Master Thesis in partial fulfillment of the requirements for the degree Master of Arts in Digital Media at the University of the Arts Bremen, February 2017.

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This book was set in Univers by Adrian Frutiger.
Printed and bound in West Germany.

ISBN CN-0-636-563452

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GLOSSARY

ADDRESS
In a digital computer ; the name of a position in Memory where some piece of information is stored.

ALEATORY
Chance, random.

ALGORITHM
A prescribed set of well-defined rules for the solution of a problem. Contrast — HEURISTIC.

ALPHABET
The symbols used in a language. A digital computer's alphabet is the two symbols ‚0' and ‚1'.

ANALOGUE
A physical, mechanical, electrical model (used for computation by analogous representation) corresponding in some respect to the original object or concept, with or upon which measurements or calculations are to be performed.

ANALOGUE COMPUTER
A device to perform calculations about real systems by constructing a (usually electrical) model or ‚analogue' of a system and making measurements on it.

ARITHMETIC UNIT
That part of a computer performing arithmetic and logical operations.

ARTIFACT
An artistic, preconceived and created object. It stands for something humanmade and serves as an umbrella term for a variety of things including buildings, artworks and machinery. Generally, artifacts are dead.

ATTACK & DECAY
Wave forms opening and closing a sound or pulse.

AUTOMATON
A deterministic machine which applies an Algorithm to its inputs to find the appropiate output.

BINARY
A characteristic, property or condition in which there are two possible alternatives. The binary code used in computers is expressed in terms of one and zero representing on or off.

BINARY DIGIT
A binary number: 0 or 1.

BIT
Common abbreviation for binary digit ; used also as a unit for measurement of information.

BIO
The Greek root word bio means 'life,'.

BIOFACT
In philosophy, sociology, and the arts, the word is a neologism invented from the blending of the words ‚bios' and ‚artifact' and expresses a being that is both an artifact and living being or both natural and artificial.

BIONICS
The science that studies biological mechanisms in order to construct machines using their principles.

BLACK BOX
A system whose inputs and outputs are known but with an unknown internal mechanism.

CHANNEL
That part of a communication system alogn which messages are conveyed.

CODE
A system of symbols for representing data or instructions.

COMPILER
A special type of computer programme which will automatically translate programmes written in some universally-known programming language such as C++ into machine language instructions suitable for a particular computer.

COMPUTER
Any system which operates on information to produce an output. See DIGITAL COMPUTER.

CENTRAL PROCESSING UNIT
Performs operations on some external data source; usually memory or some other data stream.

CORE
See FERRITE CORE.

CYCLE
A fixed period of operation.

DEBUG
To detect, locate and remove mistakes in programmes or malfuctions in a computer.

DIGITAL
System — one in which variables are presented by numbers (in analogue system, variables are represented by physical quantitites).

DIGITAL COMPUTER
A deviced composed of four main sectors: an ARITMETIC UNIT, a MEMORY, periphery for Input and Output and a CENTRAL PROCESSING UNIT.

DIGRAM PROBABILITY
The probability of occurrence of a particular pair of symbols of an alphabet.

ELECTRONIC
Pertaining to the flow of electrons in vacuum, gas or semiconductors. Electrons are quantitites of electrical energy which course from point to point in a computer making its high-speed operation possible.

ENSEMBLE
Set or collection. The ENSEMBLE of messages from a source is the collection of possible messages that the source can produce.

ENTROPY
Mathematical function rather than verbal description. A measure of the randomness, degree of disorder or chaos of a system.

FEEDBACK
Return of a signal to a controller indicating the result of an action taken by that controller and used to determine further actions.

FERRITE CORE
A minute (approx. 1mm. diameter) ring of magnetic material which may be used to store one bit of information in a computer memory.

FILTER
A device which transmits or suppresses a predetermined part of a signal going through it.

FINITE STATE MACHINE
A machine which has only a finite number of states or a finite memory.

FLOW CHART
A convenient diagrammatic method of representing the relationships among subrouting of a computer programme so that it might be more easily understood by human programmers.

FOURIER ANALYSIS
A method of analysing any period signal into its harmonic components (pure sine waves).

FREQUENCY
The repetition rate which determines the pitch of sound.

FREQUENCY MODULATION (F.M.)
A method of coding information so as to send it reliably. The frequency of a carrier signal is varied by the amplitude of the message to be transmitted.

HARDWARE
The electronic and mechanical equipment comprising a computer, e.g. logic circuits, tape readers, power supply.

HEURISTICS
Techniques by means of which the individual (or machine) can be equipped to solve problems. If the heuristics are applicable, they will provide a short cut to the goal. However, heuristic methods cannot guarantee a solution and may lead to a blind alley. See ALGORITHM.

HOMEOSTASIS
The tendency of an organism - or an organism-like machine - to remain in and return to some stable state.

INTERFACE
An element of a computer system which connects it constituent parts.

LASER
Light Amplification by Stimulated Emission of Radiation. A beam of light whose waves are cherent, differing from orgidary light as the effect of one pebble tossed into water differes from the effect of a handful.

LATENCY
In psychology, the interval of time between the presentation of a stimulus and the repsonse to it.

MACHINE LANGUAGE
A vocabulary of ‚words' meaniningful to a computer ; strings of binary digitas acceptable to and manipulable by machine circuits.

MACHINE LEARNING is the scientific study of algorithms and statistical models that computer systems use to effectively perform a specific task without using explicit instructions, relying on patterns and inference instead.

MATHEMATICAL MODEL
Facsimile in mathematical terms ; a body of a mathematical statements describing a process, parameters, and their relationships to one another and to environments ; useful for rigorously studying complex relationships, particularly with a computer. See also ANALOGUE.

MEMORY (OR STORAGE)
Any device into which units of information can be copied which will hold this information and from the information can be obtained at a later time.

MESSAGE
Any string of symbols inteded for transmission.

NOISE
Any undeseriable signal interfering with the transmission of a message. Usually random.

ON LINE
The property of being connected to a real-time system.

PARAMETER
A discrete characteristic of a system ; in conjunction with others it defines the tate of the system.

PROBABILISTIC
A probabilistic process is one which is only statistically predictable.

PROGRAMME
A set of instructions either fed to or built into a machine which determines how it will act.

PROGRAMMING LANGUAGE
A language, e.g. C++, for feeding instructions or programmes into a digital computer.

RANDOM
A random process is one whose future is not preditable from its past.

RANDOM ACCESS
Storage characteristic in which the time required to access the next position from which information is to be obtained is in no way dependent on the position from which the piece information was retrieved.

REAL-TIME
Computation controlling a physical process as it happens.

REDUNDANCY
Extra detail in a message which allows it to remain understandable in spite of noise and interference.

REGISTER
In a digitale computer, a special memory unit for temporary storage of information.

RELAY
An electromagnetic device whereby a small electrical signal may switch on and off a larger one.

SAMPLE
The instantaneous value of some continously varying quantity at a particular time.

SERVOMECHANISM
An automatic controller which uses information from its environment to control the environment, e.g. a thermostat.

SIGNAL
Any MESSAGE or part of a message.

SIMULATION
The representation of the behaviour of a physical system by the execution of a computer programme or some other model.

SOFTWARE
The programmes and languages used to operation computer machinery.

STATE
A recognisable condition of a system.

STATISTICS
The branc of mathetmatics which prescribes the way in which large amounts of data may be summarised to detect averages and trends. Thus ‚statistical'.

STOCHASTIC
Random, in whole or part.

STORAGE
See MEMORY.

SUBROUTING
A unit of computer programme.

SYMBOL
Any element of an alphabet.

TRANSDUCER
A device which converts energy from one form to another.

VALVE
A device whereby a small signal may continously control a larger one. Contrast RELAY.

VARIETY
A measure of uncertainty or the amount of selection required to remove that uncertainty.

WORD
An ordered set of characters bearing at least one meaning and handled by a computer as unit.

X-Y PLOTTER
A device in conjunction with a computer to plot co-ordinate points in the form a graph.

Originally compiled by Mark Dawson, Humphrey Evans, IBM, Andrew Logan, Peter Schmidt for ‚Cybernetic Serendipity: the computer and the arts', 1969.
The glossary still holds up with most of its descriptions. It has been slightly modified and updated with additions from the Biotic Explorers' technical terms, including a few selected biological and speculative design terms to match some of the current streams.

Abstract

The scope of this documentation is to reflect upon the theoretical, practical and experimental aspects of a piece of work within the realms of speculative design and cybernetical science. After inspecting these two disparate but seemingly close fields, a new field of experimental research emerges. By blurring the borders between speculative design and cybernetics, rule-sets for the digital and analog are repositioned ultimately.
Experiments are conducted in a second phase, upon which their underlying theories have been extracted from theoretical sources and clarified in a broader sense.
Finally, a new hypothesis for a volatile space between fiction and reality arises and manifests itself after the experiments, where it enacts its core idea in a tangible form.

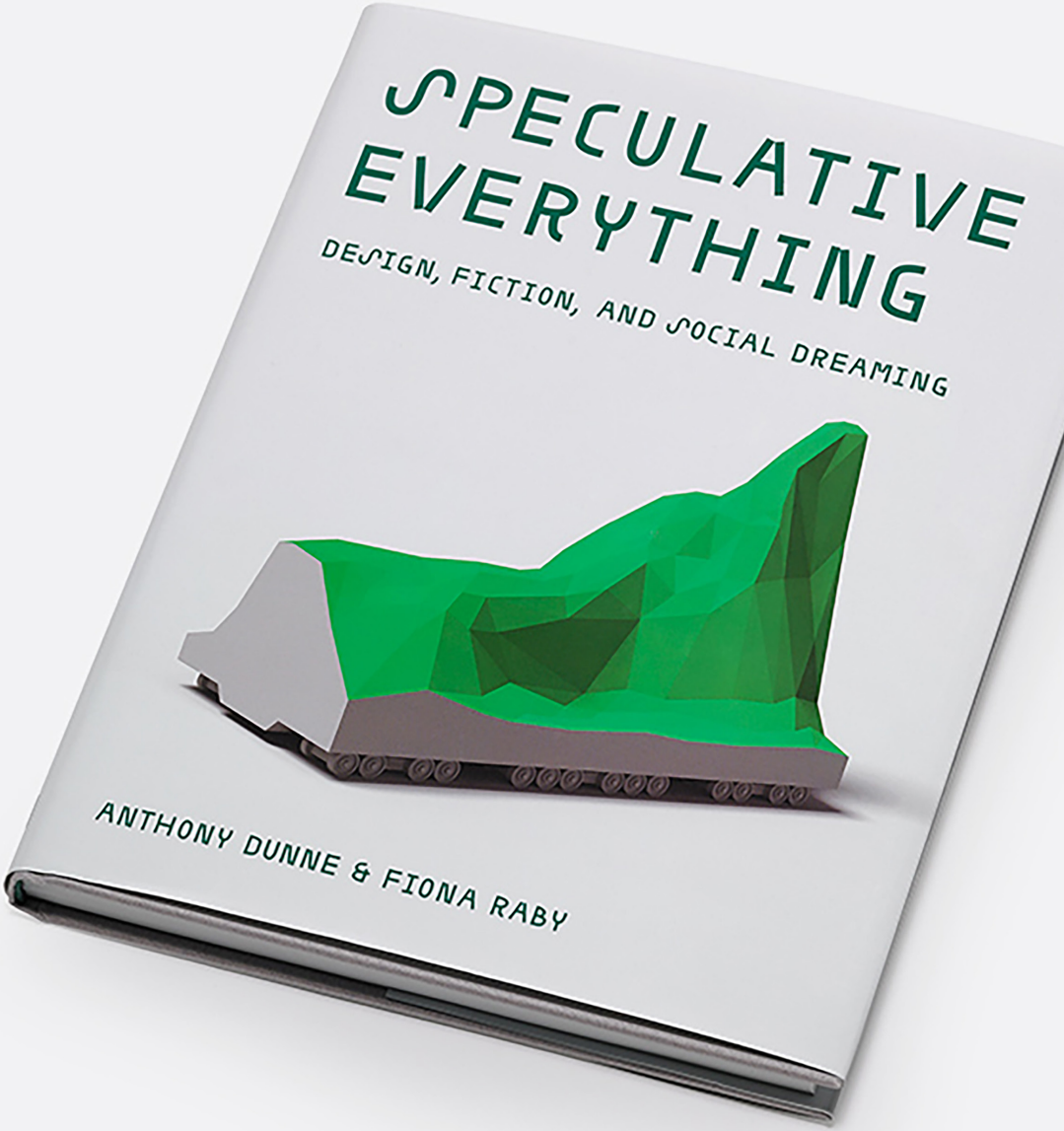


FIG. 1: First Edition of Speculative Everything

On Speculative Design

The *Italian Radical Design* movement of the 1960s is considered a forerunner of the critical design. It was one of the first forms of design as a critique. Its main criticism was going against prevailing social values, to protest against consumerism, fascism and inequality within society and against design. It was an attempt to start a revolution through and with the means of design.

