Fabian Winkler

DIELECTRIC

dielectric:
The term "dielectric" refers to a substance that is a poor conductor of electricity but an efficient supporter of electrostatic fields. A dielectric material separates the two conductors of a capacitor and enables the storage of energy in the capacitor.

“(Elec.) Any substance or medium that transmits the electric force by a process different from conduction, as in the phenomena of induction; a nonconductor. separating a body electrified by induction, from the electrifying body.”
Webster's Revised Unabridged Dictionary. Plainfield, NJ: MICRA Inc., 1998 [1996]

dialectic:
"The contradiction between two conflicting forces viewed as the determining factor in their continuing interaction."
The American Heritage® College Dictionary, Third Edition. Boston, New York: Houghton Mifflin Company, 1997 [1993].

Table of Contents:

0. Introduction:

The buzzing of power lines is a subtle yet omnipresent phenomenon in urban spaces. Often louder at night or in humid weather conditions, we are already so used to these very familiar sounds of electricity that it is hard to become aware of them or to distinguish them from other sounds in the environment. If perceived, one might interpret these acoustic manifestations of dynamic electricity as a symbolic expression of the city's enormous need for energy. This includes massive energy consumption as well as poor energy transmission eventually leading to an energy loss or outage and collapse. Simultaneously menacing and reassuring in their nature, these sounds have a broad spectrum of modulation and at the same time evoke strong visual images.

Installation view "DIELECTRIC", UCLA Kinross South Galleries, June 2003

My project "DIELECTRIC" is an interactive installation inspired by the buzzing sounds the power lines produce. Its elements evoke the technology of energy transmission. The installation's main components are two power line crossarms and wires. Halfway between the crossarms the power line's wires are interwoven to form a hammock. By approaching the hammock, the interactor triggers a high voltage generator generating electric sparks of different strengths. The amount of sparks is controlled through the user's body capacitance. Light and sounds produced by the electric sparks create an ambient presence of electricity in the exhibition space as a response to visitor interactions. Beside the interactive part, the installation has a strong sculptural quality as a hybrid object somewhere between a power line and a hammock. This introduces and mixes connotations associated with each.

This paper has a number of goals. On the most basic level it describes the installation "DIELECTRIC" and its elements technically. Furthermore, this paper explores the installation's concept of energy in its different contexts: science, technology, society and art. By investigating these fields one is led to questions such as: what is electrical energy and who were the protagonists in its scientific discovery? How is energy distributed and what is the anatomy of a power line? How is the human body susceptible to electrical energy? How is electricity perceived in society? Which previous artworks have explored the idea of electrical energy? Besides dealing with such issues, I will also discuss the installation's sculptural and interactive qualities, making a distinction between the traditional notion of sculpture as an object and sculpture as a responsive system with interrelated parts. This comparison raises another question: what is the installation's necessary degree of responsiveness? In answering these questions this paper aims at giving a contribution to the discussion about the concept of electrical energy in contemporary art practice.

Electricity is the form of energy that is most commonly referred to when talking about energy in general. It has the potential to be converted to and generated from almost every other form of energy. More specifically, Frank Popper, initiator of the 1983 exhibition on electronic art, "Electra"[1], defines electricity in contrast to "electronics" in the introduction of the exhibition catalogue. According to Popper, "… one might recall briefly that "Electricity" is the name given to one of the forms of energy which manifests its action through mechanical, caloric, luminous chemical and other phenomena, and that electronics utilizes the variations of electrical amplitudes (electromagnetic fields, electric charges) in order to capture, transmit and exploit information."[2] "Electra", held at the Musée d'Art Moderne de la Ville de Paris (MAM) from December 10, 1983 to February 5, 1984 gave an early comprehensive overview of artworks focusing on electricity, structurally as well as conceptually. However, it was not the first exhibition of its kind: in 1967, a similar exhibition at the same place titled "Lumière et Mouvement" (Light and Movement) already dealt with the phenomenon of electricity - impalpable and invisible in nature yet familiar and practical in everyday life[3] - in the context of fine art. "Lumière et Mouvement" mainly featured works produced in France and was

---

[1] "Electra" – curated by Marie-Odile Briot and Frank Popper.

[2] *Electra* (exhibition catalogue). Edition: Les Amis du Musée d'Art moderne de la Ville de Paris. Paris: Société Nouvelle de l'Imprimerie Moderne du Lion, 1983, p.22.

[3] cf. Charles W. Eliot: "Electricity, carrier of light and power, devourer of time and space; bearer of human speech over land and sea; greatest servant of man – yet itself unknown." From: David E. Nye: *Electrifying America*. Cambridge, Massachusetts/London, England: The MIT Press, 1990, p. 138.

more limited to the field of Kinetic Art. Other events were organized internationally around the same time, two of the most important ones being E.A.T.'s "9 Evenings: Theatre and Engineering" (October 13-23, 1966) at the 69th Regiment Armory in New York and "Cybernetic Serendipity" first presented at the Institute for Contemporary Art in London in 1968. However, these shows focused more on the theme of computers in art, making no distinction between electricity and electronics. Although commonly used as synonyms, it is important to differentiate between "electricity" and "electronics" – similar to Popper's definition – since the terms represent different ideas. Nam June Paik, one of the pioneers of the field of electronic art, makes this distinction very clear by commenting on "electricity" and "electronics": "Electricity deals with mass and weight; electronics deals with information: one is muscle, the other is nerve."[4]

"DIELECTRIC" also uses electronics, i.e. computer controlled parts, but it mainly deals with the idea of electricity – both as a concept and structural element. Hence this paper focuses on electricity rather than electronics. Chapter 1 begins with an introduction of the scientific approaches toward electric energy. It briefly describes Benjamin Franklin's discovery of electricity, Count Alessandro Volta's invention of the first battery and Michael Faraday's first generated current electricity. The first part of this chapter will mainly concentrate on Nikola Tesla, the eccentric protagonist in the discovery of practical alternate current (AC). Tesla is known to have been a strong competitor of Thomas Alva Edison, a supporter of direct current. Edison was a great experimentor, claiming that invention is five percent inspiration and 95 percent perspiration. Tesla, in contrast, always favored a more conceptual approach to his work, relying on inspiration and thought experiments. Tesla did not only invent a system of AC power generation and transmission, used universally throughout the world today, but also had ideas foreseeing such devices as the remote control, television and radar. The basic principles of Tesla's high voltage experiments are used for the spark generator in "DIELECTRIC".

What are the technical parts of a power line and how is energy distributed in a system of power lines? These are the questions that the second part of the first chapter tries to answer. Power lines are ubiquitous – in urban areas as well as in rural parts of the country. Yet, if we

[4] Gene Youngblood: *Expanded Cinema*, New York: Dutton, 1970, p. 137.

take a closer look, hardly anybody knows about the technical parts which constitute a power line or the system of energy transmission from the powerplant to individual households.

As already stated, interaction with my installation is based on the interactor's body capacitance. It is thus crucial to understand the principle of capacitance and the way the human body works as a capacitor. If one thinks of the human body as a capacitor, then how is it charged? How can the body capacitance be measured? In giving the answers to these questions chapter 1 also analyzes two types of capacitance sensors: digital and analog. One of the best-known examples of the usage of analog capacitance sensors is the Theremin, an instrument which generates sounds based on the proximity of the musician's hands to the Theremin's two antennas. Chapter 1 ends with an explanation of the relevance of this technology to the interface in my installation.

The third part of chapter 1 deals with the idea of electricity in society. Electrical energy has facilitated many processes in public places, industry and the home. Simultaneously, it has become almost transparent in everyday life. However, if one becomes consciously aware of electrical energy through a physical or audio-visual experience, associations with great danger may also emerge. This seemingly contradictory notion of electricity, as a power that is convenient and dangereous at the same time, is also inherent in "DIELECTRIC". Using examples from David E. Nye's book *Electrifying America,* I will analyze this ambiguous concept of electricity in a social context and explain how it relates to my installation. David E. Nye emphasizes the importance of the social context in the history of electrification when he writes: "A technology is not merely a system of machines with certain functions; it is part of a social world."[5]

Many artists have incorporated the idea of electricity into their artworks, from "Electra", the Pre-Hellenic Goddess of Light interpreted e.g. by Richard Strauss and Hugo von Hoffmannsthal to the actual usage of electricity in contemporary media art practices. Chapter 2 is dedicated to a cultural contextualization of my installation. It looks at other art works which deal with electricity not only conceptually but also practically. The analysis of these works begins with Mona Hatoum's "Homebound", shown at Documenta11. I will shortly

[5] Nye: *Electrifying America*, op.cit., p. ix.

describe the work and analyze its visual and audible aspects. Paul DeMarinis' "Gray Matter" uses the interaction of body and electricity to make music. Another of DeMarinis' works, "The Messenger", examines the myths of electricity in communication using, among other things, electrolytic jars as display elements. The works by the British product design partners Anthony Dunne and Fiona Raby deal with electricity in a very subtle way: Dunne and Rabi create design objects and architectural elements which are extremely responsive to the whole range of the electromagnetic spectrum. Chapter 2 ends with a discussion of two works by Joseph Beuys, "Energy Plan for the Western Man" and "Capri Battery". In "Energy Plan for the Western Man" Beuys dealt with the topic of energy applied to society in the United States during the time of the economic energy crisis of 1973. "Capri Battery" is based on the idea of generating relatively weak electric currents from fruit acids, in this case the lemon acid. A lightbulb in a socket is plugged into a lemon. I will propose a "thought experiment" which will be relevant again in chapter 5, when I investigate my installation's sculptural and interactive aspects: how would the meaning of "Capri Battery" have been different had Beuys made it physically working?

After this contextualization, chapter 3 is dedicated to an exploration of the installation itself. I will explain how the sculptural qualities of power lines in urban L.A. influenced the development of the hammock in "DIELECTRIC", and I will analyze the function of my installation's interface based on research of the hammock's cultural history: originally coming from the Caribbean and Central America the hammock was introduced to Europe in the early 16th century. The hammock was first interpreted by Western explorers as a net for sleeping – "rede de dormir". For "DIELECTRIC" this culturally-coined idea of the hammock as a net is important. The second part of chapter 3 continues with a description of "DIELECTRIC", with the aid of pictures and system diagrams.

