environment or the social value of art for example, hence they may be considered autonomous and closed. In some cases, the plinth, a modernist indication of the possibility of art being isolated from the rest of the world, helps to define this closed autonomy. These tensions between open systems and closed objects have been explored in particular through Hans Haacke's work such as *Weather Cube* (1965), where a desire for kinetic systems 'to function in a very literal, physical sense' (Chau 2014: 72) can be found alongside a

fascination with the ‘nearly magic, self contained quality of objects’ and a ‘confession’ of the enjoyment found in the ‘the separation and autonomy of art’ (Haacke quoted in Jones 2011). Burnham’s writing from the 1960s also reflects these tensions in its struggle to bring together object based, kinetic interactions on plinths with his more open ended, expansive systems view of art which looked towards a burgeoning world of computerised global information and data communications as well as ecological and environmental awareness. According to Chau (2014) the position that Burnham took here ultimately led to kinetic art being excluded from postmodern aesthetics.

The practical outcomes from this project work within a closed system aesthetic. *Electromagnetic Interrogations* explicitly draws attention to the relational transduction of electromagnetic energy through swinging coil microphones above the exposed inner activity of CD players which are normally closed, black boxed objects. Other electromagnetic interference from the surrounding environment, however, is excluded from the piece. *Electromechanical Oscillator* and *The Campanologists Teacup* also foreground the transduction of electrical to mechanical and acoustic energy. The various objects and energy sources necessary to the operation of these systems, such as swinging pendulums, bouncing rubber balls and exposed power transformers, are all localised and (where possible) visible and / or audible. The way in which sound events are created through, for example, the collision or vibration of physical bodies, or the swinging of a microphone through an electromagnetic field is made explicit through an autonomous performance of materials. These practical outcomes do not overtly point to any systems outside of themselves, rather they continually highlight the way in which their internal components exist in constant relation to each other. The audience are invited to suspend knowledge of bigger, more global, ecological or social systems and behold the nature of the smaller, closed events unfolding before them. Of course bigger systems are in fact at play, most notably the electricity supply powering the work. With the piece *Slinky Speakers* an attempt was made to go ‘off grid’ and provide an entirely local energy supply via wind up torches, but this resulted in an outcome that was qualitatively different, shifting the aesthetic experience away from a sense of autonomy and towards a piece that centred around human interaction and participation. *Slinky Speakers* remains a worthwhile prototype for an interactive artwork but for the purposes of exploring the closed system aesthetic it detracts from a sense of closed autonomy

hence it remains part of the lab book experiments and is not presented here as a finalised piece which fully embodies the core findings of the project.

The idea of the closed system aesthetic is an original contribution to the field of sound art. A closed system aesthetic includes the process sensibility discussed previously where behaviours and outcomes are unpredictable, but it also identifies the localised, autonomous and real time nature of the events which make up the work. A closed system aesthetic is not concerned with broader systems of information networks or environmental activity, things that could be and often are brought to bear on sound art, particularly through modern technological tools. The closed system aesthetic was intuitively explored by artists in kinetic works of the 1960s and beyond but was never well represented or critically explored, as it was suspected that such practices were outdating fast or already outdated through an awareness of more expansive global, conceptual and digital systems. These more expansive global and technological systems are now commonly acknowledged, and this allows for the closed system aesthetic to re-establish its own relevance through contrasting and identifiable values presented here in relation to sound art.

6.2.3 Creative Systems as Method

The theme of exposing inner workings of objects also speaks to the more method orientated question of how can electromechanical systems be explored through sound art practice? An exposed system is an exploration and description of itself, and creating exposed systems in this way is a practice that has been aligned to Bogost's idea of carpentry which he describes as a method of 'making things that explain how things make their world' (Bogost 2012: 93). Integrating this this with Law's notion of 'method assemblage' (Law 2004) and underpinned by Borgdorff's work on art practice as research (Borgdorff 2006, 2011), a systems and process sensibility has been applied to the research method used to explore electromechanical systems in sound art. This approach required an interdisciplinary field of possibilities be set up through the context and theoretical territory identified for the project, and through the practical lab environment consisting materials like magnets, wire, loudspeakers and motors. The inclusion of the lab book as a core part of the practical work for the project helps to describe the practice based part of this field of possibilities. The process of exploring the relationships and resonances within the field has been enacted through creative and

reflective cycles of practice and theory similar to those described by Kolb (1984), Halprin (1969) and Nelson (2013). The general method of art practice as research has been informed by these authors, but the position of viewing the research process through a creative systems approach with a ‘field’ holding conceptual and material elements and a ‘process’ which identifies resonances, connections and effects within that field has been developed as part of this project and presents an original methodological development.