Only later British thinkers, artists, designers and at one point of time in the past also readers at the Royal College of Arts London in the Design Interactions course Anthony Dunne and his long-term partner and collaborator Fiona Raby took upon the radical movement, refined, rephrased, twisted and modernized it. While in their first publication Design Noir[1] the focus sits on the secret „lives" of objects, it already gives the viewer an insight where the next publication Hertzian Tales[2] would head on to. Dunne and Raby took upon the radical movement and added a focus on new technologies into the mix, with regards to electronics products. Being very critical if certain kinds of objects even need to exist in the world as we know. They tie design as a critique with the rise of „multimedia" from the 90s: media and technology in all kinds of life situations and fields.

Nowadays we may call this field Interaction design, a highly vibrant, fast developing and wide-spread field that encapsulates the design of digital products, applications, services and deals with human-computer interfaces.

In their book Speculative Everything[3], Dunne and Raby took one more step forward towards a new critical design: They proposed a model of design that speeds past the interests of big corporations, the securities of economists, design services, design problem-solving situations and even critical design itself.
Speculative design, a framework so simple yet so effective, takes upon proven and successful methods of narration and dream-making and packs them into single punches a designer can work with. Although „Speculative Everything“ sounds at first as work of fiction for making the world better, it is actually a framework to open the discourse about the future - whether it might turn out positive or negative. In a time, where people live out only small dreams through „hopes“. These small dreams are lacking vision, desire and although there are design solutions out there promising to ease the pain or radically change the way your work, they are all short-term and even more short-sighted solutions. Speculations for an alternate timeline, on the other hand, may revive that missing spark for a bigger dream that our ancestors had in the past: the dream of flying, the dream of splitting the atom, the dream of flying to the moon. Some of the proposed speculative scenarios might feel terrible and in conclusion inevitable, but that is just a beginning for a new discourse of what is about to happen and where we as a society are heading to.
The speculative framework first and foremost breaks down the borders between design and science, opening designers to a new language and barrage of knowledge to play around with and construct new and exciting narratives. Designers start to reconfigure everyday constellations and personal needs around specific topics, objects or critical points of failure within our society and plausibly stage them, no other language would be able to help the designer to do so[4]. The fields that designers are exposed to are varying from computer science to engineering, natural sciences, human sciences and even specialized fields such as quantum-physics, biotechnology. A vast vocabulary is ready to use and is the first step in creating a scenario.
It is most interesting, that instead of giving straight answers through design, questions of a particular nuance are asked, artifacts are created to support a scenario and more profound concepts are unraveled by asking.
The honesty of a speculation paired with asking questions, brings back a sort of playfulness of a child, hitting you with accurate, untainted and well-observed questions, where the answer hasn’t been decided by the asking person yet.
The framework brings optimism and criticism together to form an excoriation of present-day (mal)practices. Speculations are not always ideal situations, but the questions which are asked allude to topics of cultural, social and ethical importance. Furthermore, what ethical implications lie within the use of new technologies and what wide-reaching economic and political fields are involved in this.
Spaces of speculation have grown to be plentiful and abundant in our society and

are not only by-products of an academic discourse of where we are going, but are desperately needed to fill in the gaps of big dreams and help us understand a bigger picture of what is to come.

Within the framework of speculative design, we find a wide range of closely related practices tied to critical design: design fiction, future design, anti-design, radical design, interrogative design, discursive design, adversarial design, futurescape, design art, transitional design. We will call these practices „genres“ onwards.
While the traditional model of design concentrates on aesthetical and functional outcomes, speculative design as a discursive practice tries to deploy imagination and visions as a principle in exemplifying proposed ideas and generate results concurrently. Furthermore, it proposes to go beyond critical design by far, and it does so by projecting itself into a far-off future. Designers are able to articulate and rethink alternative products, systems and worlds through speculation. The proposed new form of design strives away from the constraints of the commercial practice and uses fiction to speculate on future products services systems and worlds and thus reflectively reviewing the role novel technologies on everyday life and moreover, it initiates a dialogue between experts such as scientists engineers and designers and users of new technologies. The current stream of technology depicts the technological development as colonialization of the future[5]. Long lost social interaction is reintroduced to society through the use of new technology whereas traditional design holds legitimizes the status quo. Speculative design, on the other hand, anticipates the future, helping society to understand what is to or might come and thus not only rethink the current status but also further down the road.

„We believe that by speculating more, at all levels of society, and exploring alternative scenarios, reality will become more malleable...“[6]

FIG. 2: Fiona Raby & Anthony Dunne

Examining different aspects of society, particularly spaces between the “here and now” and the “there and then”, is usually lead by a “what if?” question to stage the speculation and a following of various technological developments and social impacts.
What binds the “what if?” question together with the future, is that not only a future we might desire comes out as an ideal scenario but also a future in which society fails critically in different aspects, considering the new role of technology in that future society.
A focus on (consumer) needs is not presented, but design helps to shape ideas, propels thinking forward, raises awareness, provokes action, opens discussions and sometimes offers alternatives that are necessary in today’s world.
One of the genres, design fiction, has a long history of creating romantic escapes to far away worlds with characters the audiences can identify themselves. These fictional worlds are perfect sources of inspiration and furthermore can serve as a double function to explain their own economics and ultimately asking about our own values and expectations. All to help to rethink our future.
One of the pitfalls of science-fiction is often the reinstation of technological paradigms and reaffirmation of technological progress. Thus not asking questions or being critical of it.
Outcomes of these fictions, whether they are of utopian or dystopian nature, lay out a dialogue with the future and what it could be.

Speculation, at its most basic, can be viewed as an attitude or position (Hertzian tales) rather than a design methodology; hence the added „framework“ aspect in the case of speculative design.

Narration

Until now we declared a common set of vocabulary and genres, but to fully understand the frameworks intend we have to continue a bit further and look into the different means and methodologies that are inherited from the different genres and related fields of interest.
In speculative design it is possible for a designer to take up different methods of narration to realize a scenario, such as scientifical instruments, quantitative and qualitative methods for evaluation, fabricating narratives with the help of cinematography, writing screenplays or storyboards and even have to recourse to means from User Interaction Design such as A/B testing. There is no accurately defined limit; thus scenarios can unfold in many ways and turn out to be humorous, scary, confusing or startling. The scenarios are formed around our perception of the environment and how to shape it to open a common discourse.
Only then through the eyes of a serendipitous audience needs, desires and expectations may surface in an unexpected moment.

One may say it is one the framework's strongest points: Rising awareness or open the dialogue about a particular „something" that is going to emerge at one point in the future and the creation of an alternative to it.
This very well is a precise description of reading and predicting global trends, such as scientists can read from huge data-sets, except that most speculative designers don't have the enormous apparatus of academia, which includes not only fundings but also a team and infrastructure, behind them, like in the case of global warming or other geopolitical and even cosmical issues.
The framework instead works around the „What ifs?", complex issues of using new technologies boiled down to simple questions which unravel complex problems on different levels, when discussed.
Due to the discussion, an alternative arises in which new technology, its technological forthbringing and development, is being questioned of its status quo.
From the viewpoints of these imaginary futures and their counterparts, the alternatives, we live in the past, the current present, that has been already mingled with. The audience sees a deep connection between these two points in time. This connection is a relation, around which the scenario should unfold. Many of the vast implications of misusage of new technology in the dark world of *Black Mirror* [7] revolves around relationships of all kinds and is one, if not the main core drive of the series. Further inspection gives us obvious clues that great stories also equal great relationships. As soon as the audience connects, relates and invests into a believable/plausible relationship, more than half of the work is already done. That's why designing speculative fictions around objects seem at first glance very intriguing but is counter-productive since it would slip into the same technological hole it wanted to escape in the first place.
The design of the plausible part is the job of the designer and the whole inventory which is at hands for the scenario at any time: Building prototypes with or without functions, technical and scientifical diagrams and blueprints, documentaries or mockumentaries, products, instructions, fashion, and whole apparatuses.
The so-called "diegetic prototypes"[8] originate in cinematography where they exist as fictional but entirely functional objects whereas in speculative scenarios they serve to create the suspension of disbelief about change.
So much goes into the plausible part to visualize a concept ending on a question: What if „this" relationship is real?
The power of imagination then leads the invested audience to personal interpretation.

Nostalgia

As pointed out before, speculative design by itself is a movement directed towards the future, trying to take as many aspects for a scenario into account and wrap it up in fiction. Another concept or genre as an addition to speculative design, which will be introduced this way, is the retrospeculation. Retrospeculative design conclusively takes the past, even though it is considered in the lineage the space which is preoccupied with traditional design and, into consideration and acts as a mirror to the future.

Formally depicted, everything in the past, before the now, is either described as status quo or a traditional way of doing things. The retrospeculation slips into a different past: It takes by now „traditional“ and „established“ facts, things and relationships and remixes them with the help of other genres, for example, design fiction, to create an alternative version of the past mostly surrounding a nostalgia of a better past, to falsely lure the audience into investing into a world they think they already know. It is the traditional „hook, line and sinker“ scenario, where the audience is not only caught by investing into a well-crafted situation but also allegedly true and just slightly manipulated facts about the past. At one point the audience might question the plausibility of the past itself: Are all of the facts in the scenario true? Is the audience's level of knowledge up to par with the scenario? Where is all of this leading?

Ultimately the outcome of the retrospeculation is then to connect to the normal lineage of time and finally arrive here again and act as if nothing has happened. The audience might have traveled through time and found out something new, something they might not have thought about in the past and might re-think about changing for the upcoming time and future from an even earlier point in time, then what the framework could've given it before.

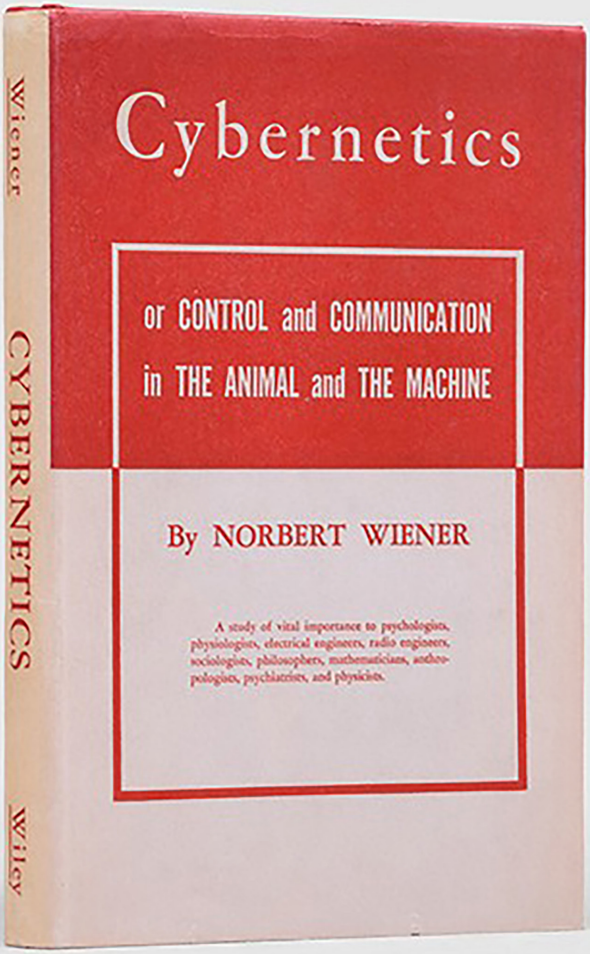


FIG. 3: First Edition of "Cybernetics"

Regarding Cybernetics

„Cybernetics is the science of control and communication in complex electronic systems – whether machines or the human nervous system.“[1]

Norbert Wiener, Warren Sturgis McCulloch, Arturo Rosenblueth, William Ross Ashby, Alan Turing and William Grey Walter are considered to have resolutely established cybernetics as a discipline. Sometime later, in the year 1948 Norbert Wiener, an American mathematician published the book *Cybernetics: or control and communication in the animal and the machine*, which marked the birth of an independent science and popularized the field.

Wiener references in his book to a publication by the British physicist James C. Maxwell from the year 1868:

„A Governor is a part of a machine by means of which the velocity of the machine is kept nearly uniform, notwithstanding variations in the driving-power or the resistance.“[2]

FIG. 4: J. C. Maxwell

While Maxwell is talking about the governor, a centrifugal feedback valve for controlling the velocity of an engine, Wiener points out that the term *to govern* is firmly tied to cybernetics and the ancient Greek word 'cybernetes': steersman or governor.
However, even before Wiener or Maxwell thought about using the term, French physicist André-Marie Ampère already suggested the following in 1834:

„The future science of government should be called ‘cybernetics’ (‘la cybernetique’).“[3]

With all this back referencing, one might ask: Was there always some unspoken truth out there, that some bright people re-discover from time to time or is there some inherent and natural truth to this discipline?