The sculptural and interactive qualities of "DIELECTRIC" are the focus of chapter 4. Based on Jack Burnham's twofold notion of sculpture[6] – sculpture as object and sculpture as system – I will look at the sculptural features of "DIELECTRIC". Furthermore, I will introduce a seminal text about the expanded field of sculpture – Rosalind E. Krauss' *The Originality of the Avant-Garde and Other Modernist Myths*. The installation's responsiveness is analyzed

[6] Jack Burnham develops this classification of sculpture in his influential book "Beyond Modern Sculpture" – Jack Burnham: *Beyond Modern Sculpture*. New York: George Braziller, 1968

against David Rokeby's models of interactive artworks described in his essay "Transforming Mirrors". Further reflecting on the "thought experiment" previously conducted with Joseph Beuys' "Capri Battery", the basic question raised by this chapter is: to which degree does "DIELECTRIC" need to be interactive? And to which degree does it need to possess sculptural qualities (in the traditional sense)?

The paper concludes with ideas for future projects, that may emerge from the concept of dynamic electricity. I will also describe "EMF", a video-based project that is shown in conjunction with "DIELECTRIC" further contextualizing and framing the installation.

1. Energy and Electricity Context:

1.1 Science: From the Discovery of Electricity to Tesla's Contribution

When talking about electrical energy, one refers to great inventors like Volta, Faraday, Edison, Tesla, etc. Units of certain qualities of electricity were named after these inventors. However, electricity was never "invented". It is a universal phenomenon that has always existed. It is more correct to state that the phenomenon of electricity was discovered and technologies making use of electricity have been invented. This part of my thesis paper deals with the discovery of electricity and some of the inventors having significantly advanced the development of electric technologies.

The history of the discovery of electricity goes back to Ancient Greece. The Greek philosopher Thales[7] discovered that an electrical charge could be generated by rubbing amber[8]. Much later, the German physicist Otto von Guericke (1602 - 1686) experimented with the generation of electricity, especially by means of his electrostatic machine, invented in 1661.

In 1752 Benjamin Franklin, the American statesman and inventor, conducted his first kite experiment, supporting his thesis that electrical energy could be harvested from lightning. Franklin used a silk string attached to his kite during a thunderstorm. Negatively charged

[7] Thales of Miletus (around 600 BC) is regarded as one of the earliest physicists.

[8] The Greek word for amber is "electron".

static electricity produced by a thunderstorm was transferred from the kite through the conductive wet silk string to a key. The key was connected by a thin metal wire to a Leyden Jar[9], a very early capacitor which collected the negative charge. Franklin himself was not electrocuted by the dangerous charge collected from the thunderstorm since he kept the very end of the silk string dry and non-conductive. The electrical charge stored in the Leyden Jar could be used for further experiments with which Franklin established his "single fluid" theory. According to this theory, electricity flows from a positively charged body to a negatively charged body.[10] Franklin also stated that electrical energy is never destroyed, it is only redistributed. This idea reappears in some of Nikola Tesla's most important thoughts on electricity.

Almost 50 years later in 1799, the Italian physicist Count Alessandro Volta presented the first device which was able to produce a consistent flow of energy: the "pila" also known as the Volta Battery or Voltaic Cell. Volta's principle of transforming chemical energy into electrical energy is the basis of almost every modern battery. Volta observed that two different metals submerged close to each other in an acidic fluid produce a small electric current. The best results were produced with a series of alternating copper and zinc rings in an acid solution called electrolyte. Volta was honored for his invention by naming the unit for measuring electric current after his name: Volt. Today many batteries use the electrolyte alkaline and nickel-iron metals and are thus called alkaline batteries. Thomas Alva Edison, whose contribution will be dealt with later in this chapter, invented this type of battery in 1914. Current electricity, as produced by a battery, builds up an electromagnetic field in contrast to static electricity. [11] The English physicist and chemist Michael Faraday (1791-1867) explored these electromagnetic features of electricity. Faraday invented an electric generator by moving a magnet inside a wire coil which produced a current. Almost the same setup was turned into a motor when a current was sent through the wire coil moving the

---

[9] cf. the last paragraph in chapter 1.4

[10] Research in the 20th century has shown that electrons, negatively charged subatomic particles, are being pushed into a circuit from the minus pole of a power source. At the same time the electrons are are being attracted by the power supply's plus pole, making them move from minus to plus. However, due to a convention from the very early research in electricity the technical direction of current is still from plus to minus.

[11] cf. capacitors and the Leyden Jar

magnet. Honoring his achievements, the unit of an electric charge, "Farad" (determining the capacity of a capacitor) was named after him.

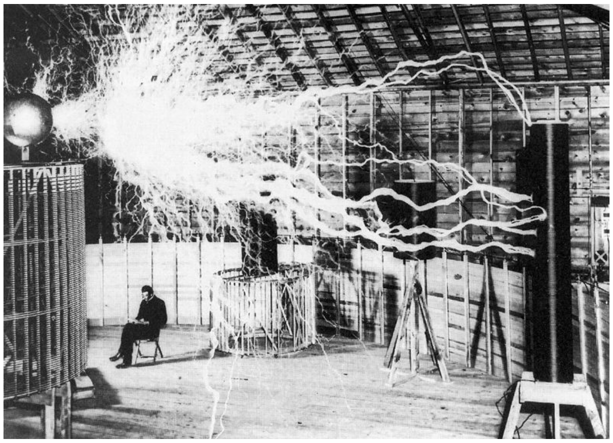
The next big step in the discovery of electricity was taken by two of the most important inventors at the end of the 19th and the beginning of the 20th century: Thomas Alva Edison (1847-1931) and Nikola Tesla (1856-1943). Both were preoccupied with the generation and distribution of electrical energy which eventually led to two rivalling ideas and a fierce competition, also titled "the War of Currents". The Serbian immigrant Nikola Tesla started working for Thomas Edison in West Orange, New Jersey in 1884. At that time Edison had already invented several powerful generators for direct current (DC) power supply. Tesla had immigrated to the United States with plans to build his own alternating current (AC) generators and motors. He asked Edison for support, but their characters and approaches to electrical engineering were too different: Edison was a self-taught man while Tesla had studied at the renowned Austrian Polytechnic School at Graz. Their backgrounds influenced the ways both engineers approached problems. Whereas Edison developed his inventions through experimentation, Tesla always tried to solve problems theoretically before building a working prototype. Finally, the discussion about direct versus alternating current resulted in a dispute and Tesla left Edison's lab in 1885.

Tesla filed several patents all related to the generation and usage of alternating current in 1887. The Pittsburgh industrialist George Westinghouse bought them from him. These patents allowed Westinghouse to build long-distance power transmission lines, a plan he had envisioned for some years. In contrast to direct current, alternating current had the advantage of being transformed to very high voltages and low currents which made it perfectly suitable for long-distance power transmission.[12] With industrial support, the system of alternating current became a serious competitor of Edison's direct current power. The "War of the Currents" broke out. The harsh competition for the dominant system of electric power generation and distribution included even propaganda strategies to guide the public opinion. For example, Edison agreed to host a test laboratory for alternating current research in his own lab for the mere purpose of developing a fully working AC electrocution system. On August 6th, 1890 the first criminal was electrocuted using an AC system based on Edison's research. As a consequence, it was very easy to shape the public opinion that AC power is

[12] explained in more detail in chapter 1.2

extremely dangerous and even lethal compared to Edison's "safe" DC power. However, other factors determined the outcome of the "War of Currents" and the AC power system as its winner: Tesla conducted first long-distance power transmission experiments with alternating current in Colorado. The Telluride coal mines were in need of cheap power supply from the valley below, yet direct current power supply was not possible due to the long distance between possible generating plants in the valley and the machines in the mines. Westinghouse, with the help of Tesla's inventions, could offer an AC system that accomplished the task. Telluride provided a good test ground for Tesla's new generators, transformers and motors. The next major step toward the victory of the "War of Currents" was the commission Westinghouse received to illuminate the Chicago World Fair, the first all-electric fair in history, in 1893. Westinghouse's proposal was based on cost effective AC power distribution in contrast to the expensive copper wires needed for DC power transmission. Adding a clever financial trick, Westinghouse made an extremely low bid (half the price of Edison's proposal), knowing that once he would get the commission, the positive publicity AC power was likely to get could easily compensate for his financial loss. Lighting the Columbian Exposition turned out to be a big push forward for the popularity of AC power. It also led to AC's ultimate victory in the "War of Currents": the "Niagara Falls Power Project". The international Niagara Falls Commission , headed by the British physicist Lord Kelvin, was in charge of finding a proposal for harnessing the power of the falls. Kelvin had been an opponent of Tesla's AC power system, but attending the Columbian Exposition in Chicago completely changed his opinion. The potential of AC power demonstrated on the Chicago World Fair made such an impression on Kelvin that he commisioned the Niagara Falls project from Westinghouse and Tesla in 1893. Three years later, the first electricity produced at Niagara Falls reached Buffalo. Again a few years later, New York City got part of its energy delivered from Niagara Falls. With the successful construction of the Niagara Falls power plants Westinghouse and Tesla's victory in the "War of Currents" was conceded. Not only was AC the system used for more than 80 percent of all the generated electricity in the U.S., Edison's company General Electric also felt the need to secure licenses for the use of Tesla patents.

Tesla always thought of electricity as a kinetic system, constantly in flux. To him energy was a given, it could be harnessed at any location and cannot be destroyed. Many of Tesla's later experiments and inventions have resulted from this world view.[13] Among them were also important discoveries exploring high frequency energy and electromagnetic radiation. Technologies still in use today, like radio communication, X-Ray scanning and particle acceleration are based on these early explorations. From the whole spectrum of his work, Tesla's high voltage experiments and discoveries are most relevant to "DIELECTRIC". The high voltage transformer used in my installation is based on the principle of the Tesla coil. In its simplest form a Tesla coil consists of a power supply, a large capacitor, the coil (or transformer) itself and a spark gap. Using the features of the capacitor and transformer for an oscillator circuit, high frequency high voltage can be produced.[14] The high voltage becomes visually and audibly present at a spark gap. The generated voltage is so high that the air between the gap's two electrodes breaks down as an insulator. As a result, a plasma arc spans from one electrode to the other. This process can be repeated up to about thousand times a second. Normally a phenomenon to avoid, the arcing between two electrodes is often present at power lines' utility poles. Due to high voltage and facilitated through humid weather condition, arcs are sometimes generated in power line transformers, stepping voltage up or down. Sometimes arcing even occurs between power line wires and grounded objects caused by insufficient insulation or the breaking down of air as an insulting layer. Although these arcs are seldom visible, their sounds can be heard as buzzing emitted from the top of utility poles. These utility poles are often part of distribution lines, one section of electricity's way from the power plant to individual households.