6.3 AN ARTISTIC CONTEXT FOR ELECTROMECHANICAL SOUND ART

The question set out at the beginning of the project relating to artistic context seeks to identify the traditions, influences and creative communities that have formed around electromechanical sound art from both an historic and contemporary perspective. This was partly developed through a review of art and music practice in related areas such as kinetic sculpture and experimental composition since the 1960s. These fields have been shown to embrace works that exist ‘in the twilight zone between a concert and an installation’ (Collins 2007: 46), produce material artists who concern themselves with sound and music, and composers who turn to building electromechanical sculptural installations and devices from component level.

An interesting finding for the context of electromechanical sound art emerges from looking closely at the initial conditions which during the 1960s led to the possibility of sound art as a genre in its own right. While the material arts were ‘dematerialising’ (Lippard, Chandler 1968) and beginning to embrace softer and more expansive materialities such as magnetism, light and conceptual approaches, some experimental composers were specifically becoming interested in music’s connection to its material source, on a kind of return journey from the conceptualism afforded by the system of the musical score. Both art forms were bucking modernism’s desire for fixed media specificity, but heading in different directions and their trajectories intersected at a point where both were consciously experimenting with a range of materials, and the idea of systems. This is the point where some kinetic sculpture and some experimental music pieces appear very similar in nature and distinctions between terms such as art and music become less important than finer distinctions concerning materials, systems, process, objects and autonomy.

From an historic perspective this is one possible artistic context for electromechanical sound art. It is one which represents a tradition which is concerned with using 'soft' materials like magnetism, electromagnetism and sound, alongside 'hard' materials like metal, electronic components and the 'visible bodily presence of audio technologies' (Rose 2014: 66). The context spans equally the fields of art and music and has been shown to encompass tensions between 'object' and 'system' at the 'crucial intellectual hinge point' between the modernist self contained object and 'postmodernist multifaceted open-endedness' (Skrebowski 2006) of the 1960s. These kind of critical and theoretical accounts relating to the context underpin the findings described previously regarding closed systems and process within creative practice, and have inspired, informed and have helped to unpack elements of original artworks made for this project.

The contemporary artistic context for electromechanical sound art is defined partly by practitioners who choose to work in this way today. Examples include current membership of Tudor's *Composers Inside Electronics* who continue to produce the *Rainforest* installation, the robotic machines of Godfried-Willem Raes' *Logos Foundation* and Pierre Bastien's installations such as *Paper Drums* (2004) and *Play Meccano Play* (2010). These examples represent practitioners who have been active since the 1960s and early 1970s, and who have connections to the original wave of creative electromechanical approaches presented in this project. Also there are a number of newer artists, people who have grown up with readily available, convenient and accurate digital tools for creative productions including Ethan Rose (*Transference,* 2009), Daniel Wilson's 'miraculous agitations', Andrea Valle (the *Rumentarium Project)*, Zimoun (various pieces such as *157 Prepared DC Motors, Cotton Balls, Cardboard Boxes 60x20x20cm*, 2014) and Peter Bosch and Simone Simons (various pieces including *Krachtgever)* who are found to be making 'object based sound installations', 'acoustic computer music' and large sculpturally installed 'music machines' through electromechanical means. Original pieces created as part of this project contribute to this contemporary context particularly where they have received public exposure through exhibition and presentation (see list in appendix 1).