Cybernetics revolves around insights on self-regulating systems, structures, boundaries and the interaction of goals, predictions, actions, feedback, and response in these systems. During its years of establishing as an independent science, it was mainly driven by military research, such as calculating trajectory lines of rockets to deflect, use of radar antennae, maneuvering simple robots or designing electrical circuits. At its core, the term stands for having a goal and means to achieve that goal. Knowing if a goal is in reach or not, a cybernetical system needs

a feedback mechanism. In most generic systems a sensorial input takes care of this. This also lays out the foundation for the cybernetics in its first iteration after Wiener et al., where cybernetics connects control and communication with the intent to get insights into observed systems. Whereas control is the mere hope of achieving a set-goal and communication is what is happening inside of the observed system.
According to Wiener's observations, not only artificial systems but also biological systems run on cybernetical principles. Hence the "animals" in the sub-title of his book. When traced back to the origins of the idea, we end up with a fantastic view of the world, where the environment is an always state of equilibrium: Balance of nature.
The theory proposes that all ecological systems are in a state of homeostasis, an optimal state of function of a system, may that be a functional organic body or even a cell. Small changes within a balanced system are "caught" and corrected automatically by negative feedback (control or balancing feedback).

In his TV series documentary *All Watched Over by Machines of Loving Grace*, Adam Curtis is in pursuit of that concept and comes up with a conclusion:

> "In the 1960s, an idea penetrated deep into the public imagination that nature is a self-regulating ecosystem, there is a natural order, [...]The trouble is, it's not true – as many ecologists have shown, nature is never stable, it's always changing."[4]

This, however, was not news to cyberneticians of the first hour and a smaller core was formed around the concept of "observing systems" from the inside – or as the founder of the movement, Gordon Pask, called it "conversation". This movement was strengthened even more, since, in the years after his first publication in the field, Wiener wrote another book 'The Human Use of Human Beings', which deals with how cybernetics could benefit society by cooperating with machines and elevating society to higher levels, by giving lower-level tasks to machines.
According to Pask, later on, joined by Heinz von Förster and Margaret Mead, this new movement, the second order Cybernetics or also known as Cybernetics of Cybernetics or New Cybernetics, had to look at itself. The second order deals with applying critique of Cybernetics to Cybernetics, hence observing systems of Cybernetics from within and finding conversation. This conversation can only happen if the experimenter actively participates in the experiment: Tweaking parameters, tuning the design and managing an outcome. Until here, in its first iteration Cybernetics would have to deal with a magical Black Box, which would correct short-comings of the experimenter in a homeostatic way. Second order cyberneticians would disagree with having a Black Box: They would rather unbox it, act on the inside and live-adjust its inner-livings.

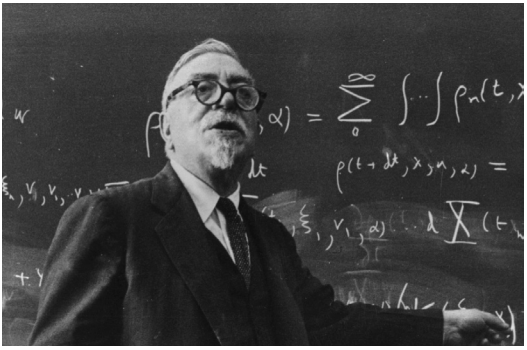


FIG. 5: Norbert Wiener

This concept was more close to real-science, since, in a scientific experiment, experimenters not only put down all of the needed elements for an experiment in a precise way but also take in more of the environment into consideration: Is it too hot; too cold. Will something else interfere with the experiment? An experimenter, or better known as an observer of a system before, is now deeply involved in a circularity of a system, becoming a part of it in action. With this mindset, second order cyberneticians would then go on to discuss the nature of Cybernetics.
In 1968, the American Society for Cybernetics was formed and held a symposium during the American Association for the Advancement of Science meeting. In her keynote paper "Cybernetics of Cybernetics", Margaret Mead lays out

> Cybernetics as a way of looking at things and as a language for expressing what one sees.[5]

Renewal and progression from first to second order cybernetics was completed for the group in 1976.

Right after this, Cybernetics peaked as a stand-alone field and dispersed and seeped into tangential fields of science with the new core principle of the second-order: Cybernetics as an applied epistemology. Language and society are subjects of cybernetical research; "it is we who observe"[6].
Other science branches and social and ecological systems now could be rethought under the premise of including the observer into descriptions, while simultaneously taking feedback, goals, and information into consideration. Scientists of psychology, sociology, anthropology, psychology, philosophy, architecture, biology and many more would take upon cybernetical methods and include them in their research.
Even before this field dispersed, Cybernetics reached designers, artists and other creative thinkers.

FIG. 6: Margaret Mead

FIG. 7: Heinz von Foerster

In 1968, British art critic, curator, and writer Jasia Reichardt curated the exhibition "Cybernetic Serendipity", which was shown at the Institute of Contemporary Arts in London and later on also toured in the United States of America.
Serendipity, as described by the catalog is "...the faculty of making happy chance discoveries" and not only describes what second-order Cybernetics is, but also that randomness is sometimes crucial to exploration and an integral part of the exhibition.
By itself, the exhibition was the first of its kind with historical value. It had Cybernetics explicitly as a common denominator for all participants: artists, engineers, scientists, musicians, mathematicians and poets. There were cybernetic devices on display, that would showcase algorithms in creative ways, such as making music, as also explaining the working of the algorithms. Other devices were in the category of computer projects and even some would invite viewers to participate and interact with the exhibits. It was indeed an expression of the exploration of relationships between creativity and technology.
Jasia Reichardt says in her introductory words to the Cybernetic Serendipity catalog:

> "Cybernetic devices can convert sound into light patterns. Machines can produce amazingly complex drawings, choreograph dances, or make films. Programed to make combinations of words grouped by sound or sense, computers write surprisingly intense poems."[7]

This is, in a way, an almost universal and still valid description of what is happening within the creative use of such cybernetical devices.

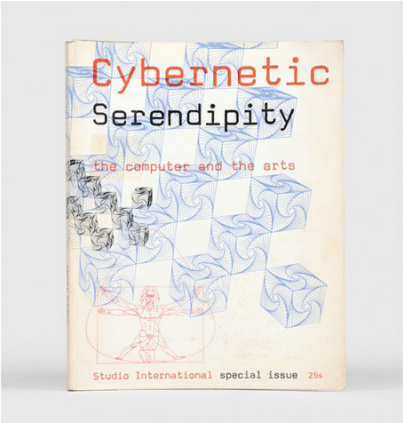


FIG. 8: Exhibition catalogue

If we look past the ways how cyberneticians look at Cybernetics, there are a couple of essential core principles, ideas and topics deeply routed within the field. Most essential and well known are the following:

Negative Feedback is the most common known idea of cybernetics, where an outside influence introduces a disturbance to a system. The system then auto-corrects it to reach a state of equilibrium and furthermore to reach its goal.
Example: Thermostat of a heater and adjusting the influx of warm water to the heater, when it is too cold.

Positive Feedback is the opposite and invites chaos to a homeostatic system. It can be described as an action A, which has a massive influence on an action B which in return again influences action A. This could go on infinitely.
Example: Microphone and a speaker feedback loop.

Self-regulation / Autoregulation is the ability of a system to learn and adapt functions to influences from the outside and regulate the balance. It is essential to most lifeforms and connected with their most vital organs.
Example: Heart regulating blood flow.

After this, we find a series of other core topics which all touch upon cybernetics and various other surround fields, including Homeostasis*, Steady State, Adaption / adaptive Regulation, Trigger + Control, Is and should be values, Receptor + Effektor, Self-organization, Autopoiesis (Neurobiologist Humberto Maturana / Biologist and Neuroscientist Francisco Varela) and Variety.

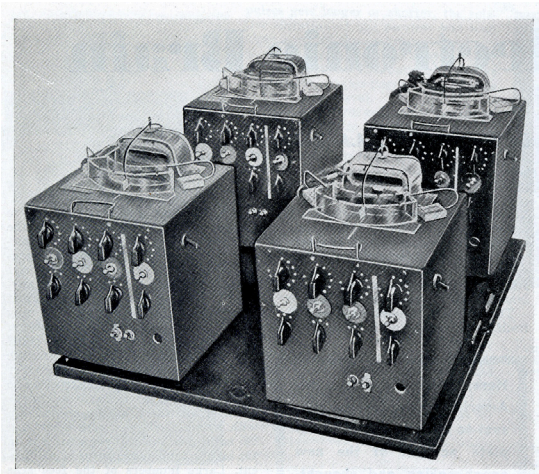


Fig. 1—The homeostat, with its four units, each one of which reacts on all the others.

FIG. 9: Ross Ashby built a 'homeostat', an adaptive ultrastable system with inputs, feedback, and magnetically driven, water-filled potentiometers

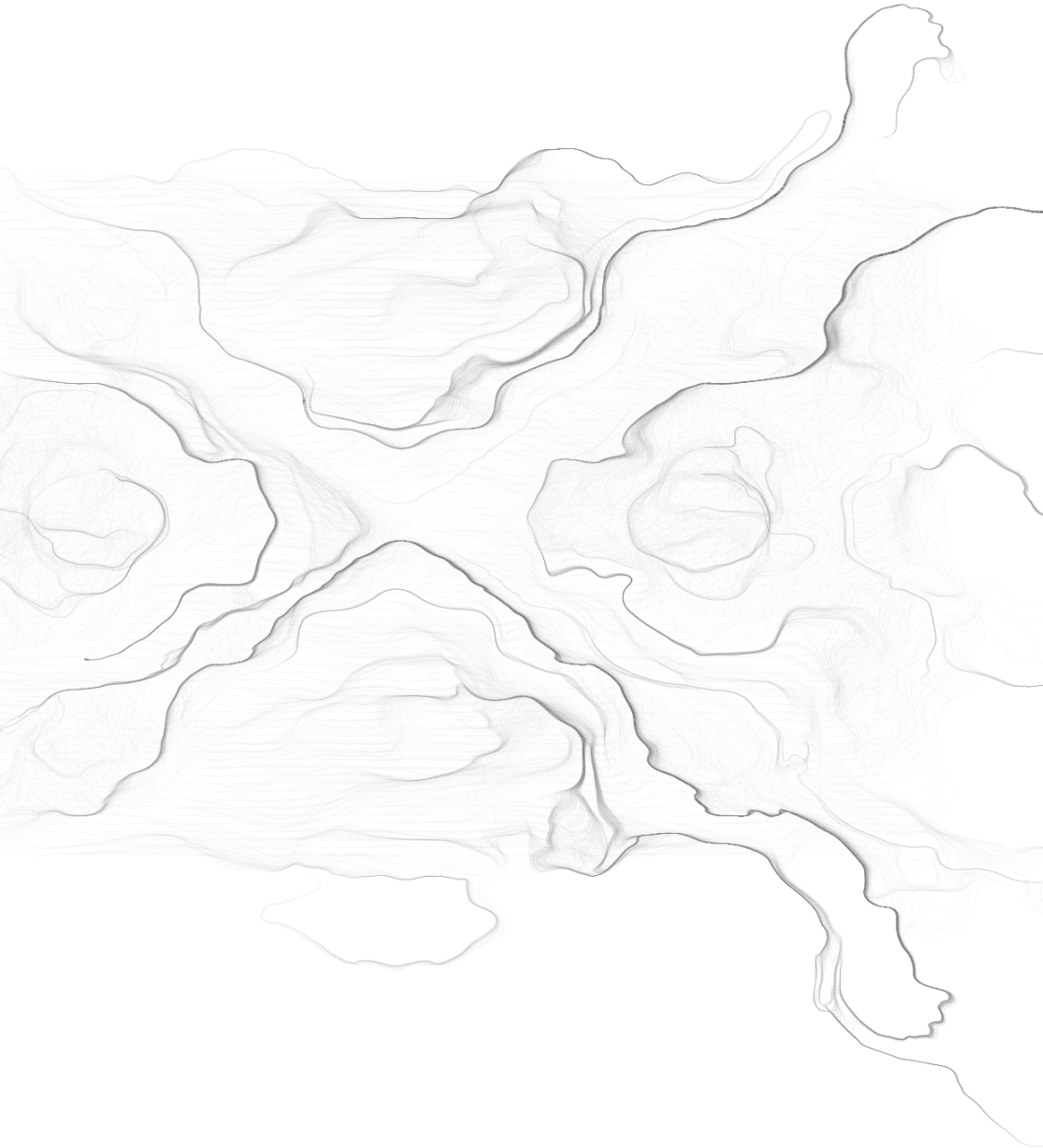


FIG. 10: Topography generated with a Processing sketch

Research Group

From object realities to nostalgia and naïvety in technology

Biotic Explorers is an experiment.
Biotic Explorers is an amalgamation between first-order and second-order cybernetics.
Biotic Explorers is a speculative design scenario.
Biotic Explorers is also a theory on recontextualization outcomes of a real scenario.
Biotic Explorers works through backward induction in time and tries to reason why certain things come to an inevitable outcome.
Biotic Explorers are scientists.
Biotic Explorers is an observed system.
Biotic Explorers are observing systems.