Nikola Tesla in his Colorado Springs laboratory. Taken from Marc J. Seifer: *Wizard-The Life and Times of Nikola Tesla*. Secaucus, N.J.: Carol Publishing Group, 1996. Photo from the Nikola Tesla Museum, Belgrade.

---

[13] Tesla's later experiments, which are not the focus of this paper, led to the large variety of speculations about Tesla's life and personality. Media reports have often mystified and obscured Tesla's life and work. This is one of the reasons why Nikola Tesla has become an almost forgotten protagonist in the history of electrification in the United States.

[14] "Whereas current builds quickly in a capacitor as it charges up, voltage lags. In an inductor [the transformer], voltage is felt immediately, while current is retarded. If a coil and condenser [capacitor] are sized and selected to act with exactly opposite timing – with voltage peaking in the coil just as it reaches a minimum in the capacitor – then the circuit may never reach an electrically quiet, stable state." Jim Glenn and Margaret Cheney: *The Tesla Coil*, website, http://www.pbs.org/tesla (last checked May 08, 2003).

1.2 Energy Distribution: Power lines

Electrical power travels from the power plant to households in a system called the distribution grid. Electricity is generated in the power plant through either a water wheel in a hydroelectric dam, a diesel engine or a steam turbine, typical for nuclear power plants. These generators output 3-phase AC power. 3-Phase AC power consist of 3 single phase 120 Volts sine waves oscillating between – 170 and 170 Volts.[15] The alternating current (AC) oscillates at 60 cycles per seconds which is noted as 60Hz. In the 3-phase AC power system the 3 phases are offset from each other by 120 degrees. This creates an output function of the voltage where there is constantly one of the three phases near a peak (in contrast to the single phase system in which the sine function of the voltage crosses 0 Volts 120 times a second). The 3-phase system is represented visually in the three wires that come out of the power plant into the power plant's transmission substation. There, the couple of thousand volts generated in the power plant are stepped up to high voltage (hundreds of kilovolts) for long distance transmission through the power grid. High voltage transmission towers and wires transport electricity for a maximum of 300 miles. These high voltage transmission lines carry three wires for the three phases and one wire for ground usually on top (also as a protection against lightning). The high voltage is stepped down again in a power substation for further distribution in more local grids of distribution lines. These power lines typically carry between 7000 and 10.000 volts and still consist of the three wires for the 3-phase AC power and one wire slighty separated for ground. In urban spaces these are the power lines that produce the buzzing sounds that inspired my installation. Before being delivered to individual households, the wires are split up into one or two cables that run down smaller streets in the neighborhoods. Normal household appliances only need single-phase AC power, so less wires are needed to connect end consumers to the power distribution grid. In a final transformation process the high voltage of 7000-10.000 Volts is stepped down further to 240 Volts which allows the +/- 120 Volts alternation.

---

[15] It is only the peaks that go up to +/-170 Volts, the effective voltage (rms) is 120 volts.

Power line wires are carried by utility poles – for distribution in cities these utility poles consist of tree trunks, impregnated with a reddish brown wood preservation resin. Attached to utility poles are different parts, e.g. insulator pins sitting on the crossarm. Insulator pins insulate the wires of the 3-phase AC power against ground and from each other keeping them a certain distance apart. The pins come in different varieties, made of glass or ceramics and in different colors. Another characteristic part attached to the utility pole is the transformer, a cylindrical metal tank that converts the power line's high voltage to either 120 or 240 Volts. Electricity is carried to the consumer's electric meter through the secondary tap – a wire connecting transformer and individual houses. "Power Line Anatomy 101", an article in the magazine "Ruralite"[16] gives a detailed overview of the most common attachments to power line utility poles. All these attachments are part of a visual language of power lines which is strongly referenced by "DIELECTRIC".

Beside power lines' visual qualities, there are also tangible features of the power distribution grid, mostly present in the long-distance transmission of AC power. Due to the extremely powerful electrical energy traveling through high voltage transmission lines, strong electromagnetic fields (EMF) emerge. The frequency of the fields produced by power lines is 50-60 Hz, which is the frequency of AC power. These numbers are very low compared to the whole range of frequencies of the EMF spectrum, ranging from 0Hz (static EMF) to 1015Hz (visible light) to 1017Hz (X-Rays)[17] and beyond. Electromagnetic radiation of a frequency higher than 1016 Hz is strong enough to break molecular bonds and is considered a potential cause of cancer. Because of its very low frequency, EMF oscillation between 30 and 300Hz is called extremely low frequency (ELF). Almost everybody has experienced the effect of a strong ELF EMF which makes one's hair stand up and creates a slightly tingling effect on the skin. EMFs are caused by electrically charged particles traveling through and leaking off the power line's wires. The particles exert forces on objects spatially separated from the electricity's source. In this process, the field's strength decreases with distance from the emitting source. Traditionally, the discussion of EMFs radiated by power lines has been

---

[16] see Appendix A at the end of the paper, "Power Line Anatomy 101", *Ruralite*, September 2001, p. 6.
[17] cf. chapter 2.4

motivated only by their potential health risks. This is not the focus of my installation. Instead, “DIELECTRIC” uses the idea of the EMF as invisible spatial entitiy unique to the phenomenon of electricity. I am interested in EMFs on a structural and conceptual level to gather information about the installation’s spatial environment. Rather than working with computer vision or ultrasound to sense interactors, I chose capacitance sensors to keep the installation consistent with the idea of electricity: the hammock works as the antenna of a capacitance sensor collecting electromagnetic information of its surrounding space. In the following I will describe the concepts of body capacitance and capacitance sensing to illustrate my installation’s sensing technique in detail.

1.3 Body Capacitance:

Capacitance is the capacity of an object or surface to store an electrical charge. The principle of capacitance is comparable to that of a jar holding a fluid. Bigger objects normally have a greater capacity to store electrical charge in the same way that the storage capacity of jars is related to their physical size. However, the distance between two objects is also an important factor determining the capacitance between them.[18] The less distance between two objects the greater their mutual capacitance. From these observation a very simple rule is derived: “The amount of capacitance between two objects decreases with distance and increases with the sizes of the two objects“.[19] Other factors determining the capacitance of an object are the material of the respective object and the material between them. Accordingly, the amount of capacitance between two objects increases with conductivity of the objects and decreases with the conductivity of the space between them.

The same principles apply to the human body. The human body is an electrical conductor, full of salty fluids. Like any conductor, it has the capacity to store electrical charge. Because of his or her physical size, an adult has more capacitance and can store an electric charge for a longer time than a child. In most cases human bodies get charged by friction (friction-

---

[18] cf. The Quantum Research Group: *Capacitance Explained*, website, http://www.qprox.com/background/capacitance.php (last checked Mar. 14, 2003): “In 99% of all cases capacitance is thought of as being *between* two adjacent objects, where the objects are separated by some non-metal substance, or even just air or a vacuum. This is called *mutual* capacitance, and this form of capacitance is much more important and usually more dominant than simple 'free-space' capacitance.“

[19] The Quantum Research Group: *Capacitance Explained*, op.cit.

generated electricity is called “triboelectricity“): triboelectricity can be generated in many different ways: combing hair; walking on a carpet; sliding out of cars, etc. Sometimes human bodies become electrically charged by the proximity of a strong electromagnetic field, e.g. radiated by high voltage power lines. Electrical charge can be accumulated in the human body but it will eventually, over a certain time span, leak off again. Sometimes the process of discharging is accelerated by grounding oneself (e.g. grasping a metal door handle, etc.). One experiences, based on the amount of charge that was accumulated, a weak but sensible electric shock.

The principle of capacitance was discovered by accident in the 18th century: a glass jar, filled with water got charged by a person’s electrical charge while he was grasping the jar. The same person experienced a weak electric shock grasping the same jar a couple of days later. Shortly afterwards, the jar was optimized at the University of Leyden in Holland so that it was able to store static electricity for a considerable time. Thus the so-called Leyden jar can be considered the first capacitor.

1.4 Sensing: Capacitance Sensors, Digital and Analog:

After explaining the phenomenon of capacitance it is logical to ask: how is capacitance measured? There are many ways to do it. In developing “DIELECTRIC” I have followed a strategy that first measures the background amount of capacitance on an object, in this case the hammock. The sensor then treats this amount of capacitance as a “tare” with which incoming sensor values are compared. Small deviations from the reference value are caused by interactors approaching the hammock. Technically, the sensor works by placing a fixed voltage on the hammock. By claiming back the electrical charge and transferring it into a measurement circuit, the capacitance can be determined. As explained earlier, the mutual capacitance of objects is increased by reducing the distance between these objects. Visitors literally “add” small amounts of charge to the system dependent on their proximity to the hammock. The closer they come, the greater the change of capacitance on the hammock. This change of capacitance is measured by the sensor and interpreted by the responsive system.

It is important to distinguish digital from analog capacitance sensors. Whereas digital capacitance sensors only output results on an ON/OFF basis (i.e. once a certain threshold is reached the state of the sensor switches), analog sensors measure different grades of capacitance change. One of the best-known creaqtive uses of analog capacitance sensors is the Theremin, a music instrument that was invented in 1919 by the Russian physicist Lev Termen (whose name was later changed to Leon Theremin). As an instrument the Theremin was unique at the time in that it is played without being touched. The main elements of the instrument are two antennas: one controls pitch, and the other controls volume. These two antennas are each connected to an analog capacitance sensor. Bringing one's hand closer to the antennas, the mutual capacitance between the antenna and the hand gradually changes. The values are reflected in the sounds the Theremin produces: The closer the hand is to the vertical antenna, the higher the pitch; the closer the hand is to the horizontal antenna the lower the volume. According to a similar principle, "DIELECTRIC" uses analog capacitance sensors to detectect the distance between the hammock and interactors.

1.5 Electricity in Society: Notions of Comfort and Danger

Electricity's effects on the human body have stimulated public interest since the late 19th century. According to David E. Nye's research "By the middle 1890s magazines such as *Popular Science Monthly* carried articles asking "Is the Body a Human Storage Battery?"[20] Nye goes on explaining that diseases were thought to be cured electrically and many electric devices were invented to restore lost energies in the body. One such electrotherapeutic device, Dr. McLaughlin's electric belt, consisted of a "triple silver plated battery of great power, silver plated non-irritating electrodes, and a very powerful electric sack suspensory."[21] In contrast to recent beliefs in possible health risks caused by electric fields[22], early therapeutic applications of electricity suggested the opposite: the healing effects of electrical energy. Nye refers to the an Indianapolis sanitarium in the 1910s which advertises to "treat patients with electrical baths, using "Galvanic, Faradic, and Static Electricity"[23] – similar electric fields that are nowadays supposed to cause potential health risks. In this example, the public attitude toward a certain quality of electricity has changed over time.