The broader contextual question of why work of this nature enjoys exposure, exhibition, funding and debate today could in part be answered by acknowledging the contrast it

strikes with the seemingly immaterial condition of much current cultural activity, which is in the form of digital media. Parikka observes a 'perceived immateriality brought by digital culture, and by what postmodern theories flagged as the abstraction and immaterialisation of cultural reality' (Parikka 2012: 84), and Alt (2011) identifies that the development of computer programming techniques in the 1960s led to the system itself becoming the dominant medium rather than any hardware devices that may be running it. In the context of this digital immateriality and post modern 'multifaceted open-endedness' (Skrebowski 2006) where everything is assumed to be connected and available via information streams over global wireless networks and on portable devices, the limiting conditions of a localised, closed material system seem fresh and aesthetically rewarding. It follows that a close inspection and enactment of creative activity from a time just before ubiquitous digital media throws up many useful insights for this mode of creative practice today. Hence media archaeology as a practice and theory of media art exploration that seeks out hidden, lost or forgotten modes of activity (Parikka 2012: 136), is another contemporary creative context for electromechanical sound art.

The original piece *Electromagnetic Interrogations* embodies this contrast between the material and immaterial through its interrogation of electromagnetic interference around the inner workings of a piece of digital technology. The piece highlights the immaterial nature of electromagnetic energy in contrast to the material components of the compact disc players. Digital technologies and wireless information transfer are relatively contemporary concerns, but Takis' magnetic sculpture from the 1960s was also exploring similar themes of immateriality and 'unseeable energies' (Anderson 1968: 23). In an approach that could be described as media archaeological, *Electromagnetic Interrogations* descends inside CD players and develops a context which fuses the exploration of materials and immateriality that surrounds digital technology, with Takis' magnetic, musical and kinetic pendulums of the 1960s.

6.4 THEORETICAL FRAMEWORKS FOR UNDERSTANDING ELECTROMECHANICAL SOUND ART

The question relating to theoretical frameworks reflects the interdisciplinary nature of this project by asking for frameworks that can hold both a technological condition (electromechanical systems) and a cultural endeavour (sound art). The theories explored for this have come from interrelated ideas from the fields of sound art,

materialist and object orientated thinking, science and technology studies and media archaeology all of which in some way try to span the nature / culture divide. These theoretical positions have run parallel to, intersected, informed, resonated with and worked as metaphors for the practical work of the project.

Cox (2011) comments that sound art is 'profoundly under-theorised' and has failed to generate rich and compelling literature (Cox 2011: 146) due in part to what he terms the 'linguistic turn' that dominated cultural criticism during the 1970s and 1980s, which is primarily concerned with signs and representations. According to Cox, this approach served to 'bolster' conceptualism while insisting that our access to the real is fundamentally discursive (Cox 2013). Also, topic reviews by Licht, which identify the broad and interdisciplinary nature of sound art as a relatively new and at times niche field of practice go some way to explaining why it may suffer from a lack of overarching theoretical premise. Kinetic art, meanwhile, according to Chau (2014) has been 'sequestered' from postmodern aesthetics as systems art became aligned more to conceptual approaches, keen to distance itself from a modernist scene of objects on plinths. A similar point is made by Keylin (2015) in regard to sound sculpture (the type that uses materials and objects) being excluded from sound art discourse, shunned for being 'so unmodernly modernist' (Keylin 2015: 182). With these positions in mind the territory for investigating electromechanical sound art from a critical or theoretical perspective does not look fertile. Fortunately, Cox offers a potential way forward when he states that 'the emergence of powerful realist and materialist philosophies since the late 1990s has been paralleled by a renewed interest in sound' (Cox 2013).

In a specific and direct way, less overarching than Cox's development of a general theory of sound art, these 'realist and materialist' philosophies are useful in developing a critical framework for electromechanical sound art and its appropriation of materials and objects as real time, kinetic sounding bodies. On closer investigation the theoretical territory that Cox points to contains not only a way of thinking about materials and objects that transcends either linguistic exclusion or scientific formalism, but also presents a broader picture of material systems through the work of Law, Latour, Bogost, Harman and others within fields such as science and technology studies, actor-network theory and object orientated ontology. These scholars present a way of thinking about the world in terms of heterogeneous material relations, black boxes, objects and

systems which resonates with findings from within the creative context and artistic practice of this project. Theories from these fields allow for an agency and vibrancy of materials as well as humans, and this supports the investigation and making of artwork that seeks to give material assemblies a freedom to present their own dynamic interactions and relations.