Experiments

My process on this thesis can be compared to staging a scenario, except that i was myself not aware of where it would lead to. Initially, the work was planned to be a technological research of a novel device for transmitting or relaying information. Inspiration stems from nature itself. Plants, trees and other growing things in forests are connected on the undersurface via common mycorrhizal networks and form communities. These mycorrhizal networks are formed by mycorrhizal fungi which stretch out their hyphae cords to form bonds between roots of plants of the same species and even more form complex rhizomatic structures. Within these communities, connected points of the forest can transfer water, carbon, nitrogen, and other nutrients and minerals to weaker individuals. Stronger individuals in sunny and optimal places are willing to share their portion of nutrients, food and other information with weaker individuals in shades and sub-optimal places. Spreading resources with a robust altruistic method may help to grow the population. Moreover, certain species even developed methods to alarm other individuals of attackers, such as bugs or parasites. Precautions can then be met. In the case of some plants, their fruits or leaves will be covered in some liquid that deflects the attackers.
Based on this network theory of forests, I wanted to set out and create a mechanism that would willingly interact and communicate with and through the given structure. After some discussions and research, I settled on altering the liquid household of the mycorrhizal networks by either adding a more acidic or alkaline liquid. This would change the pH-value of the network. When measured against a base value, for example, a base value would be pH value 6, changing this value by adding more alkaline liquid and driving up the value to 8 would then represent an electronic HIGH – or a 1 in binary. The network absorbs the excess fluids and sinks them in another part, especially where there are capacities. This would lead automatically through normalization of the pH value and is in no way harmful, as long as it is done in a controlled manner. A faster way to normalize values is by adding acidic liquids back, which is chemically known as neutralization. Adding together an acidic (pH value 4) and alkaline (ph Value 6) liquid gives theoretically a result of liquid with a value of pH value 5. Theoretically, as long as the liquid does not interact with each other in myriads of other ways. However, this can be seen as nothing more than a mathematical function or a technological proposal.

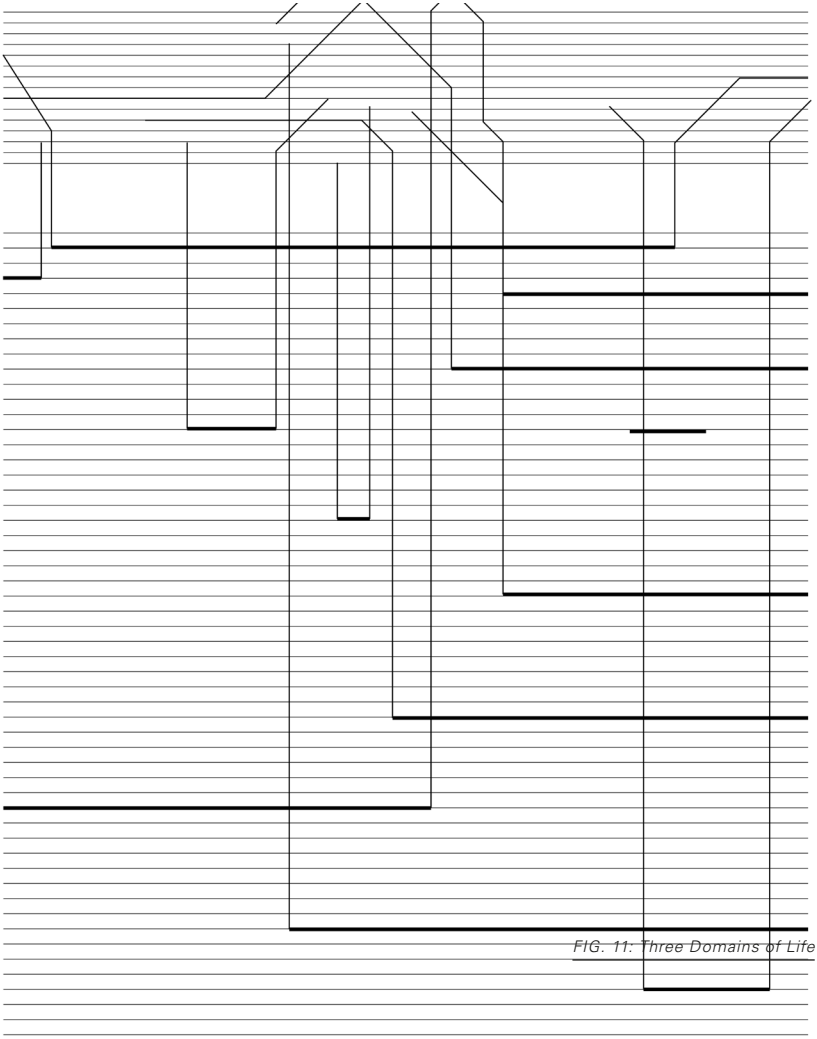


FIG. 11: Three Domains of Life

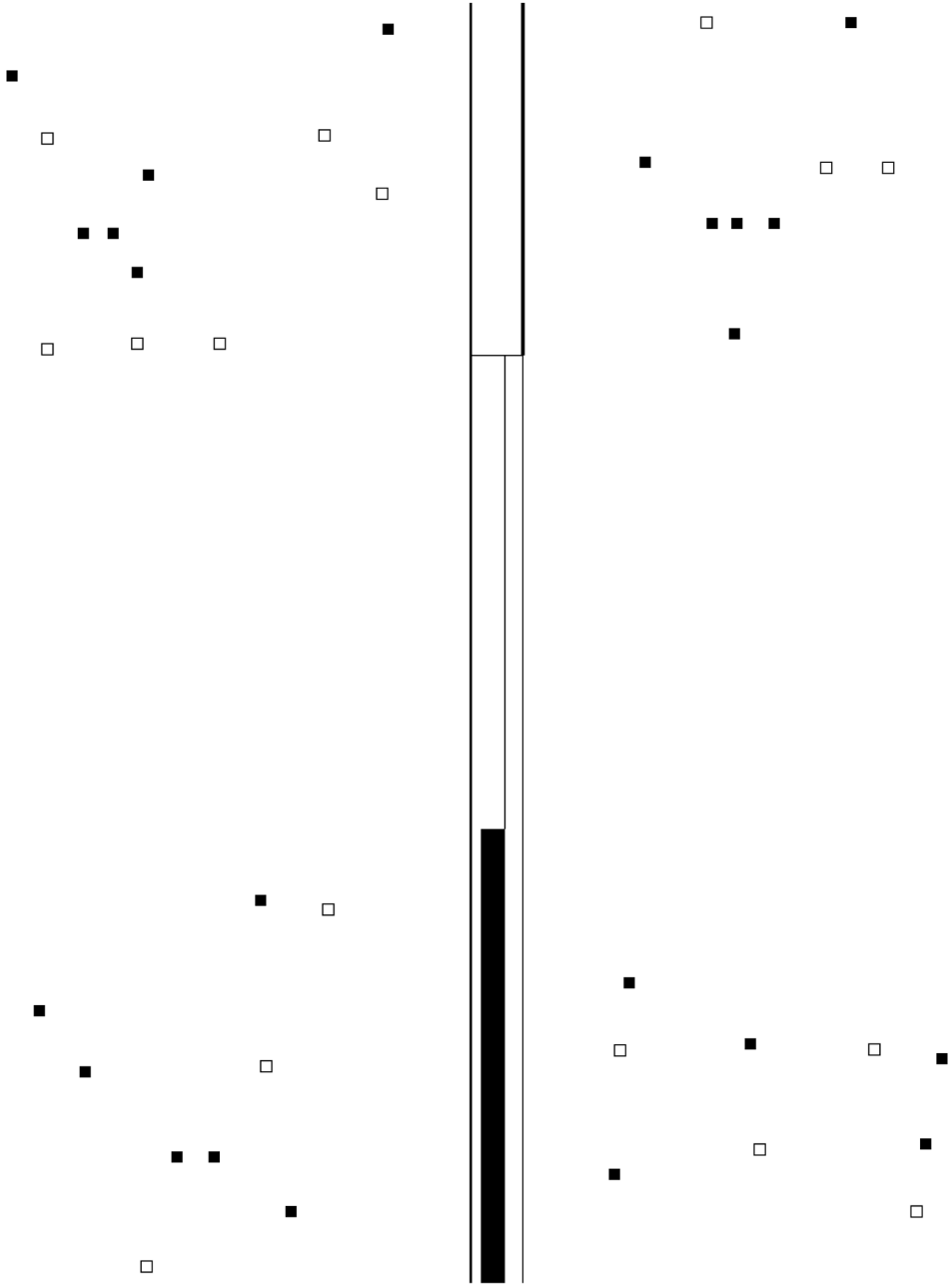


FIG. 12: Abstract visualization of pH probe results

Only later, through consultation and some change of heart, I noticed that the scope of the work was more framework information. Having worked with speculative scenarios in the past, I could imagine different directions where the project would lead to, but a vocabulary and even more a narrative was lacking. Through the works of Norbert Wiener, Anthony Dunne and Fiona Raby and the Cybernetic Serendipity movement, I could summon up a new vocabulary and thus a whole fundus of fiction came to fruition. Ideas would come alive organically and make their way, come together and form an amalgamation of speculative design and cybernetics as a *science* fiction scenario.

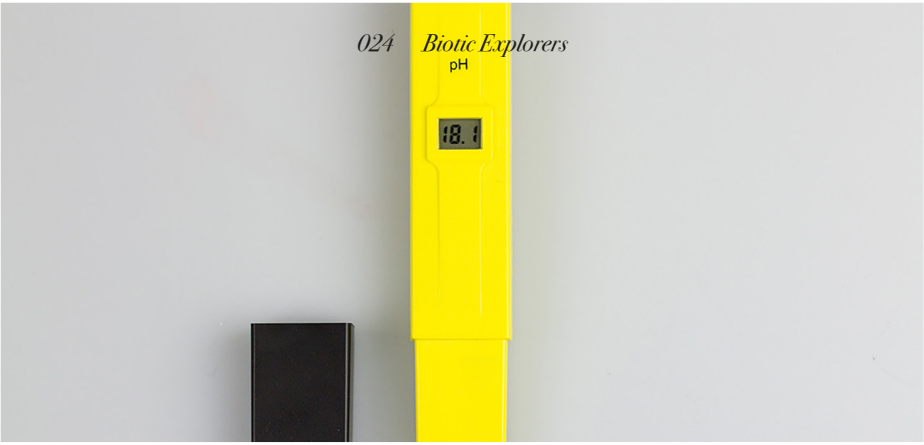
From the very beginning, I selected the sub-title "Narrative Explorations with Eukaryotic Systems". This was done deliberately since I wanted to explore the narrative side of a) media art piece of my own and b) wanted to stay within the fields of biology and especially living systems. Eukaryotic systems and especially Eukaryota is the categorization of are all living beings, where on cells have a nucleus with a membrane protecting it. Everyone you know and have ever interacted with is, consequently, an Eukarya.*

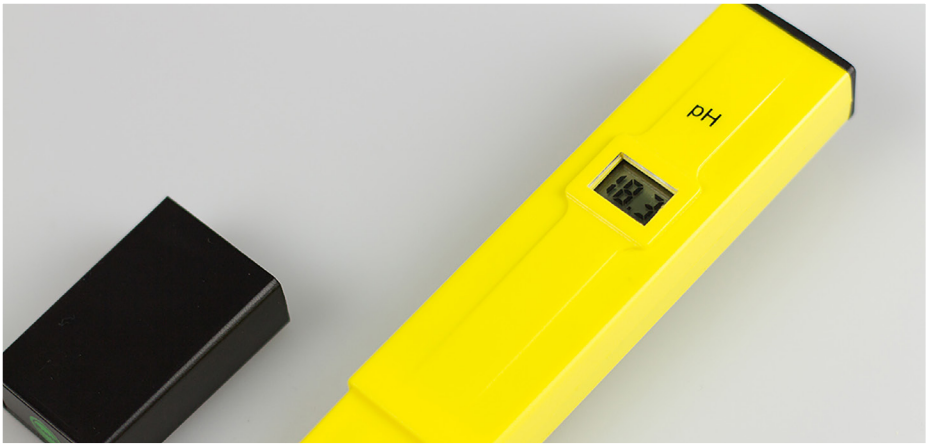
* Unless you are friends with Bacteria

At first glance, Speculative Design and Cybernetics seemed like two fields that have not much in common. Still i thought it would be interesting trying to bring them closer to each other. Only later I saw, that they had more in common:
Both came from a time of metamorphosis and improvement in their respective fields: Radical period and Cybernetics during the war. Furthermore, in their iterations they tried to steer outside of their fields, establishing more of a common denominator for those that are regularly using it. Lastly, they rather describe methods and functions and concepts, which are supposed to interact and seep into other fields.
Building a narration for this work and the sub-title with a focus on forest communication, from previous experiments, was inherently a manageable task. Following the progress until I reached the goal was the more exciting part now — in a rather cybernetical way.