---

[20] Nye: *Electrifying America*, op.cit., p.153.

[21] ibid., p.153. Physicist's Institute, pamphlet, "Supreme Electric Belt."

[22] cf. the potential health risks of permanent exposure to strong power line ELF EMFs described in chapter 1.2

[23] Nye: *Electrifying America*, op.cit., p.153.

More generally, society's notion of electricity has been ambiguous from the outset, embracing opposing feelings of comfort and danger. In his book "Electrifying America" David E. Nye illustrates examples how these concepts of comfort and danger have already been attached to the phenomenon of electricity since the early days of electrification in the late 19th century. According to Nye, the comfort of electric energy was first experienced in the United States in urban spaces: streets were lit by electric lights in the mid 1880s; electric streetcars and trolleys followed very soon. Often streetcar lines ended at amusement parks outside the city. Driven by excess energy and owned by the streetcar companies these parks were popular destinations for family trips on the weekends. Visitors could conveniently take the trolley to reach these attractions. Influencing an increasing number of areas in everyday life, electrical energy also made the private life more comfortable. By 1915 most households in the United States were electrified – from the kitchen to the living room and the childrens' rooms. Among the most popular electronic novelties at that time ranked: the electric refridgerator; the radio; toasters; the telephone and electric toys. Some of these early electric houshold devices had already visually and functionally incorporated the idea of comfort. One example described by Nye is the electric girl – a life sized puppet, that would open the door once the door bell rang. The puppet's cloth were covered with lights so that it would also light up the house's front hall. According to Nye: "The present system of lighting the front hall of a dwelling-house has the disadvantages that that the light – whether it be gas light or an electric light – must be kept burning all the evening, and that a servant must be employed to answer the bell. Thus there's a double expense – the cost of the light and the cost of the servant. To solve this distinctively upper-class problem, the girl could be hired "from dusk till midnight – or as much later as may be desired."[24]

The comfortable and convenient features of electricity are opposed by its inherent concept of danger: electricity is frequently associated with discomfort when one becomes aware of its immediate presence. These situations often involve a tangible, audible or visual manifestation of electric energy such as: thunder and lightning; strong electromagnetic fields under power lines or sparks and arcing caused by shorted wires. By instinct, most people react to these phenomena with feelings of discomfort and fear. Thes very human reactions were effictively used by Edison in the "War of Currents" as already described earlier. However, in some

[24] Nye: *Electrifying America,* op.cit., p. 244.

cases, including Edison's propaganda against the alternating current, some of these fears are not based on scientific facts but rather on obscure notions about electricity. David E. Nye describes these feelings of discomfort and fear, especially in the early days of electrification: "When Edison began to lay the first electrical cable in New York in 1881, he found that "the Irish laborers of the day were afraid of the devils in the wire"[25] and in a quotation of Sidney Alexander Mitchell, Nye goes on: "One resident of frontier Seattle wrote to the local paper to warn against the construction of an electric tram system in the following terms: "electricity is eccentric and shocking; its shocks will make the cars jump off from the tracks and endanger the lives of passengers; water is a conductor and rain will divert the electric current from the wires, collisions and appalling accidents will inevitably occur; the rails will be electrified and horses stepping on them will be shocked and fall."[26] Feelings of uncertainty and discomfort aroused by electricity also influenced the design of new electrical devices in the beginning of the 20th century. These electrified household appliances, advertised to to make life and work easier, had to be disguised in order to be accepted by a larger number of consumers. David E. Nye illustrates this situation from the early days of electrification in the following quote: "Given these developments, antimodernists focused on electrification's capacity to increase the powers of subjection and destruction. Electrical corporations tried to minimize such fears through the styling of products, so that the earliest appliances often appeared to be not so radically new but rather familiar, even visually identical with their nonelectric competition. Many early electric light fixtures were designed to look like crystal chandeliers, candles, or gas jets. Electric coffee pots often looked like parts of a typicla Victorian silver table service."[27]

The design of "DIELECTRIC" addresses notions of both, comfort and unease evoked by electricity. The hammock, a piece of furniture designed for relaxation, connotates comfort and ease. On the contrary, the arcing of the power line's high voltage transformer creates an atmosphere of discomfort and menace. The ambient presence of electricity generated by my

---

[25] Nye: *Electrifying America*, op.cit., p. 152.
[26] ibid., p. 152.
[27] ibid, p. 145.

installation is as ambiguous as society's notions of electricity[28], comforting and dangerous at the same time.

2. Electricity and Energy in the Arts:

The previous chapter examined the concept of electricity from historical, technical and social angles dealing with developments in the discovery of electricity, issues in energy distribution and field sensing, and some of the social implications of electrification. This chapter specifically concentrates on the idea of electricity in the arts. I will introduce a representative selection of artworks that address the topic of electricity both conceptually and structurally.

2.1 Mona Hatoum "Homebound":

Visitors of Documenta11 encountered one exhibition space they couldn't enter. The entrance to the room was cut off by metal wires behind which household objects were arranged: sieves; plates; silverware and pots on a table; chairs; a bed frame; a bucket; etc. All these objects were made of metal, connected with heavy duty electrical wires. At irregular intervals, the whole installation started to produce buzzing sounds of electricity, and lights hidden in some of the objects were dimmed on and off. Electricity was sent through the cables animating the interconnected household objects. As Gesine Borcherdt points out in her short discussion of this work,[29] the objects are deprived of their original functions and are literally charged with new meanings. Analyzed against Hatoums palestine background and her former political artworks, the use of electricity in "Homebound" also implies a political meaning – disquiet, conflict and disturbance. The wire barrier behind which the installation is setup is reminiscent of an electric guard fence. It also keeps the visitors from touching the electrified metal household objects. With the buzzing sound of electricity coming from the installation, the idea emerges that the wire barrier itself might also be charged electrically. Many visitors felt the need to touch the metal wires, after some time, needed to overcome the natural fear produced by the visual and sonic representation of electricity. "DIELECTRIC"

---

[28] This double-faced notion of electricity was extremely obvious in the early days of electrification, since the technology was new and very visible. In today's society, electricity is taken for granted and has become ubiquituous and invisible. However, the dual concept of comfort and danger is still present, now enforced by electricity's invisibility and ubiquity.

[29] cf. Gesine Borcherdt: *Gefährliche Schönheit*, website, http://blitzreview.de/b-785.html (last checked June 16, 2003).

makes use of the same feeling – a combination of natural fear and curiosity evoked by electricity. Often Nikola Tesla psychologically based his public high voltage demonstrations on these feelings. In “DIELECTRIC” it is the surprising palpable qualities of the hammock combined with visual and sonic representations of electricity that simultaneously evoke feelings of fear and curiosity.

2.2 Paul DeMarinis “The Messenger”:

Paul DeMarinis’ work “The Messenger”, like many of his other installations, explores metaphors encoded within “lost” or “orphaned” technologies. In “The Messenger” DeMarinis investigates the early concepts of communication through electricity. The work itself consists of three types of telegraphic receivers on which e-mail messages from the internet are displayed letter by letter: 26 washbasins, prepared as speakers; 26 dancing skeletons and 26 electrolytic jars with electrodes in the shape of the alphabet’s letters. Whenever a new e-mail message is received, it is announced letter by letter, each of the 26 washbasins utters one letter of the alphabet at the time. DeMarinis had already implemented the idea of the washbasin speaker in one of his earlier works, “Gray Matter”. In this installation interactors produce sounds by striking electrified objects with their hands. DeMarinis describes the underlying technical principle in the following way: “By some obscure and little studied phenomenon, a vibrating electrical field seems to modulate the coefficient of friction of our skin, so that when we bow across an electrified surface with our fingers, we excite mechanical vibrations. These mechanical vibrations, suitably coupled, give rise to audible sounds.”[30] The 26 skeletons in the work “The Messenger” wear little ponchos each bearing letter from A to Z. The skeletons are a reference to the early days of electrical telegraphy: In 1798 the Catalan scientist Don Francisco Salvá i Campillo devised an experiment in which he used 26 separate wires one for each letter of the alphabet. The receiving ends of the wires were connected to 26 persons, presumably servants. By receiving sensible electrical shocks the respective servant had to call out the name of the letter assigned to which him or her. A 27th servant was assigned to write down the letters in the order they were called. Finally, “The Messenger” uses 26 glass jars, filled with an electrolyte and holding electrodes in the shape of the letters A to Z to display the incoming e-mail messages. Once a message is received by this display, the respective letters change their color from shiny metallic to black, caused by the induction of an electrical

[30] Paul DeMarinis: *Gray Matter* (Essay), website, http://www.well.com/~demarini/graymatter.html (last checked Mar. 14, 2003)

current. At the same time an electro-chemical reaction produces hydrogen bubbles in the glass jar. The electrolytic jars DeMarinis uses are very similar to the Leyden jars, primitive capacitors described in chapter 1.4. “The Messenger” and “Gray Matter” have a palpable approach to electricity as an invisible and mysterious yet familiar phenomenon of everyday life. In this sense these works resemble “DIELECTRIC”.