Other observations from this theoretical field emerge from Law's descriptions of the scientific method creating 'arrangements for converting relations' and 'shifting material modalities' (Law 2004: 29) which are also fitting descriptions for aesthetic concerns relating to material systems in electromechanical sound art. The desired outcome of emergent and ever changing sound organisation however is different to the desired outcome of a fixed and repeatable scientific reality. This is reflected in Bogost's observation that typically human culture 'is allowed to be multifarious and complex, but the natural or material world is only ever permitted to be singular' (Bogost 2012: 4). Making electromechanical sound art entails technical and scientific effort for an intended outcome which is in part a description of processes which are traditionally understood through a techno-scientific perspective. Reflections on science and technology from scholars such as Law help in developing an art practice that entails and is reflective of science and technology.

The identified theoretical area also forms a tributary to the newer field of media archaeology, which has emerged partly in relation to media arts practice, and which also aims to span the nature / culture divide, as well as pursue a theory / practice union. A special issue of the journal *Organised Sound* published in 2013 serves to strengthen these connections between media archaeology and sound art. Parikka (2012, 2011b) shows that this kind of materialist cultural sensibility is also present in some older areas of media theory and criticism with writers such as Marshall McLuhan, Walter Benjamin and Fredric Kittler. The territory of materialist media theory brings such important ideas as 'descent' from the higher levels of software and meaning, down inside the media machine to expose its inner hardware, potentially remaking and rewiring it. Also the idea of 'material noise', creeping in from the real world, introducing noise to an informatic signal path in the form of, for example, a crackly gramophone record, a poor electrical connection or a deformed speaker cone. Both these constructs of material noise and descent serve as effective descriptions of many of the works explored as part of this

project including original pieces created such as *Electromagnetic Interrogations* and *Electromechanical Oscillator.*

6.5 END NOTE

Just as with any systems or process orientated creative endeavour these findings and conclusions are entirely dependent on each other, and on the field from which they emerged. This field is an assemblage, an ad-hoc collage with the capacity to embrace a wide variety of incompatible components, ideas and technologies connoting ‘active and evolving practices rather than a passive and static structure’ (Law 2004: 41). Further enactment of this art practice as research process would no doubt bring about other findings, shifting the emphasis and nuance of this chapter and other elements of the project. Following some of Law’s descriptive terms for method, it is best to think of the findings presented here as amplified moments and resonances rather than fixed objects or overarching systems of governance.

7. BIBLIOGRAPHY

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APPENDIX 1
LIST OF PUBLIC EXHIBITION AND PRESENTATION OF WORKS

2017. Exhibition: *Electromagnetic Interrogations*. Kinetica 10th anniversary exhibition. London. http://www.kinetica-museum.org/news/latest-info/kinetica-10th-anniversary-exhibition.html

2016. Presentation: 'Material Systems as Art Practice and Method' presenting *Electromechanical Oscillator* and *Electromagnetic Interrogations* at 4S/EASST conference Barcelona 2016. https://easst.net/conferences/

2016. Presentation: 'Electromechanical Perspectives of Sound and Music' presenting *Electromagnetic Interrogations* and *Electromechanical Oscillator* at *Alternative Histories of Electronic Music* (AHEM) conference, Science Museum, London UK. https://ahem2016.wordpress.com

2015. Presentation: *The Campanologist's Tea Cup*. *Making Futures* conference, Plymouth UK. http://makingfutures.plymouthart.ac.uk

2015. Exhibition: *The Campanologist's Tea Cup*. British Ceramics Biennale, Stoke-on-Trent. http://www.britishceramicsbiennial.com

2015. Exhibition: *The Campanologist's Tea Cup*. Oriel Q gallery, Narberth Wales. http://www.orielqueenshallgallery.org.uk

2015. Exhibition: *The Campanologist's Tea Cup*. Part of *The Sensorial Object*, Cardiff Craft in the Bay. https://thesensorialobject.wordpress.com

2014. Presentation: *Electromagnetic Interrogations*. Sussex University Musical Materialities conference. http://reframe.sussex.ac.uk/musmat/