The new scope of the work encompasses the development of a novel communication apparatus and the background story of the device. World-building for the validation of the apparatus has to be done as well. Thus the creation of a scenario has to be incorporated into the scope.
With these new goals as outlines of the work, I tried to work in parallel on different ends.

With the communication device, at first, I wanted to have an input terminal. Some place to invite viewers to participate and turn them into active observers, so I was





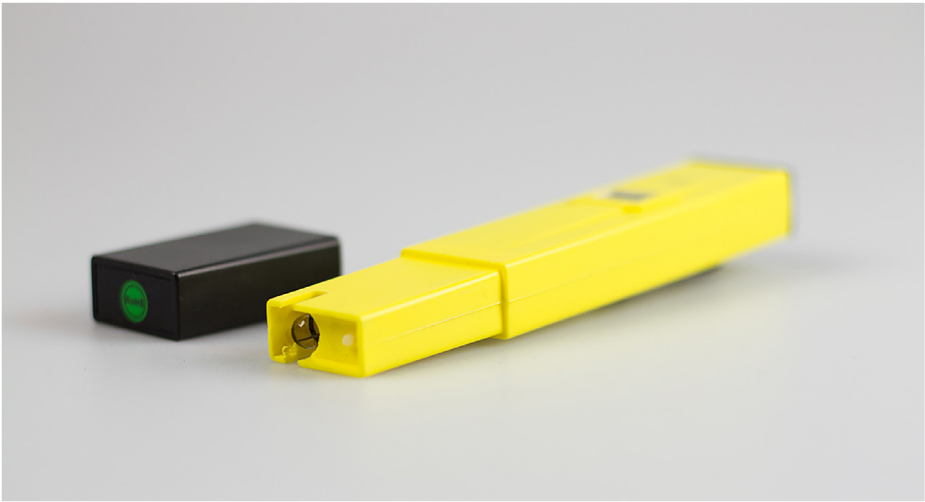


FIG. 13 – 15: Cheap pH sensor

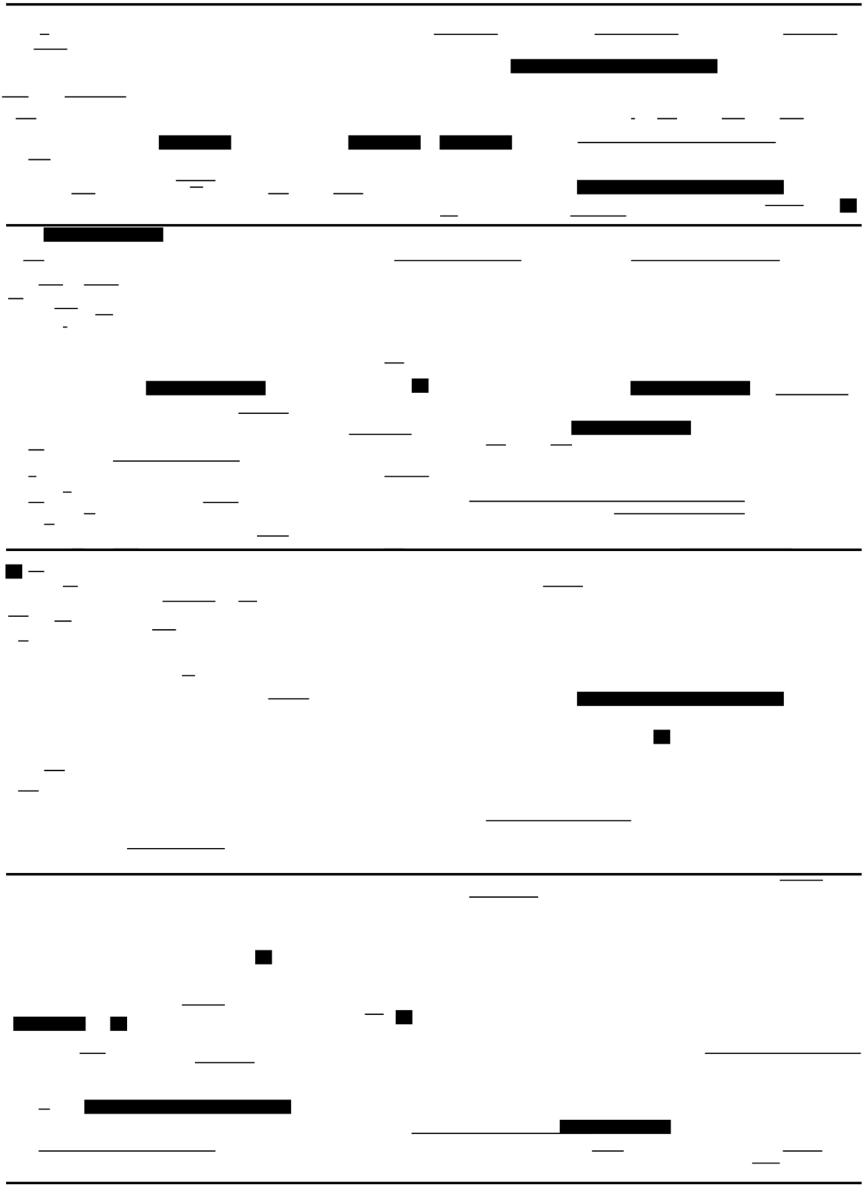
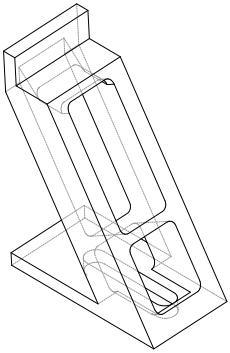


FIG. 16: Visualization of a transmission of bits in a soil network

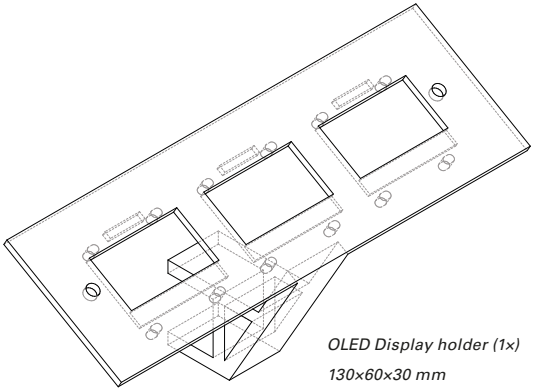
Assortment of 3D printed PLA parts

Isometric views of CAD parts



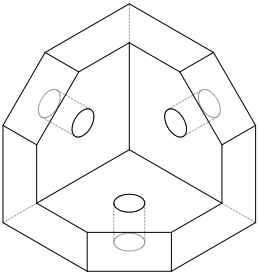
Tank holder (16x)

26x52x70mm



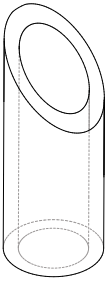
OLED Display holder (1x)

130x60x30 mm



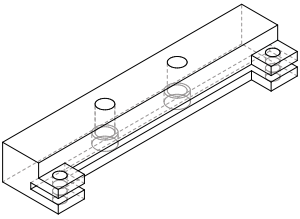
Three sided edge holder (4x)

30x30x30 mm



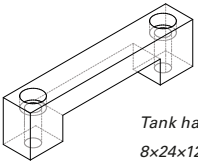
Nozzle (4x)

6x16x6 mm

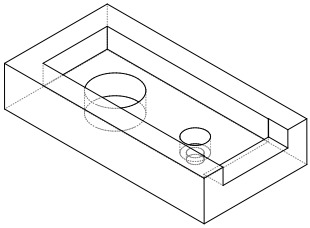


Holder for Printed Circuit Board (2x)

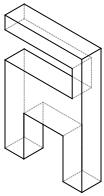
17x73x10.5 mm



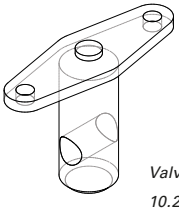
Tank handle (4x)
8x24x12 mm



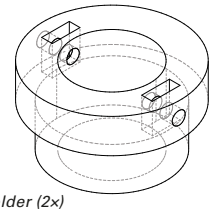
Servo motor holder (8x)
26x50.5x10 mm



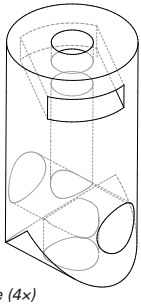
Corian plate holder (8x)
5x20x30 mm



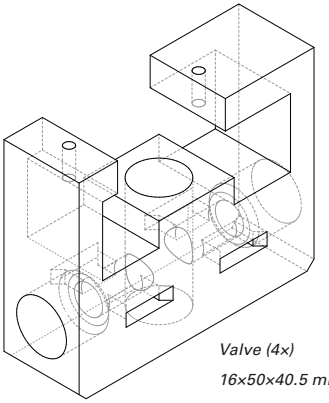
Valve shutter (4x)
10.2x26x10.2 mm



pH Probe holder (2x)
25x15x25 mm



Tube guide (4x)
10x19.5x10 mm

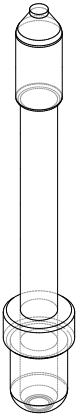


Valve (4x)
16x50x40.5 mm

FIG. 22: Tank handle
FIG. 23: Servo motor holder
FIG. 24: Corian plate holder
FIG. 25: Valve shutter
FIG. 26: pH Probe holder
FIG. 27: Tube guide
FIG. 28: Valve

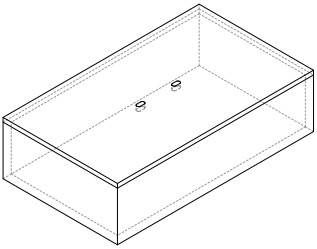
Assortment of higher level objects: constructed, ready-made or assembled

Isometric views of CAD parts



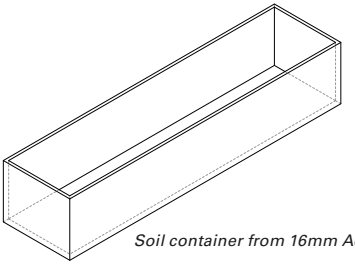
pH-Probe with BNC Connector (2x)

23×155×23 mm



Tank from Acrylic Glass, 3mm thickness (4x)

112×192×52 mm



Soil container from 16mm Acrylic Glass (1x)

25×102×20 cm

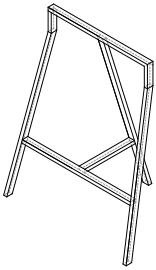
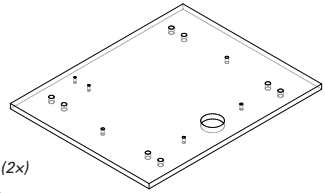


Table legs from IKEA (2x)

60×70×39 cm



Corian Plate (2x)

205×255×6.7 mm

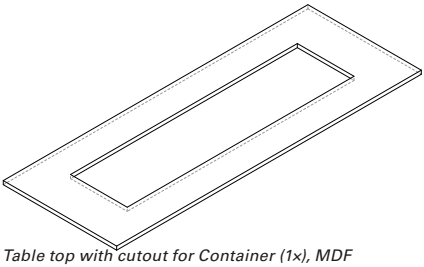
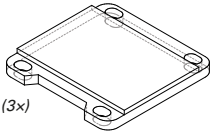


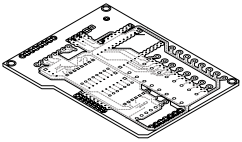
Table top with cutout for Container (1x), MDF

51×137×0,16 cm



OLED 128x64 Pixel Display (3x)

27.3×27.3×3 mm



Printed circuit board (2x), FR4 1.6mm

70.7×92×1.6 mm

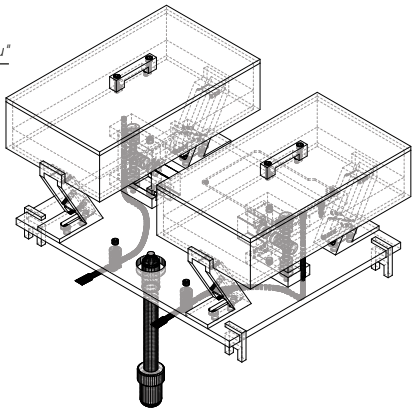


FIG. 37: Fully assembled "plateau"