2.3 Anthony Dunne and Fiona Raby *The Secret Life of Electronic Objects*:

“Hertzian space” is the name for the volume that is occupied by the electromagnetic field of an electronic object, so defined by British industrial designers Anthony Dunne and Fiona Raby. In their book *Design Noir: The Secret Life of Electronic Objects*, Dunne and Raby explore the hidden dimension of everyday electronic devices. Dunne and Raby poetically define the invisible leaking of electromagnetic radiation into the surrounding space as “dreaming”: “The dreams of electronic objects are made from electromagnetic radiation. These dreams radiate outwards from the object, creating a new, invisible but physical environment that we call hertzian space.”[31] Dunne and Raby list all the frequencies of the electromagnetic spectrum, the lowest ones being fields emitted by electrical wiring in the range of 50-60Hz.[32] The spectrum continues through the frequencies of radio, TV, mobile phones, bluetooth to infrared and visible light, the only two frequency ranges which human bodies can perceive (as warmth and light). The electromagnetic spectrum ends in the range of ultra-violet, X-rays and Gamma rays. Although the human body is only susceptible to a very limited range of this spectrum, all of these frequencies occupy a space: “In fact, every electronic object is spread over many frequencies of the electromagnetic spectrum, some of them visible, others not. If our eyes could see (or tune into) energy of a lower frequency, these objects would not only appear different, but their boundaries would extend much further into space, interpenetrating other objects that would be considered discrete at the frequency of light.”[33] It is the aim of Anthony Dunne and Fiona Raby to explore the hertzian space by means of furniture that is highly responsive to various parts of the electromagnetic spectrum. According to Dunne and Raby, the rules of the hertzian space are similar to the ones of visual

[31] Dunne, Anthony and Raby, Fiona: *Design Noir: The Secret Life of Electronic Objects*. London: August; Basel: Birkhäuser, 2001, p.11

[32] cf. ELFs and EMFs in chapter 1.2

[33] Dunne and Raby: *Design Noir: The Secret Life of Electronic Objects* op.cit., p. 12

threedimensional spaces: "…like light, electromagnetic radiation is emitted by some objects, reflected by others and and absorbed by others again. Hertzian space is three-dimensional and spatial. It is an environment that needs to be fully understood if it is to be made habitable. As the spectrum becomes better understood, it will begin to shape architecture and other objects."[34] The furniture series "Placebo" was developed by Dunne and Raby to reveal the "secret life of electronic objects" in the hertzian space but also to make users aware of the presence of electromagnetic radiation. The furniture series consist of eight different prototypes that are not meant for eventual production and distribution but rather for rental. According to Dunne and Raby: "Living with them for a while might encourage the borrower to think about their environment in a different way, especially in relation to electromagnetic fields."[35] I will briefly describe two of these objects "Parasite Light" and "Compass Table" as representative examples of the whole furniture collection. "Parasite Light" is a lamp that only works in the vicinity of objects that radiate electromagnetic fields. An electric field sensor scans its environment and relates the amount of light emitted by the lamp to the field's strength. "Compass Table" has 25 compasses integrated into its surface. It responds in a very direct way to electronic objects put on the table or electromagnetic fields in rooms. The table can be positioned in a room in two ways: first, obeying the rules of visual space (i.e. aligning with other objects such a sofa, sideboards, walls, etc…); or second, being influenced by the hertzian space. In this case the direction of the compass needles determine the orientation of the table.

Many of Dunne's and Rabi's ideas relate to "DIELECTRIC". Most importantly, Dunne and Raby introduce the notion of the electromagnetic space, realized in my installation through the hammock's electromagnetic field that detects the presence of visitors. Related to the spectrum of electromagnetic radiation, "DIELECTRIC" deals with the lower frequencies, emitted by electric wires in the range of 50-60Hz[36], the frequency of AC. Like the 'Placebo'

---

[34] Dunne and Raby: *Design Noir: The Secret Life of Electronic Objects* op.cit., p. 12, cf. also the following quotation on the same page: "Just as different building types evolve in realtion to specific climatic conditions, so too will new building typologies evolve in response to different electro climatic conditions."

[35] ibid., p. 75

[36] in Europe the frequency of AC is 50 Hz, in the U.S. it is 60 Hz

series, my installation also stimulates the visitors' awareness of electricity and the fields that are emitted by electric devices.

2.4 Joseph Beuys "Energy Plan for the Western Man", "Capri Battery":

In 1974 the gallerist Ronald Feldman made Joseph Beuys' first appearance in the United States possible. However, Feldman had to agree not to present any tangible works in Beuys' first American exhibition: that is, he showed an empty room. Beuys travelled instead - lecturing, listening and discussing - through the United States. The focus of Beuys' "Energy Plan for the Western Man" lecture series was his idea of the Social Sculpture. The process of creation in the context of the "Social Sculpture" was based on three stages: the transformation of chaotic energy and unformed mass through a process of harmonization and molding to a very determined and crystallized form. Starting in New York Beuys scheduled 30 meetings in ten days, lecturing for and discussing with all interested people. Chicago and Minneapolis were the second and third stations. Just like his concept of "Social Sculpture" the Energy Plan was for Joseph Beuys an essential and immaterial act of shaping creative ideas and fostering creative energies - specifically applied to the energy crisis in the United States interpreted not only as economic but social as well.

Joseph Beuys' "Capri Battery" from 1985 deals with the topic of energy, especially electricity, in a more direct way. "Capri Battery", is based on a simple natural phenomenon: by sticking a zinc and a copper electrode (a sliver of metal) in a lemon, the citric acid in the lemon reacts with the metals and produce a low electric current. Beuys' work consist of a yellow lightbulb attached to a portable socket. The socket with the lightbulb is plugged into a lemon. Of course the lightbulb does not light up physically, but the way Beuys combined the three elements (lemon, lightbulb and socket) suggests strongly the flow of energy from the fruit, potentially lighting up the bulb. In this work, as well as in many preceding works, Beuys expolored the idea of energy transformation. In batteries, energy is transformed (from chemical to electrical) as well as stored. In "Capri Battery", Beuys emphasizes this idea by providing instructions which read: "Change battery every thousand hours". This and other artworks by Beuys, e.g. "Silent Grammophone" from 1962, suggest a mechanism that could potentially work. However, by the choice of the materials and combinations these works only hint at their intended function. The viewer is asked to imagine the behavior of these physically inanimate objects. An interesting question arises, especially if applied to the field of realtime responsive sculptures: how would the meaning of these artworks have been different had Beuys' made them fuctional?

It could be argued that in Beuys' case, the artworks would have lost much of their impact and imaginative power. A very literal approach to the represented topic would have interfered with and limited the viewer's subjective process of interpretation. David Rokeby writes about the artwork's authority and freedom of interpretation, comparing "static" traditional artworks and interactive installation: "The static artwork can be looked at in two opposing ways. It can be seen as authoritarian in its refusal to reflect the presence and actions of the spectator, or, it can be seen as giving the spectator complete freedom of reflection and interpretation by not intervening in this process. An interactive artwork can likewise be seen as loosening the authority of the traditional work, or as interfering in the interactor's subjective process of interpretation."[37] Chapter 4 will deal with Burnham's and Rokeby's theories about sculpture in relation to interactivity more in detail. It will also show that interactivity and responsiveness need not necessarily be factors that limit the possibilities of an artwork's interpretation. On the contrary: reactive or interactive elements are vital in responsive installations. It is important to realize that the "prime mover" of these installations is no longer the "élan vital" (mentally constructed lifelike properties) of traditional sculpture or a literal technical animation.[38] It is rather the concept behind the Greek word "kybernetes"[39] on which responsive installations are based. Chapter 4 will provide a more detailed introduction to the history of responsive sculpture. Before dealing with the sculptural and interactive aspects of "DIELECTRIC" it is necessary to take an in-depth look at the installation and its prime interface first.

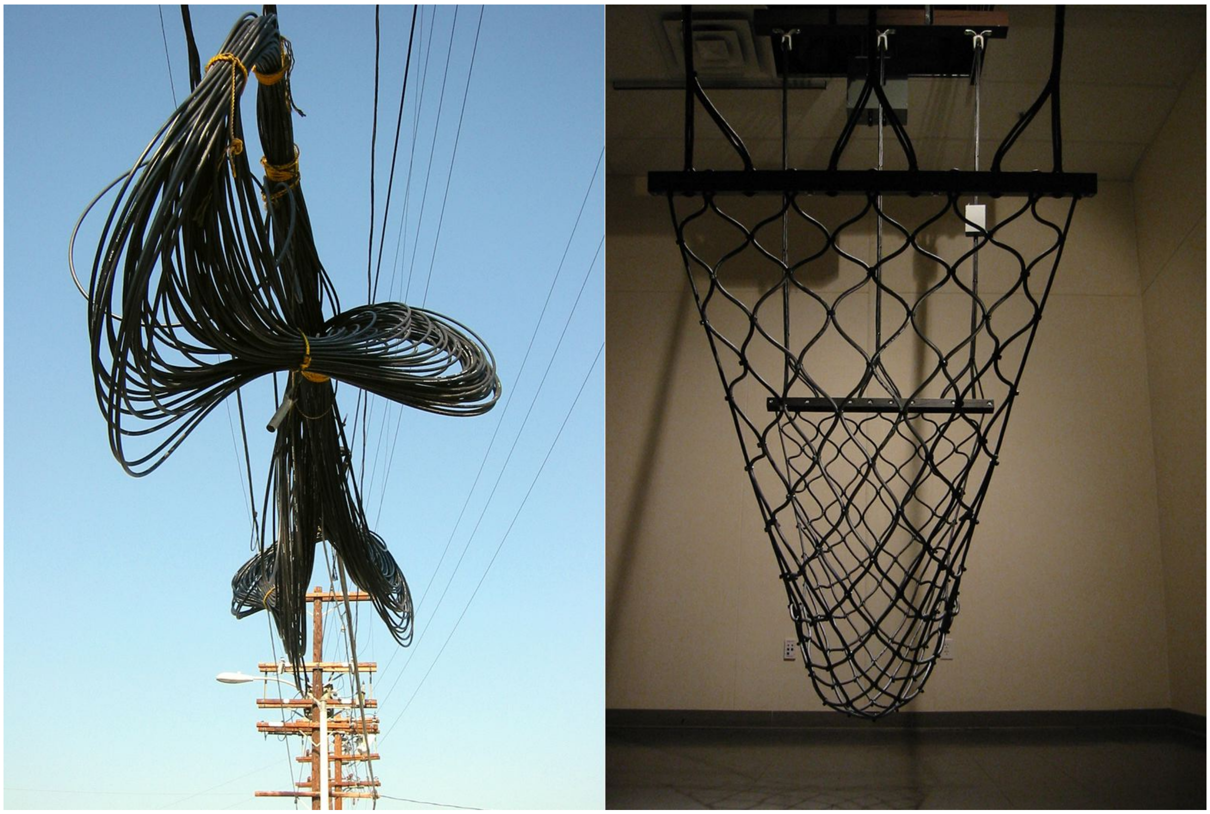
3. Project Description

3.1 Hammock as Interface:

Observations of the sculptural qualities of power lines in urban L.A. were a central source of inspiration for the development of my installation's interface. One of the power lines I saw in the Downtown L.A. area was being prepared to branch off and connect to another power line

[37] Rokeby, David: "Transforming Mirrors", in *Critical Issues in Electronic Media*. Edited by Simon Penny. Albany, N.Y.: State University of New York Press, 1995, p. 141.
[38] cf. Burnham: *Beyond Modern Sculpture* op.cit., p. 16
[39] kybernetes translates as steersman, the basis of the word "cybernetics"

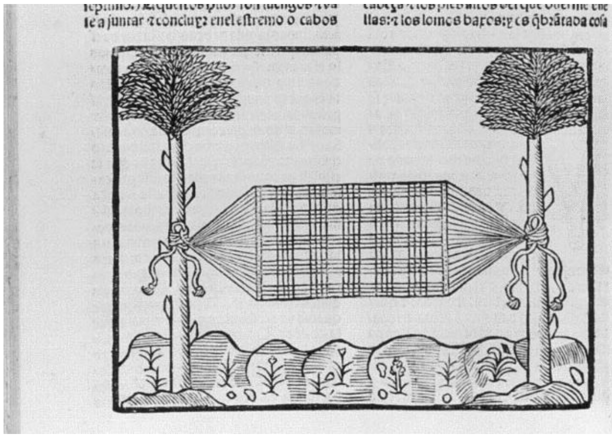
system. The new extra wires, needed to connect the one power line pole with the other were already connected to the old wires, but still bundled together. It was in this situation that I realized the power lines' sculptural potential, and began to think about weaving a hammock with power line wires.