2014. Exhibition: *Electromagnetic Interrogations*. BV studios, Bristol. http://www.bvstudios.co.uk/aboutbv.html

2013. Exhibition: *Unfixed Media Pt 1*. BV studios, Bristol. http://www.bvstudios.co.uk/aboutbv.html

2012. Presentation: 'Unfixing Media in Electromechanical Sonic Art' presenting *Unfixed Media Pt1* at the *Welsh Institute for Research in Art and Design* (WIRAD) conference 2012, Wales Millenium Centre. http://www.wirad.ac.uk/

2011. **Exhibition: *Slinky Speakers.*** BV studios, Bristol. http://www.bvstudios.co.uk/aboutbv.html

2011: Exhibition: *Unfixed Media Pt 1*. Part of *Telenesia*, Quay Arts, Newport, Isle of Wight, UK. http://www.telenesia.com/videoblog/exhibition/

2011. Exhibition (audio only): *The Infinite Spring* at *Audiograft Jukebox*. Audio documentation of the installation presented at Oxfords festival of sound art and contemporary music. http://www.audiograft.com/

2011. Presentation: 'A practice and Theory of Electromechanical Sonic Art' presenting *Infinite Spring* at *Sound Sight Space and Play*, Leicester DMU. http://www.sssp.dmu.ac.uk

2011. Presentation: 'Vibration, Volts and Sonic Art' presenting *Infinite Spring* at *New Interfaces For Musical Expression* (NIME) international conference, Oslo 2011.
http://www.nime2011.org/

2010. Exhibition: *The Infinite Spring*. *BV Studios*, Bristol.
http://bvstudios.blogspot.com/2010/10/bv-open-studios.html

APPENDIX 2
GLOSSARY OF TERMS

AC (alternating current) - a type of electrical current that flows in both directions (usually described by a waveform) e.g. as produced by a generator.

Acousmatic – a sound heard without seeing the source. Also a genre of music (also referred to as electroacoustic music) specifically composed for presentation using speakers.

Autonomous – free from external control or influence. In relation to artworks this can imply a separation from social, economic or environmental concerns. In relation to technology it can imply a device that appears to work of its own accord.

Black boxing – a term which describes the bundling and concealing of complex components and relations within a simplified exterior. An important concept within systems thinking and technological design.

DC (direct current) – a type of electrical current that flows in one direction only e.g. as produced by a battery.

Electromagnetic –a technology or assembly of components that uses the magnetic field generated by an electrical current. Electromagnetic interference is also a by-product of all electrical activity.

Electromechanical - a technology or assembly of components that uses electricity to drive mechanical movement e.g. a motor or loudspeaker.

Fluxus - an international, interdisciplinary and experimental group of artists, composers, designers and poets that emerged through the 1960s and 1970s. See figure 2.6, Fluxus artist Dick Higgins' Intermedia Chart.

Happenings – in relation to the art world this term emerged in the late 1950s in reference to performances, events or situations which were considered to be art.

Intermedia – artwork that uses a combination of media or non-specific media in its make up. See figure 2.6, Dick Higgins' Intermedia Chart.

Media – 1. A type of material used in the making of an artwork (e.g. bronze, oil paint). 2. A channel through which information may pass or be stored on (e.g. television, digital networks).

Modernism – A movement in western arts, culture and philosophy which emerged in the late 19th and early 20th centuries. In relation to art, particular features of modernism include abstract painting and the autonomy of the art object i.e. its disconnect from other aspects of life.

Piezoelectric – a type of crystal that produces electrical voltage when pressure is applied. Also exhibits the reverse behavior of vibrating when voltage applied. Used as contact microphones and small loudspeakers.

Postmodernism – a term used to describe changes that took place in western culture and society from the 1960s onwards which could be seen as a reaction against modernism. Postmodernism is not a single style or theory and to some extent defies definition. Pluralism, collage, a merging of high and low culture and a connectedness between the social, the ecological and the art world are all features of postmodernism.

Prepared speaker – a loudspeaker which has been physically manipulated to alter the sound quality.

Sound art – artistic practices that use sound as a medium and / or a subject. See section 2.1.1 for further discussion.

System (systems)- a set of things working together as parts of a mechanism or an interconnecting network; a complex whole. In the mid twentieth century terms such as systems thinking, systems engineering and systems art emerged to refer to approaches which paid particular attention to the interconnected nature of elements.

Transducer – a device that converts from one type of energy to another e.g. a loudspeaker or microphone transduce between acoustic and electric energy.