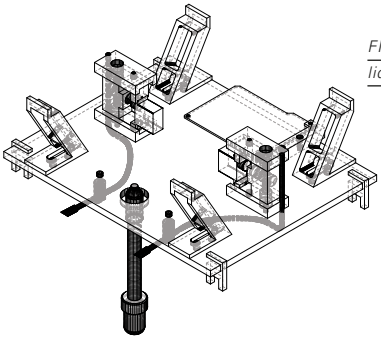


FIG. 38: "Plateau" without the liquid tanks

FIG. 39: "Plateau" flipped upside down

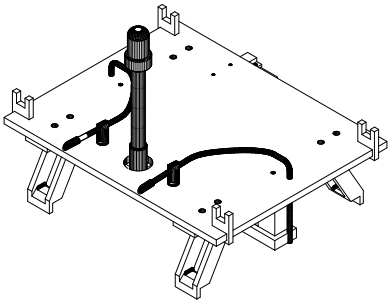
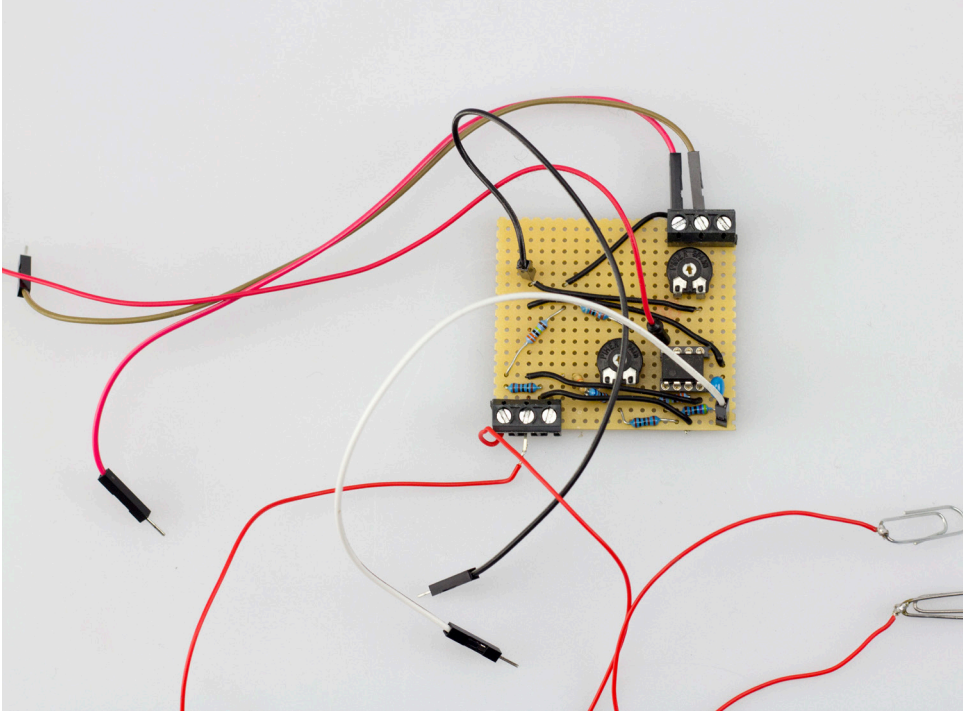


FIG. 40: Prototype of a galvanic sensor utilizing a wheatstone bridge circuit per Guto Nobrega's instructions



searching for ways of interaction between humans and plants. In my research, I quickly landed at capacitive sensors, which are acting upon the touch of a human and are generally understood. I deconstructed the history of capacitive sensors quite quickly. A galvanic skin sensor is an optimal choice for human skin interaction. When I stumbled upon the work of Guto Nobrega, I immediately reached out to him. Luckily, he was kind enough to listen to my proposal and provided me with an electrical design on how to design my own leaf-sensing galvanic sensor, which was utilizing a Wheatstone bridge[1]. The Wheatstone bridge was invented in 1833 and is an electrical circuit to measure an unknown electrical circuit. With proper programming, I would end up with a negative feedback, which could tell if a human has touched a plant or not. After initial testing, I found the results one-sided: The whole plant would detect the presence of someone touching it, no matter where it was touched: stem/leaves, soil. The signal would always give out a digital high.
The work of Leslie Garcia, "Puls(um) Plantae"[2] sounded at first like an elaborated and well-evolved version of Nobrega's circuit. After testing out the circuit by itself and examining its qualities, I found out that it felt different because it was doing some trickery in the Node-based programming environment Pure Data. Working with Pure Data would require a whole dedicated PC for the work and some live fine-tuning by a human, which would result in more of a performance than an installation piece. After much consideration, I decided that this was not the direction I wanted to go into. Another side-effect of using the galvanic sensors was that the plant was constantly under "voltage" and would wither quite rapid after just some time. Death by electrocution, so to say.
As time went by and I tried to get out the best results from both of these circuits, I stumbled upon a project by Berlin-based studio TheGreenEyl in collaboration with Studio NAND called "Botanicus interacticus"[3+4] for the Disney research lab. An orchid is able to sense touch gesture of a human on various parts of the plant. Disney research lab developed a sensor technology they call "Touché: Touch and Gesture Sensing for the Real World. Disney researchers used a Direct Digital Synthesizer IC to generate pure sine wave signals. It is in a way different than the galvanic skin sensor, since it does not put the voltage on a plant but instead sweeps a specific bitstream at various clock speeds over the plant. If a person is now touching the plant, some of the electrical impulses sent out by the touché sensor will be absorbed by the mass of a human body. Whatever is left of the bitstream is then up for the sensor to determine not only if a person has touched the plant, but also in which place and with how many fingers.
TheGreenEyl and Studio NAND visualized these interactions with streams of particles going off an orchid in real-time. A screen behind a spy mirror made it seem as if the particles were coming from a seemingly digital layer behind the plant.
Since I could not get my hands on a real touché[5] sensor, I found a DIY cheap Arduino

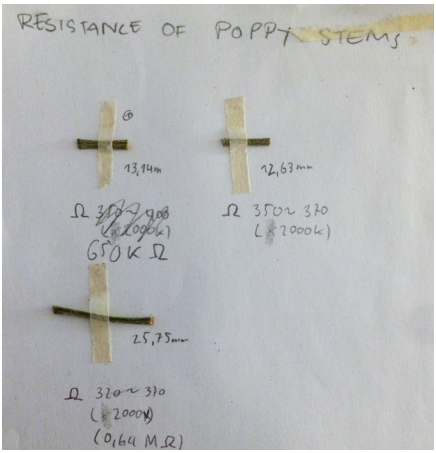


FIG. 41: Collected samples from poppy stems and their measured electrical resistances

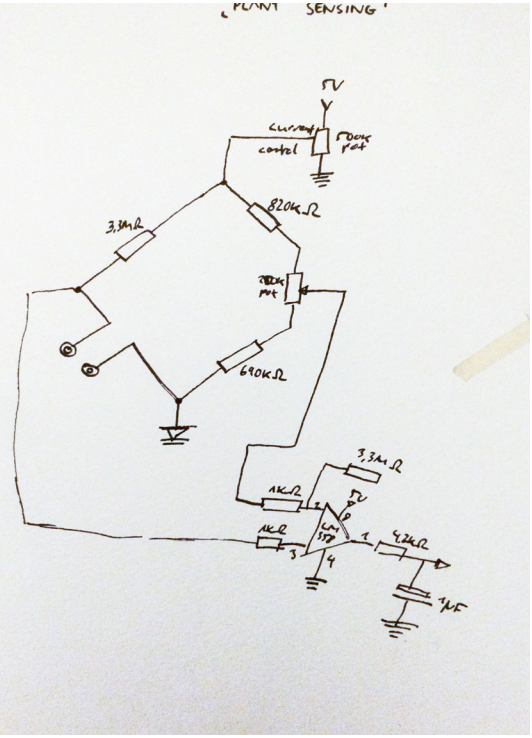


FIG. 42: Galvanic sensor schematics

version. All in all, I had no problem with the DIY touché sensor: It worked astonishingly well and could detect all kinds of gestures if trained enough. In my personal opinion, I think it would be better to find a use case where a predictive model takes care of the gesture recognition part. For this particular work, I ended up gaining nothing from all of these experiments except for some anecdotes, which I would incorporate later in the written part of the work.

Another part I was planning around in the first hours of this work was an output device. I stumbled upon a very cool and elegant looking Flipdot Display. Flipdots are electromagnet magnetic display. To flip a "Dot", the coils underneath it have to be magnetized for a certain amount of time. The Dot will stay in the flipped position, even when there is no current flowing, which makes a Flipdot Display also a "memory". There are more qualities than just low power consumption. Displays of this kind are of high contrast and work in almost all light setups. When a disc is flipped, another quality reveals itself momentarily: Sound. One can hear the display when it switches dots.
I was deeply fascinated and enchanted by this device, but only one thing was stopping me from using it: Its electric circuit.
Since the technology is rather old, Flipdots were all the fun back in the 1970s through 1980s, and only slowly came back into fashion, there were not enough resources out there to put together a working example fast.
In my first attempt I got in contact with someone, who would ensure me with some help and hints, but then left me on my own. These were some frustrating weeks since in case I messed up somewhere along my electronics I could say goodbye to either the controlling chip, which is one kind of a rare Integrated Circuit, or the whole display at all.
Painstakingly I mapped shift-registers to voltage regulators on couple boards. When I tried to use my "hand-made" solution it luckily only burnt the voltage regulators and resulted in a small cloud of magic smoke. I assumed that I plugged some Dupont-cable into the wrong pin "somewhere", even though I checked the whole board 20-times and went over every pin again and again.
Next, I converted my drawings and findings into a printed circuit board. This solution which was then fabricated in China.
I was reasonably sure that this board had no flaws since I checked all tracks digitally in the electronic design automatic of my choice: KiCAD.

FIG. 43: Studio NAND with Studio TheGreenEyl: "Botanicus Interacticus"

FIG. 44: Fabricated version of a Flipdot controlling PCB

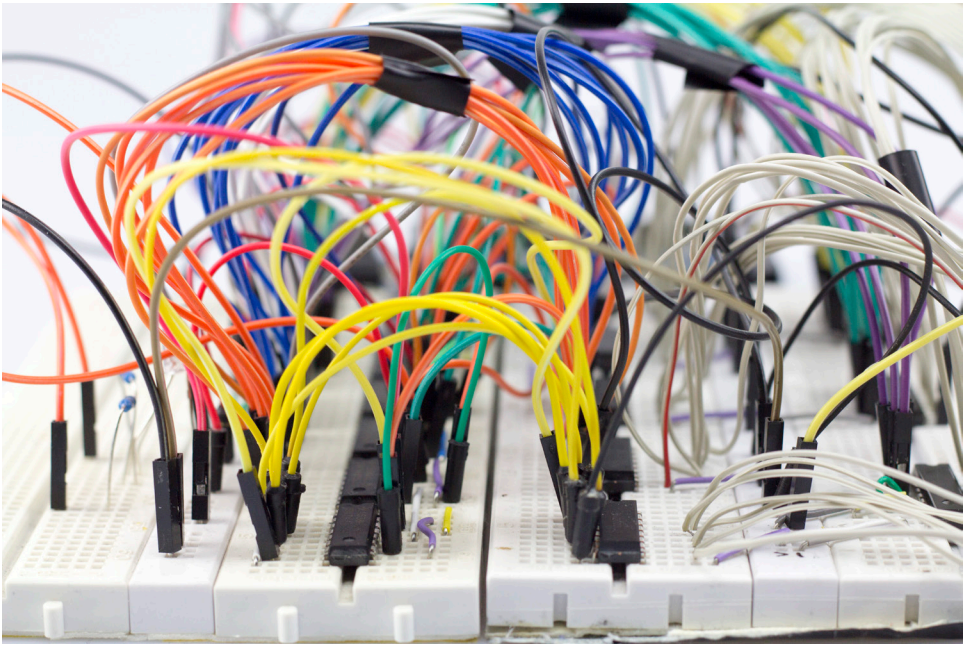


FIG. 45: On attempting a dupont-jumper-cable-flipdot-PCB-layout-prototype on a breadboard