The Picture on the left was taken by Daniel Sauter in the Downtown L.A. area in October 2002. On the right: hammock made of power line wires in "DIELECTRIC".

Physically, the hammock I made has a very raw and rough appearance: standard electrical wires with a black rubber shielding are held together by black wire straps; the two wooden beams on either side of the hammock are black, too. The hammock's mesh is wide and crude, compared to the sometimes finely woven meshes of traditional hammocks. The visual impression already anticipates the sensual experience should an interactor decide to lay in the hammock. It becomes very obvious that this hammock is not meant to be comfortable. It thus opposes the idea of physical interaction with a traditional hammock. At the same time it retains the hammock's connotative meanings as a the net and shelter. I discovered these in my research of the hammock's cultural history.

3.2 The Cultural History of the Hammock:



Hammock: Fernández de Oviedo y Valdés: *La Historia general y natural de las Indias*. Seville, 1535. The picture was taken from the website http://www.loc.gov/exhibits/1492/america.html (last checked 05/30(2003)

There is no evidence when hammocks first appeared, but in the Caribbean and Central America this artefact has been part of everyday culture for a long time. The first time the word “hammock” enters Western culture can be very precisely dated back to an entry in the journal of Portuguese explorer Pero Vaz de Caminha. On the 27th of April in 1500 Vaz de Caminha walked on a beach in Brazil and made a strange discovery which made him note down the following observation: “In their thatched houses the natives sleep in nets that are attached with cords to the wooden beams above. Below always burns a small fire to keep them warm and to repel bugs and demons.“[40] Caminha saw people sleeping in what he first believed to be fishing nets. This led to the Portugese word for hammock: “rede de dormir”, which translates literally “a net for sleeping”. There are two roots for the English word “hammock”: one goes back to the Spanish “hommoca“, a word the conquistadors derived from the native Caribbean inhabitants who used woven fibers from the hammok tree for their hammocks. The other one relates to the word “hamaca” that the indians in Central America used to refer to their hammocks. The cultural importance of the hammock was enormous around the time it was discovered by the first explorers of the American continents and the Caribean. Hammocks were the place where life begun and ended, they were beds and protected the person sleeping in them from insects, snakes and other dangers coming from the ground. Sleeping and resting in a hammock implies the feeling of being detached from the ground, almost weightless in a perfect equilibrium.

3.3 Installation Setup

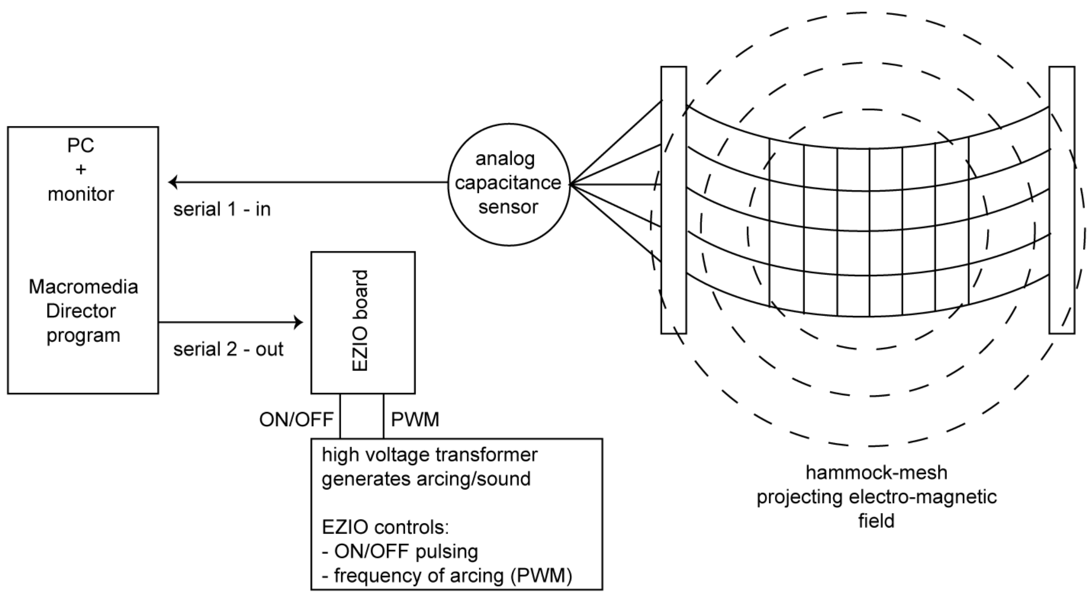
[40] James J. Bogan: *Hammock Variations*, website, http://web.umr.edu/~jbogan/hammock.htm (last checked Mar. 13, 2003).

Interactor laying in the hammock.

The hammock as interface in "DIELECTRIC" also implies the idea of a net – technically a net collecting electromagnetic information from the surrounding space. This is achieved by connecting the hammock to a capacitance sensor, as illustrated in chapter 1.4.

The hammock is insulated against ground by carefully separating suspension wires and wires of the hammock's mesh. The insulation ensures exact capacitance measurements, not influenced by the electric charge of other objects, such as the crossbars or metal beams on the ceiling. The wires that attach the hammock to the ceiling are fastend around a heavy metal track which is connected with the ceiling's beam structure. This structure is strong enough to guarantee full stability of the hammock up to a maximum weight of 250lbs. From the fixtures on the ceiling, the three wires (symbolizing the 3-phase AC power system) run through 3 ceramic insulation pulleys attached to the upper crossbars on either side of the hammock. The crossbars, also fastened to the ceiling's heavy beam structure, are painted reddish brown, the same color of the wood-impregnating resin used for power lines. The hammock's two outer wires are connected in a U-shape and are used as the capacitance sensor's antenna. Under ideal circumstances, the sensing field produced by the U-shape is strong enough to detect objects at a distance of more than 4ft. away from the hammock. The field is also strong enough to be projected through the wire's insulation into adjacent wires and from there to the next row of wires, eventually covering the whole hammock. On the side of the transformer box one of hammock's outer wires runs up into a cylindrical black tube that is located halfway on the wire strand between the hammock and the crossbar. This tube has two functions: it houses the capacitance sensor and resembles a similar part attached to power lines in urban space. Another wire runs from the black cylinder to a computer, the installation's control unit, hidden underneath the ceiling. This is the serial cable transmitting sensor values to a Macromedia Director application running on the PC computer. Based on these sensor values the computer controls the arcing of a high voltage transformer[41] located in a metal transformer enclosure next to one of the installation's crossarms. The closer interactors are to the hammock the more arcs are triggered in the transformer. The proximity of interactors also influences the frequency of pauses between the arcs as well as the duration of the arcs themselves. The closer the interactor, the longer the duration of the arcs and the shorter the pauses between discharges. If the interactor decides to lay in the hammock, his or her body assimilates into the hammock's electromagnetic field after a predefined time. The arcing calms down and is only triggered again through the interactor's movement in the hammock or by other interactors approaching the interface.

System Diagram:



Systemdiagram, "DIELECTRIC"

4. Sculptural and Interactive Aspects of "DIELECTRIC"

4.1 Sculpture and Interactivity:

In his book *Beyond Modern Sculpture* Jack Burnham describes the development of sculpture from an object to a system. Burnham defines sculpture in its most traditional form as a "free-standing human form with life-emitting properties".[42] These sculptures are characterized by the occupation of space and the concept of lasting long, if not forever. On the contrary, as a

[41] The concept of this high voltage transformer is described in detail in the last paragraph chapter1.1

[42] Burnham: *Beyond Modern Sculpture*, op.cit., p. 1

system, sculpture departs from its object state; sculpture is no longer static but exhibits - to some degree - lifelike behaviors. Rather than being a solid object, the system consists of interrelated and mutually dependent components and may become responsive. One important step of sculpture's transition from object to system is the process of sculpture's vanishing base. Burnham sees the sculpture's pedestal as "a convention for recognizing sculpture's innate lack of biological autonomy and mobility".[43] In the same paragraph he also explains how sculpture's condition has changed mostly because of two factors: "the gradual realization of sculpture's material status simply as an object, and the rise of the conviction that physiochemical conditions rather than spiritual energies are responsible for the origination of biological life".[44]

Rosalind E. Krauss has a different approach to explain the disappearance of the sculpture's base. She points out the traditional function of the sculpture's pedestal as an element mediating between "actual site and representational sign"[45] thus creating the context in which the sculpture can be seen. However, by the end of the 19th century a gradual change set in: the sculpture's base disappeared. The period of modernism, defined by the sculpture's loss of site had begun. Being disconnected from the base the sculpture entered a state of homelessness resulting in a complete loss of place. On the other hand this evolution led to the concept of pure abstraction – without a pedestal sculpture became largely self-referential, nomadic. Sculpture developed downward "to absorb the pedestal into itself and away from actual place".[46] In this process, according to Krauss, the field of sculpture became too heterogenous. This led her to redefine sculpture as "not-landscape" and "not-architecture". Krauss continues by developing a matrix structure[47] which allows her to further classify other forms of sculpture like the early 1970s emerging form of land-art. The negation of "not-landscape" and "not-architecture" is a structure that is architecture and landscape at the same time. Krauss calls these forms "site construction". One example of such a structure would be a Japanese Garden. Structures being simultaneously "not architecture" and "architecture" are defined as "axiomatic structures". These are mostly temporal interventions into real

[43] Burnham: *Beyond Modern Sculpture,* op.cit., p. 9
[44] ibid., p. 9
[45] Rosalind E. Krauss: *The Originality of the Avant-Garde and Other Modernist Myths*. Cambridge, Mass.: The MIT Press, 1988 [1984], p. 279.
[46] ibid., p. 280
[47] ibid., p. 284

architectural spaces, e.g. Sol Lewitt's open cube sculptures. Finally, Krauss introduces "marked sites" as being "landscape" and "not landscape" at the same time. Examples for marked sites are land-art works, characterized by their often temporal nature with photographic documentations being mostly the only proof or the artwork.

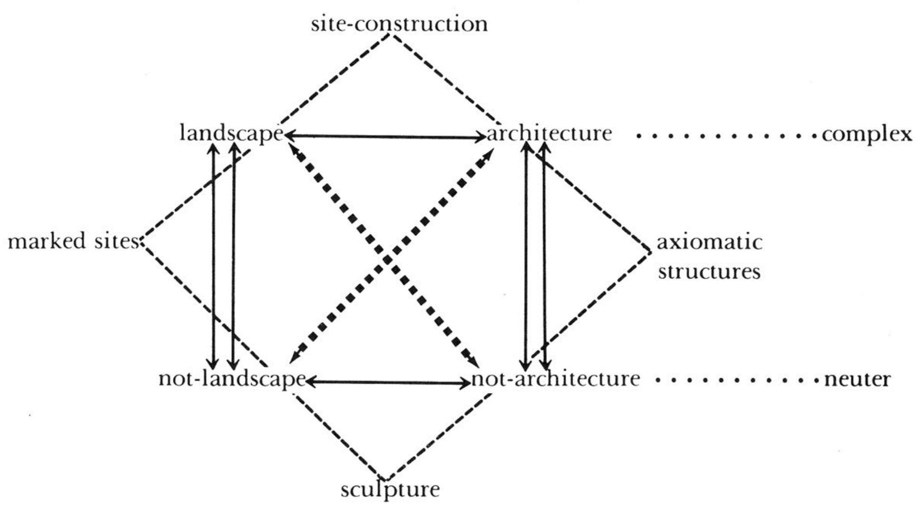


Diagram taken from Rosalind E. Krauss,.: *The Originality of the Avant-Garde and Other Modernist Myths*. op.cit., p. 284.

The defintion of these new emerging structures in the field of sculpture are extremely helpful, particularly with the advent of minimalism and land-art in the late 1960s. However, what none of the structures in Krauss' matrix represent is the aspect of time and/or motion inherent to kinetic and responsive sculptures. These artworks are covered extensively in the second part of Burnham's book *Beyond Modern Sculpture*. Burnham connects the history of kinetic and consequently responsive sculpture with the history of the automaton, "seemingly self propelled or self animated images of animals or men".[48] It is interesting to note that automata have almost always been looked down on as subsculpture, i.e. objects that are aesthetically inferior to sculpture and not being part of the world of fine art. The reasons for this judgement are manifold: from a technical point of view "the maker of automata has always dealt with an ephemeral art, one far outdistanced by by the life span of stone".[49] But also the kinetic qualities of automata contributed to this development: "The pathos of automata lies in that they are doomed to failure, not only by physical disintegration, but in the mind of the beholder, by a final sense of inconviction".[50] Finally, from an aesthetical point of view

---

[48] Burnham: *Beyond Modern Sculpture*, op.cit., p. 185.
[49] ibid., p. 193
[50] ibid., p. 187

automata have been inferior to sculpture, stimulating people's intellect but not any emotional resonance.

Almost 30 years later, David Rokeby refers in his article "Transforming Mirrors" to automata as one of the four models of interaction between an artwork and an interactor. However, how can "interaction" be defined in the field of media art? According to David Rokeby, the principle of interaction is comparable to an infinte feedback loop: an installation responds to actions of an interactor which in turn changes the way the interactor behaves. Both, interactor and system are profoundly changed in the process of interaction. The same actions from the interactor will cause different results dependent on when these actions are performed. Rokeby compares interactive artworks with mirrors that transform the mirrored image to a certain extend and project it into infinity, similar to two mirrors facing each other. In contrast, the terms "responsive" or "reactive" can be used for systems that do not change their responses over time, they simply "respond" to user actions. Similarly, same actions will cause the same reactions. Rokeby's four models of interaction between artwork and interactor are based on the his definition of "interaction" as the ideal situation but don't exclude responsive artworks.[51] His four models include: the automaton; the "navigable structure or world"; the "creative medium in its own right" and the "transforming mirror". Similar to Burnham, Rokeby claims that the aim of the creators of automata is the "self-replicating, self sustaining machine – artificial life."[52] Interactive artworks that can be considered navigable structures or worlds imply a representation of space, either real, virtual or conceptual.[53] It is rather the interactor's trajectory through space than an actual destination in space that constitutes the experience of these artworks. Exploring and changing space in the process of discovery is the main focus of navigable structures. The interactive artwork as "creative medium in its own right" blurs the line between artist and audience. A

---

[51] "One might take the extreme position that a significant interaction between an artwork and a spectator cannot be said to have taken place unless both the spectator and the artwork are in some way permananetly changed or enriched by the exchange. A work that satisfied this requirement would have to include some sort of adaptive mechanism, an apparatus for accumulating and interpreting its experience. While few interactive works currently contain such mechanisms, many have exhibited a form of evolution, not through internal mechanisms but through the refinements and adjustments made by their creators-responses to observations made of interactions between the work and the audience."
David Rokeby: "Transforming Mirrors", in *Critical Issues in Electronic Media*. Edited by Simon Penny. Albany, N.Y.: State University of New York Press, 1995, p. 137.

[52] ibid., p.151

[53] These artworks can be communications systems and networks, virtual reality artworks, hypermedia artworks.

contemporary example in this category is Golan Levin's "Audiovisual Environment Suite"[54], a set of software tools that allow users to generate dynamic shapes and sounds at the same time. According to Rokeby, "presenting a limited range of possibilities reduces the likelihood that the interactor will run up against a creative block, and allows the medium to guide the inexperienced hand of the interactor, reducing the fear of incompetence."[55] Finally, Rokeby defines interactive installations that provide a mediated feedback as "Transforming Mirrors". The most obvious examples are interactive video installations that transform the video image of the interactor and reflect it back to her/him: ".. the character of the experienced phenomenon is discovered as a change in a representation of self."[56] Ideally, this process of transformation happens in both, the interactor and the art piece.

4.2 To Which Extend Does "DIELECTRIC" Need To Be Interactive?

In his definition of "interactivity", David Rokeby focuses on artwork that incorporates technology to a certain extend. As mentioned before, Rokeby also shows the relation between beholder/interactor and artwork comparing static artworks which are technologically non-interactive and interactive media art works: traditional artworks stress the authority of the artist but offer complete freedom of interpretation to the beholder. In contrast, interactive artworks loosen the artist's authority but impose limits in the process of subjective interpretation. The restraints of not experiencing all the possibilities of an interactive artwork are based in the artwork's responsive qualities. The static artwork only limits the beholder's reception through his or her size or position in relation to the artwork, e.g. normally one cannot look on top of a 10ft. high sculpture. In contrast, interactive artworks can limit the interactor's experience to a very great extend, since the artwork is moulding itself based on the interactor's behavior.

"DIELECTRIC" combines features of static, responsive and interactive artworks. In its first exhibition setup in progress, in late December 2002, the installation only consisted of the crossbars, insulators and the hammock in between. Without any responsive or interactive features, the installation was already a consistent design object surprising the beholder

[54] http://acg.media.mit.edu/people/golan/aves/ (last checked: May 24, 2003)
[55] Rokeby: "Transforming Mirrors", op.cit., p.144.
[56] ibid., p.147.

through its hybrid form, half power line half hammock. The sculptural qualities of the work gave complete freedom for individual interpretations. It was then that I started the "mind experiment", similar to the "mind experiment" with Joseph Beuys' "Capri Battery"[57] – thinking about eventually making the installation responsive. By keeping my installation's responses consistent with the idea of electricity, "DIELECTRIC" does not lose any of its imaginative power. Consistency is achieved through the use of a capacitance sensor as input device and a high voltage transformer as actuator. As a result, "DIELECTRIC" mixes elements of traditional sculpture with the qualities of kinetic sculpture as described by Jack Burnham. The responsive nature of my installation is very direct, electrical arcing is triggered depending on the interactor's proximity to the hammock. Rokeby refers to this very direct responsive behavior of interactive artwork as the "proof" for a recognizable reflection of the interactor in the installation: "The proof that will most easily satisfy the audience is "predictability" (i.e. if one makes the same action twice, the work will respond identically each time). Unfortunately this test only works for simple interactive devices with no memory and no ability to adapt."[58] In addition to its very direct response, "DIELECTRIC" also has the ability to adapt. As described earlier, the capacitance sensor used in my installation measures the amount of background capacitance on the the hammock and treats it as a tare. New sensor input is compared with the reference value. Every time an interactor sits in the hammock, the sensor value reaches a maximum (full body contact with the capacitance sensor's antenna, i.e. the hammock). After a preset time of maximum amplitude, the sensor is programmed to reset its tare. The interactor laying in the hammock or touching the hammock is assimilated and becomes part of the hammock's electromagnetic sensor field. Electric arcing is only triggered once the interactor moves in the hammock, once he or she leaves the hammock or once another interactor approaches the hammock. If responsive and interactive elements interfere with subjective interpretations of "DIELECTRIC", it is only to emphazise the installations main goals which are summarized in the following.

5. Conclusion

---

[57] cf. chapter 2.4

[58] Rokeby: "Transforming Mirrors", op. cit., p. 148

5.1 Summary of Key Objectives and their Realization

One of my installation's main goals is the creation of an ambient presence of electricity. Originally , I was inspired by the buzzing of power lines in urban L.A. These acoustic manifestations of the city's energy consumption and energy dissipation are mostly caused by leaks in the distribution grid due to improper insulation. My installation's sculptural elements integrate the visual language of power lines and create a very physical and palpable presence of electricity. Additionally, "DIELECTRIC" references key inventions in the field of electricity, such as Nikola Tesla's high voltage generators or the AC power system. On a structural level, I deal with electricity dynamically – manifested through light and sound in the installation space.