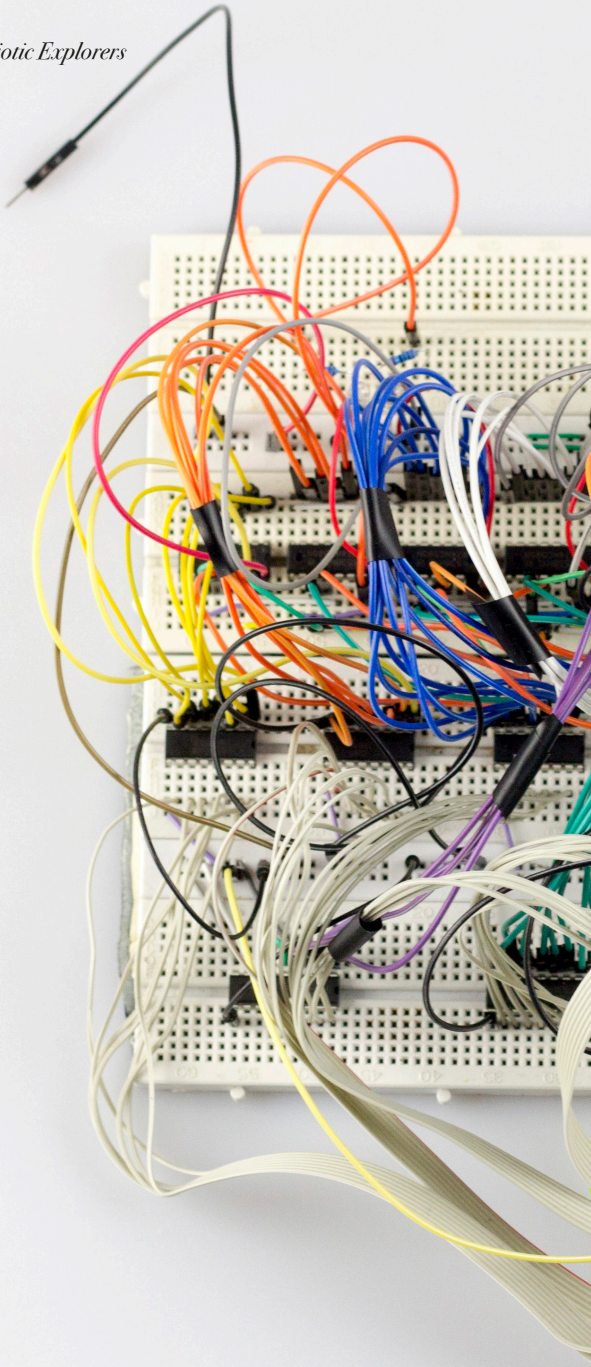
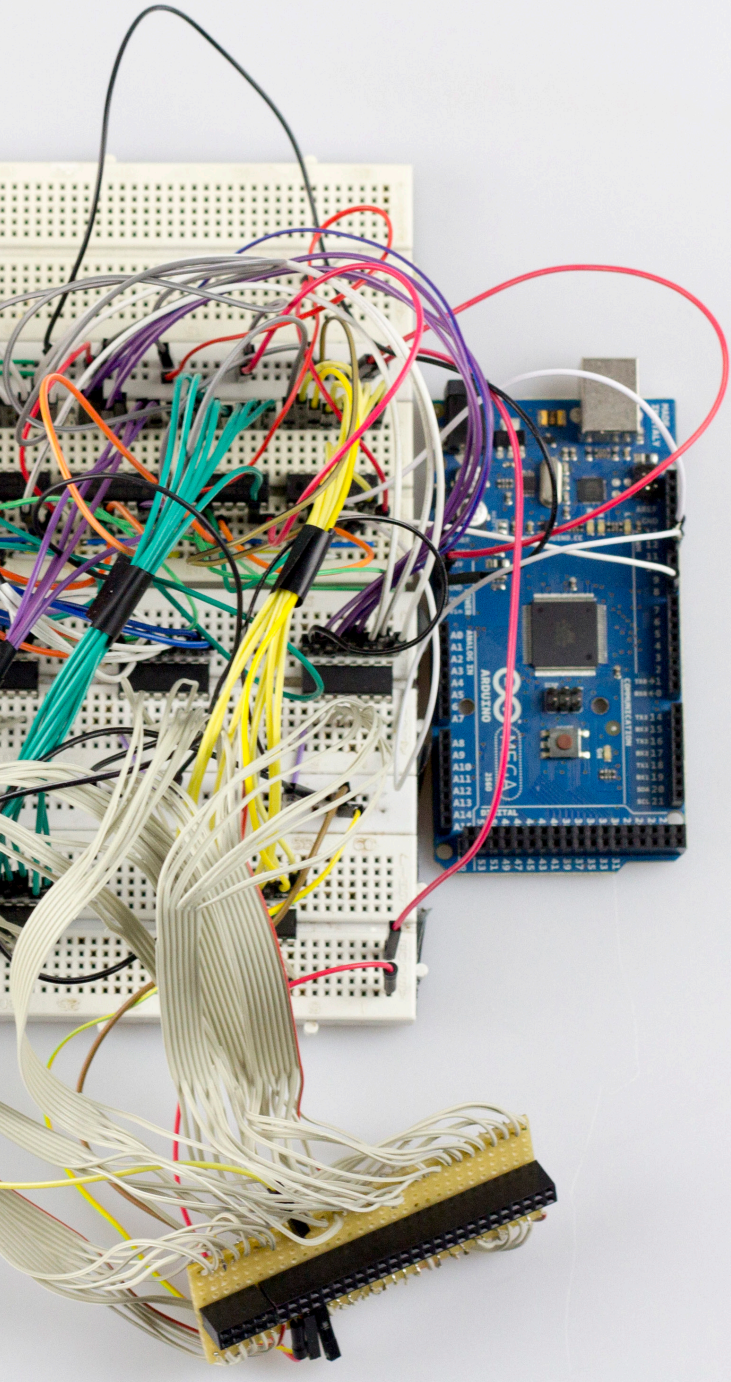


FIG. 46: Within these circuits lies a certain horror: excitement mixed with the fear of a short-circuit


ARDUINO
MEGA
ANALOG IN
DIGITAL
POWER

When the boards arrived, I carefully soldered them together and was once again greeted by magic smoke.
At this point, time was already running out and I had to make a choice: Go on and trying to figure out how to make the displays run or go for a cheaper solution.
In the end, I went for a cheaper solution: OLED displays, since they could be connected quite quickly, driven by an I2C protocol and can also be obtained in more significant numbers from Chinese sellers on the internet.

Only weeks after I settled for OLED displays and was already trying them out, my first contact for the Flipdots came alive again and told me that somewhere in my circuit there was indeed a deep flaw. After checking once again, I ended up gaining nothing, except a name for an anecdote.

Last stop on the technological research was a liquid dispensing mechanism and a moderately novel sensor. There are pH sensors, but since there are demand is low with hobbyists sensor producers such as Adafruit, seeed, Grove, Sparkfun, ITEAD and many more didn't feel to develop cheaper versions of it. A commercial ph sensor would cost around 150-200€ and I would not need just one.
So I ordered a cheap Chinese version and tried to find a different way. It turned out it is way much more straightforward to bypass the onboard chip with the black glue, which is an epoxy resin trying to shield off the EEPROM of the electronic board, on top of it and just read out all the numbers from the display into a shift register. I learned, that sometimes it is worthwhile to find new routes and gained a working and moderately cheap pH value sensor clocking in at about 11-12€ — of course depending on the seller.
The liquid dispensing mechanism was more of trying out how much water pressure is needed to have a servomechanism opening/closing, or rather twisting, a clear plastic tube. There are indeed different ways how to do this more elegantly, but at the time it was the best solution that came to me since it could also hold a load of water even when the current was off.

FIG. 47: OLED Display holder front (first iteration)

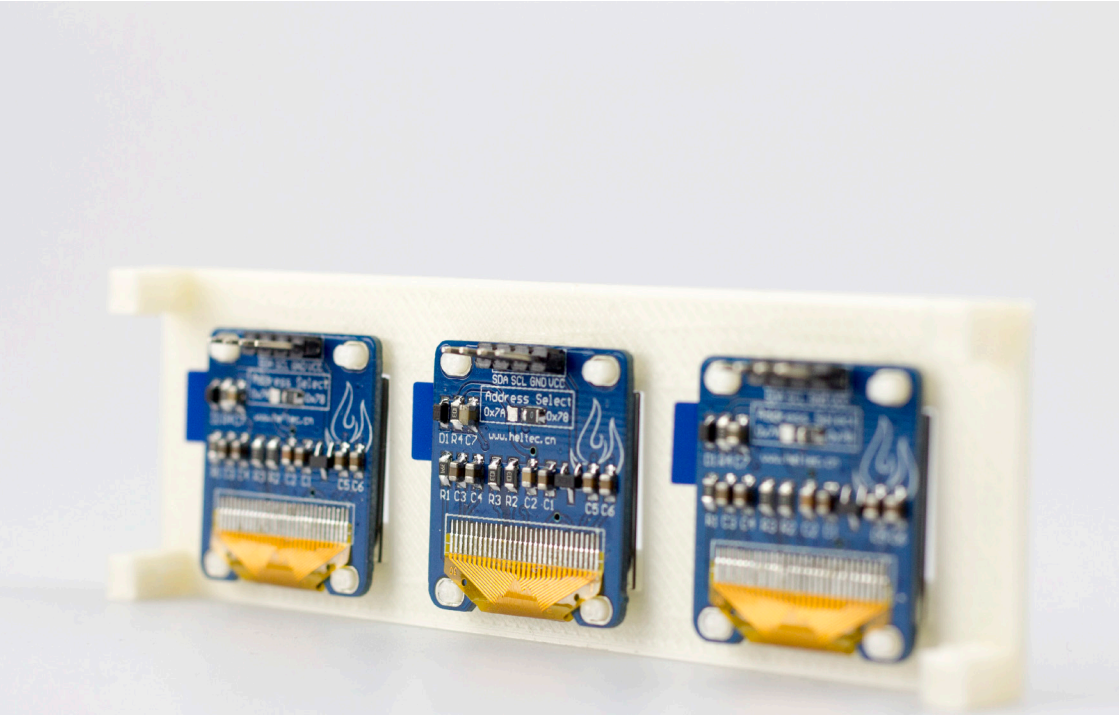


FIG. 48: OLED Display holder back (first iteration)

New cybernetics

The technical research and experimentation were some bits and pieces I wanted to pick up along the way. There was still one major developing point and that was the rationale of the work: World-building and making things seem plausible.
In order to justify the communication apparatus with mycelium, I wanted to have a world that anyone can be comfortably familiar with and that is worthwhile for an audience to invest his or her time into.
I felt no need to create a contemporary or even future piece since the technological development right now is at an all-time high.
The double exponential growth[6] of humanity through technology is according to Ray Kurzweil[7], futurist and thinker, a curve we can barely keep up with. I wanted to ground the narrative on on the base of nostalgia.
As someone who grew up in the 90s, there is much nostalgia involved in that past: Flashing lights, weird music and the cold-war.*
As a common denominator, the cold-war era was not only splitting countries and worlds apart but also brings us together when we talk about it today. Maybe a simpler time, still complex enough, probably raveled in many mysteries. The perfect hiding place for a retrospeculative narration that through backward induction hides its fictional piece in real life events.

* Growing up in West-Germany as a kid in the 90s I did not get to feel effects of the cold war, but it has been a bubble around my younger years still.

Next questions for the design of the apparatus:

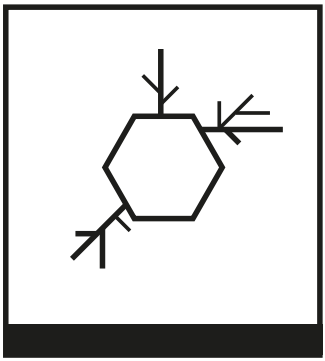
Who builds a machine like this?
Why would someone build it?
What could other purposes than the inward directed technological development be involved here?

Open up the stage for the Biotic Explorers, a *new cybernetics* research group:
The Biotic Explorers Research Group is a US-funded multi-national European based research programme on the exploration of biotic systems and their inhabitants for the advancement of an economic system with the help of social, cybernetical and biological studies. Three European scientists, all excelling in their fields, were asked by the US Department for the Transcontinental Science Exchange to cooperate, share their knowledge, find suitable group members from their respective fields and form a practice that would sustain for a long time. Any traces back to the amount of the group's funding have been censored. The group's leaders are Anthony Reed, Aurore Fleur Duval and Davy Francis.

Born in Cambridge, England, Anthony Reed is a mathematician, logician, cryptanalyst and theoretical biologist and holds a professorship in Cryptology at King's College, London. His dissertation on exceeding the cardinal system of black-boxed systems at Yale University ranked him high between his colleagues at Yale University. His former research staff of cryptology within the department of mathematics included the research of breaking coded information and getting insight into the deep entanglements of the system economics and controlling machines via sensorial signals. Now he is the main lead of the cybernetical research division of the Biotic Explorers group.
Aurore Fleur Duval is a biologist by profession and passion. She was born in Paris, France and studied under Professor Jean-Paul Clautier at Faculté des Sciences de l'Université Paris-Sud. She holds a Ph.D. in biology from the same university, entitled Investigation of photosynthesis and modifications on phycocyanin, carotenes, and xanthophylls in rhodophytes: On recombinations of proteins in light-harvesting complexes. Her research interest dwells within that of natural science, namely that of the prediction of life cycles and the interference of humankind with the global ecosystem as well as criticism of modern life development. She is one of the first professors at Université Paris Diderot (Paris 7) after the University's regrouping and main head of Unité de Formation et de Recherche of Science of the Earth, Environment and Planets. Her role within the Biotic Explorers research group is mainly communication with the Department for the Transcontinental Science Exchange but also leading her group of biologists and chemists with her rich experience in laboratory and theoretical setups.
Davy Francis, born in Chester, England, is a socio-anthropologist with profound knowledge and interests in astrophysics and chemistry. He currently writes his dissertation, entitled Issues of interaction between human and natural systems at the Chester College of Higher Education. He is head of communication within the research group but also acts as an active vascular for the many experiments the group is conducting on their subjects and how results reflect on the group's scientists.
Together, the three govern in accordance with each other the Biotic Explorers research group, following a strict codex – a manifesto – a set of rules which sets them (secretly) apart from their US funding and the military focus of research, but also sets up additional ethical principals heeding the boundaries of humans, animals and machines.