Furthermore, "DIELECTRIC" emphasizes electricity's socially determined ambiguity, evoking feelings of comfort and danger. This ambiguous notion of electricity is present in today's society as it was more than 100 years ago, in the early times of electrification. My installation illustrates this ambiguity by the contrasting connotations of the hammock and the transformer arcing, the first connotating comfort and relaxation, the latter representing danger and stress.

Finally, "DIELECTRIC" relates the human body to the phenomenon of electricity. With my installation I am investigating the spatial qualities of electromagnetic fields and interferences of the human body with these fields. The capacitance sensor used in "DIELECTRIC" detects human presence by measuring a human body's weak electric charge. Using the phenomenon of electricity itself, I turned the hammock into an interface for simple body tracking. This strategy adds responsive and interactive elements to my installation, a necessary step to establish a direct relation between the human body's electric qualities and the concept of electricity.

5.2 Future Explorations

Obviously, the phenomenon of electricity is a rich field for artistic production. The main goals of "DIELECTRIC", summarized in the preceeding paragraphs, cover only certain areas of the broad spectrum of possibilities but still motivate further research and exploration: for example, the archeology of early electronic devices and their socio-thechnological context yields inspiration for further work. I am mostly interested in the long forgotten electronic devices from the 1850s to the 1910s used for electropathic purposes. The belief in electricity as an all-purpose cure was one of the earliest concepts that related the human body to the new technology of electricity. Other interfaces beside the hammock in "DIELECTRIC" could be developed incorporating this idea.

Another field open for exploration is the relation of "DIELECTRIC" to specific situations in urban space. My installation was inspired by phenomena of power lines in urban L.A. These references have been abstracted to a visual and sonic language of power lines tailored for a gallery situation. Taking this as a starting point, the concept of a power line "language" could be extended in two ways: first, in the direction of a "system" or network. Other aspects of the power distribution grid, monitored from the outside world, could be incorporated into further work. A very direct example would be the monitoring and interpretation of energy consumption from the respective exhibiting institution, or in the case of a group exhibition, from other electricity-driven artworks. Second, the installation's design could be related physically to the outside world. In this case, the sculptural elements of "DIELECTRIC" are taken out of the gallery, into urban space again. For example, the installation's interface, the hammock, could be suspended from two power line utility poles close to each other. The realization of this project would be based on digital montages rather than physical setups. This approach rather focuses on design issues, a utopian design proposal for urban power distribution grids.

Finally, I introduce "EMF", a project accompanying "DIELECTRIC". "EMF" combines sonic qualities of electromagnetic fields (EMFs) with images of wire coils, found in the distribution grid in urban L.A. Technically, these wire coils produce an electromagnetic field when current flows – similar to Faraday's early experiments with electro-motors. I use this observation for the presentation of the documented wire coils: the wire coils are videotaped and shown on a TV screen. The TV screen itself produces an electromagnetic field around its cathode ray tube (CRT). Sometimes, a weak electrostatic field can be felt by touching the TV screen. The electrostatic field is a by-product of the electrons produced and accelerated in the CRT. It is a tangible manifestation of the TV screen's EMF. Conceptually, the EMF created by the wire coils shown on the TV screen and the screen's "tangible" EMF converge. The physical setup of the video-installation "EMF" consists of three TV screens, each showing the documentation of the wire coils. All the coils were shot against the pure blue sky. The center screen shows the videodocumentation with the sounds of buzzing power lines, acoustic manifestations of electricity traveling through the wires inducing the EMF. The documentation played on the outer monitors features crackling sounds from the monitor's electrostatic field. The EMF generated by power lines and the EMFs emitted by the TV screens are oscillating at the same frequency: 50-60Hz. As previously mentioned, a very intricate wire coil in the Downtown L.A. area inspired the creation of "DIELECTRIC". Since then, I have looked at these coils of excess wire as possible material for new sculptural forms. "EMF" completes the circle referencing the original inspiration for "DIELECTRIC". At the same time, "EMF" motivates further explorations in both, the visual and sonic language of power lines and the spaces created by electromagnetic fields.

Appendix A:

Pam Blair: “Power Line Anatomy 101”, in *Ruralite* magazine, September 2001 issue.
Artwork by Phil Asay.

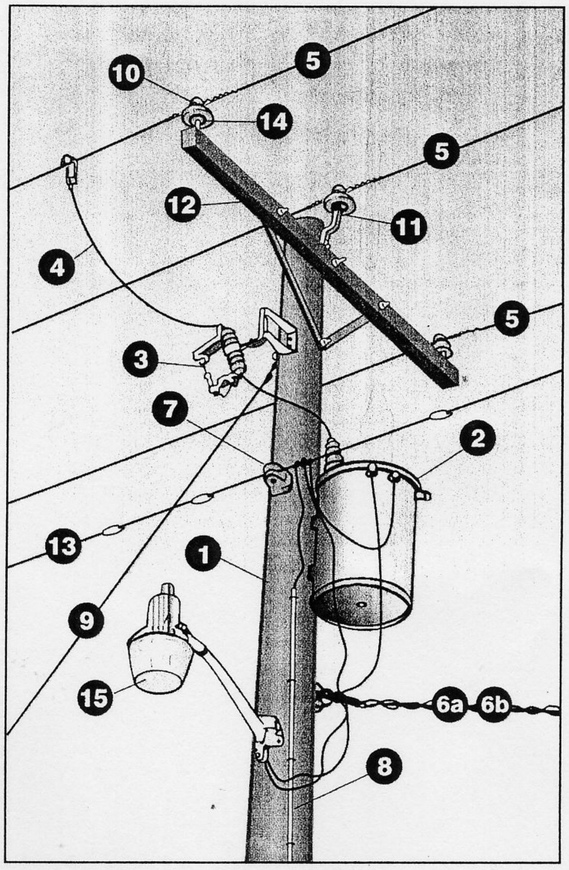
Power Line Anatomy 101

What do you see when you look at a power line? What are all those attachments, and why are they important?

The power lines that carry electricity from the substation to your home or business are called distribution lines. They are part of a system of poles, wires, transformers and other equipment used to deliver electricity.

Sometimes the power lines are buried underground. However, more frequently they are run overhead.

Below is a description of the main components of an electrical distribution system.



1. Utility pole: The half-ton wooden pole is the backbone of the electrical line. It is partially buried to support all of the equipment. It usually is about 40 feet in length, and typically is made from logs made of cedar, pine or fir trees.

2. Transformer: The cylindrical metal tank-shaped device steps down the voltage to a level safe for delivery to the customer, either 120 or 240 volts. Many transformers have a lightning arrestor, which protects them from a strike.

3. Fused cutout: This provides overload protection. A link inside a fiberglass barrel operates the cutout, which isolates the tap from the main line. When a loud blast is heard from a utility pole, it is the fused cutout operating.

4. Wire and clamp: This wire is secured by a clamp, and connects the main line to the transformer.

5. Primary conductor: This is the main series of wires that carries electricity from the supplier to the consumer through the distribution system. A three-phase line—typically used to serve large power users, such as commercial and industrial accounts—has three separate current-carrying conductors. A single-phase line—which serves most homes—has just one current-carrying conductor.

6. Secondary tap (hot and neutral): This conductor carries electricity between the transformer and the consumer’s electric meter.

7. Strain insulators: These ceramic objects hold the conductors in place and insulate them from the pole.

8. Pole ground wire: This wire is connected to a metal rod driven eight feet into the ground. Its job is to ground the system.

9. Guy wire: This stranded wire helps stabilize the pole. Hardware connects it to the pole and an anchor in the ground.

10. Insulators: These porcelain or rubber objects support the electric wires and prevent an undesired flow of electricity.

11. Pole-top pins: These support the insulators on the pole.

12. Crossarm and braces: This is the horizontal piece on the pole that makes the structure look like a cross. It holds the insulators, and keeps the lines on a three-phase line from touching one another. It usually is made of the same wood as the pole.

13. Main line neutral conductor: This wire is the neutral conductor in a distribution circuit.

14. Insulator pins: These support the insulators on the crossarm.

15. Security light: Although not on all power poles, a dusk-to-dawn light is visible on many power poles.

Bibliography:

Beuys, Joseph: *Energy plan for the Western man : Joseph Beuys in America, writings by and interviews with the artist*. Compiled by Carin Kuoni. New York: Four Walls Eight Windows, 1990.

Blair, Pam: “Power Line Anatomy 101”, in *Ruralite* magazine, September 2001.

Bogan, James J.: *Hammock Variations*, website, http://web.umr.edu/~jbogan/hammock.htm (last checked Mar. 14, 2003).

Burnham, Jack: *Beyond Modern Sculpture*. New York: George Braziller, 1968.

DeMarinis, Paul: *Gray Matter* (Essay), website, http://www.well.com/~demarini/graymatter.html (last checked Mar. 14, 2003).

DeMarinis, Paul: *The Messenger* (Essay), website, http://www.well.com/~demarini/messenger.html (last checked Mar. 14, 2003).

Dunne, Anthony and Raby, Fiona: *Design Noir: The Secret Life of Electronic Objects*. London: August; Basel: Birkhäuser, 2001.

Electra (exhibition catalogue). Edition: Les Amis du Musée d’Art moderne de la Ville de Paris. Paris: Société Nouvelle de l’Imprimerie Moderne du Lion, 1983.

Glenn, Jim and Cheney, Margaret: *The Tesla Coil*, website, http://www.pbs.org/tesla (last checked May 08, 2003).

Hunt, Inez and Draper, Wanetta W.: *Lightning in His Hand – the Life Story of Nikola Tesla.* Hawthorne, California: Omni Publications, 1977 [1964].

Krauss, Rosalind E.: *The Originality of the Avant-Garde and Other Modernist Myths*. Cambridge, Mass.: The MIT Press, 1988 [1984].

Nye, David E.: *Electrifying America.* Cambridge, Massachusetts/London, England: The MIT Press, 1990.

Rokeby, David: “Transforming Mirrors”, in *Critical Issues in Electronic Media*. Edited by Simon Penny. Albany, N.Y.: State University of New York Press, 1995.

The Quantum Research Group: *Capacitance Explained*, website, http://www.qprox.com/background/capacitance.php (last checked Mar. 14, 2003).

Youngblood, Gene: *Expanded Cinema*, New York: Dutton, 1970.