In compliance with the official statute of US government departments, the departments – called United States Department for the trans-continental science exchange – combined the three fields of Anthropology, Biologics and Cybernetics in its isgnia.

FIG. 49: Official insignia of the Department



The official biotic explorers insignia followed the same principle in illustrating the three fields, but by forking three branches into different directions. Simplifying the group's research effort's in a minimalistic logo.

FIG. 50: Official Biotic Explorers insignia

In their researches, journals and findings the Biotic Explorers would answer the aforementioned questions. It is clear that only in their hands a machine like this could come into existence in the right context. Their rationale is that at the peak of their research and the ending of the cold war they would throw all of their "brain-power" and resources together to develop one last apparatus and it would also explain the purpose of it

The Biotic Explorers were divided into three divisions.

A – Anthropology: on the concern of human behaviors in regards to technology and nature

B – Biology: on the concern of nature itself

C – Cybernetics: on the concern of cybernetical systems in biological and non-biological systems

Each of these divisions was lead by one of the central figures and consisted of a small number of scientists.
Working closely underneath Davy Francis's directions, Corwin Luther (GB), Merletta Edwards (GB), Gabriele Rosenberger (DE) and Hanna Félin (IT) formed the anthropological division of our research group. Concerns of the A group were always directed towards implications of the results on human-biota relationships.
The biological division, led by Aurore Duval, includes the hard-working and ever so happy and enthusiastic bunch of Øyvind Solberg (DK), Rosalie Lécuyer (FR), Freyr Steinsson (IS) and Mefistah Tolgur (IS), always ready to travel the world and expand the field research.
Anthony Reed was leading the cybernetical division, composed of computer scientists and future thinkers such as Cassius Beasley (GB), Rens Apeldoorn (NL), Franca De Filippis (IT) and Mao Park Wong (SK).

FIG. 51: Attempt to create novel faces out of ordinary year book pictures with the help of machine learning style transfer platform "deepart.io". Results can be seen in the first column, the image that is "mushed" and watermarked.

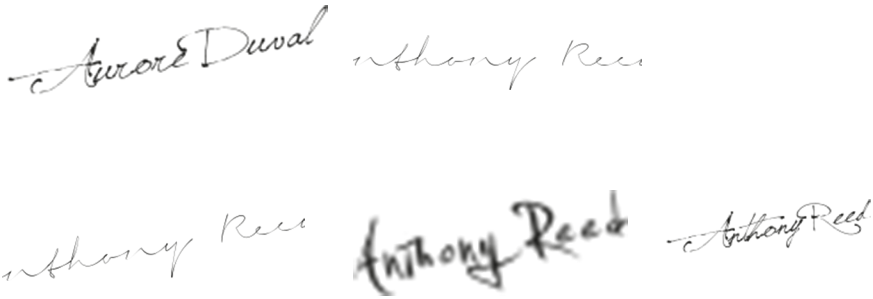
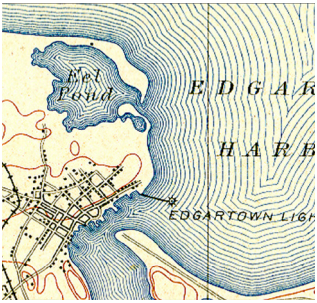
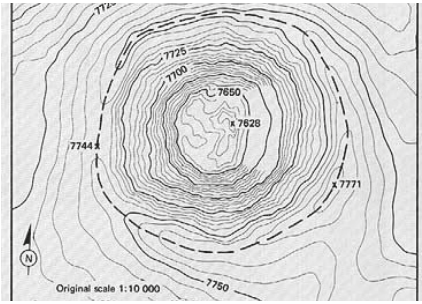


FIG. 52: Generated signatures for Professors Duval and Reed





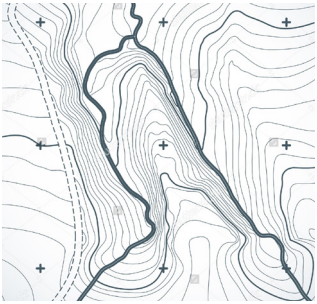


FIG. 53 – 58: Creation of a topographical map for the solidifcation of plausability: Research of styles, an area from Google maps, around Torc mountain in Ireland, and knowledge transfer to Cinema 4D to recreate a proper topographical map.

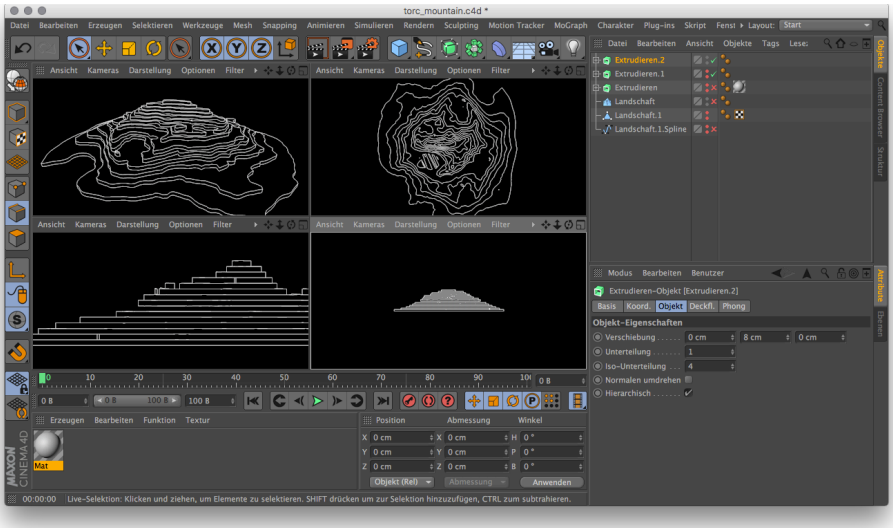
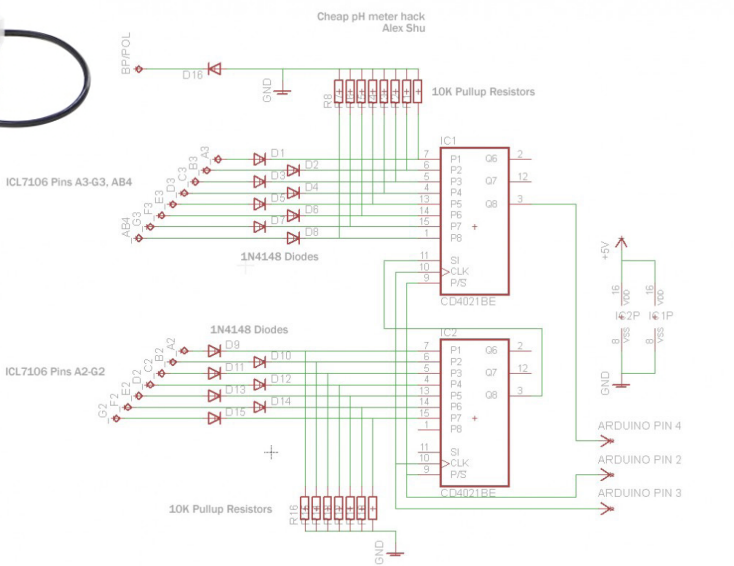
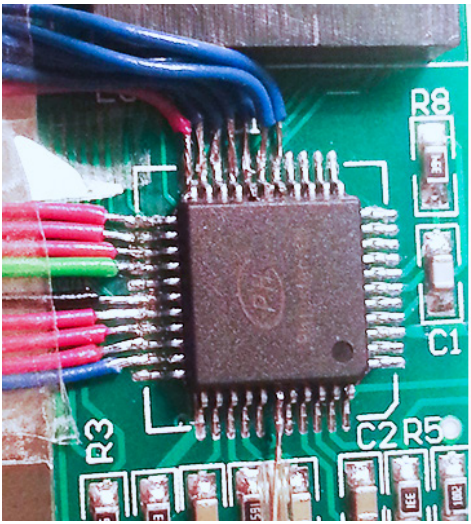


FIG. 59 – 62: Hacking of a cheap pH sensor





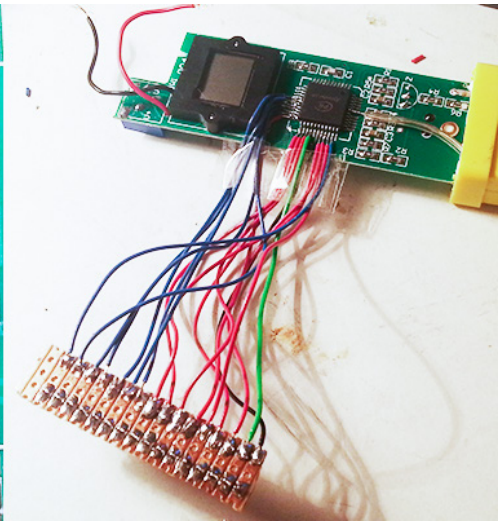
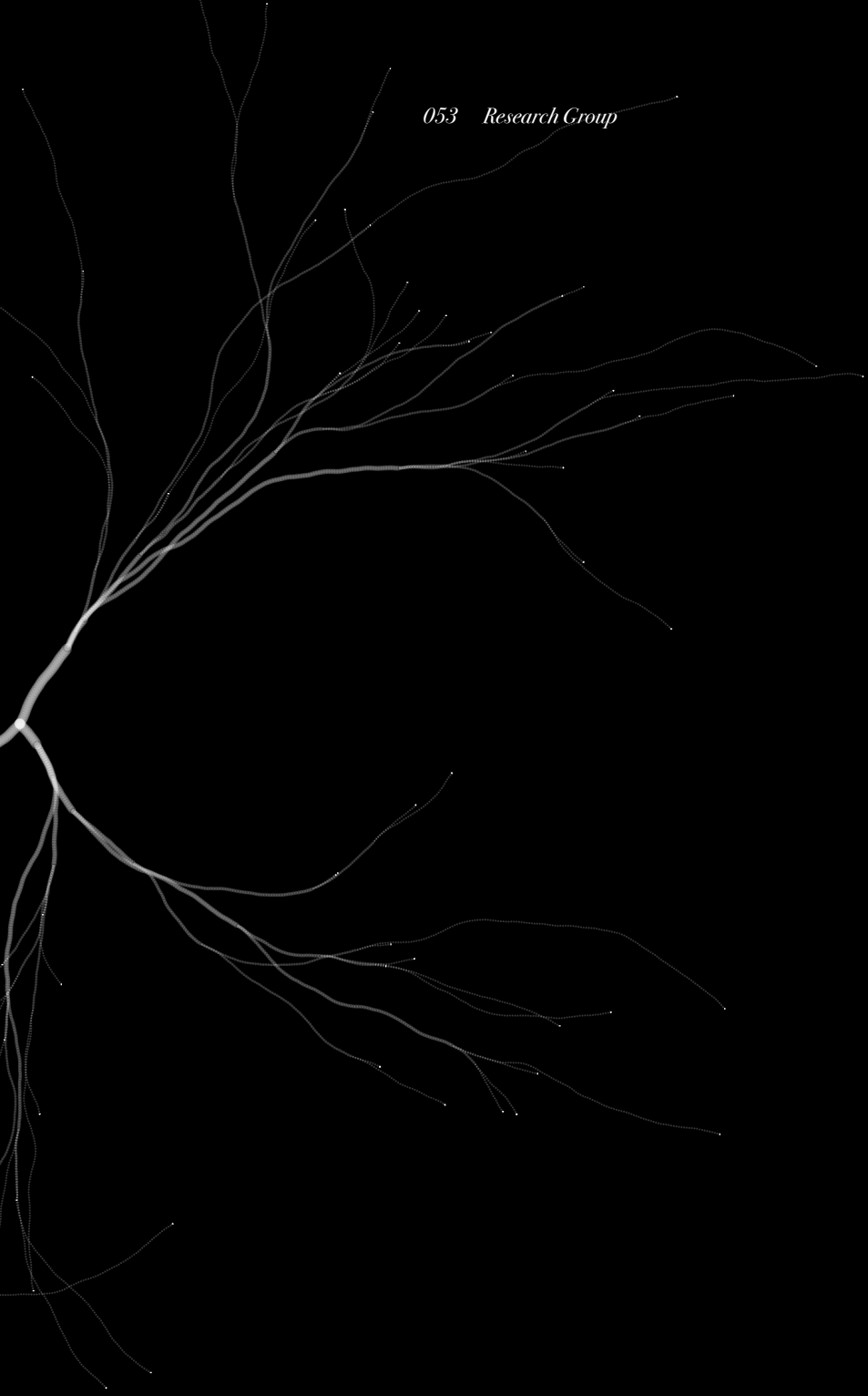


FIG. 63: Final output "Torc Mountain map" from Cinema4D, cleaned in Adobe Illustrator for further use.


UCKROSS LAKE
200
535
TORC
MOUNTAIN

FIG. 64: A rhizomatic network generated in Processing with the help of self-steering agents



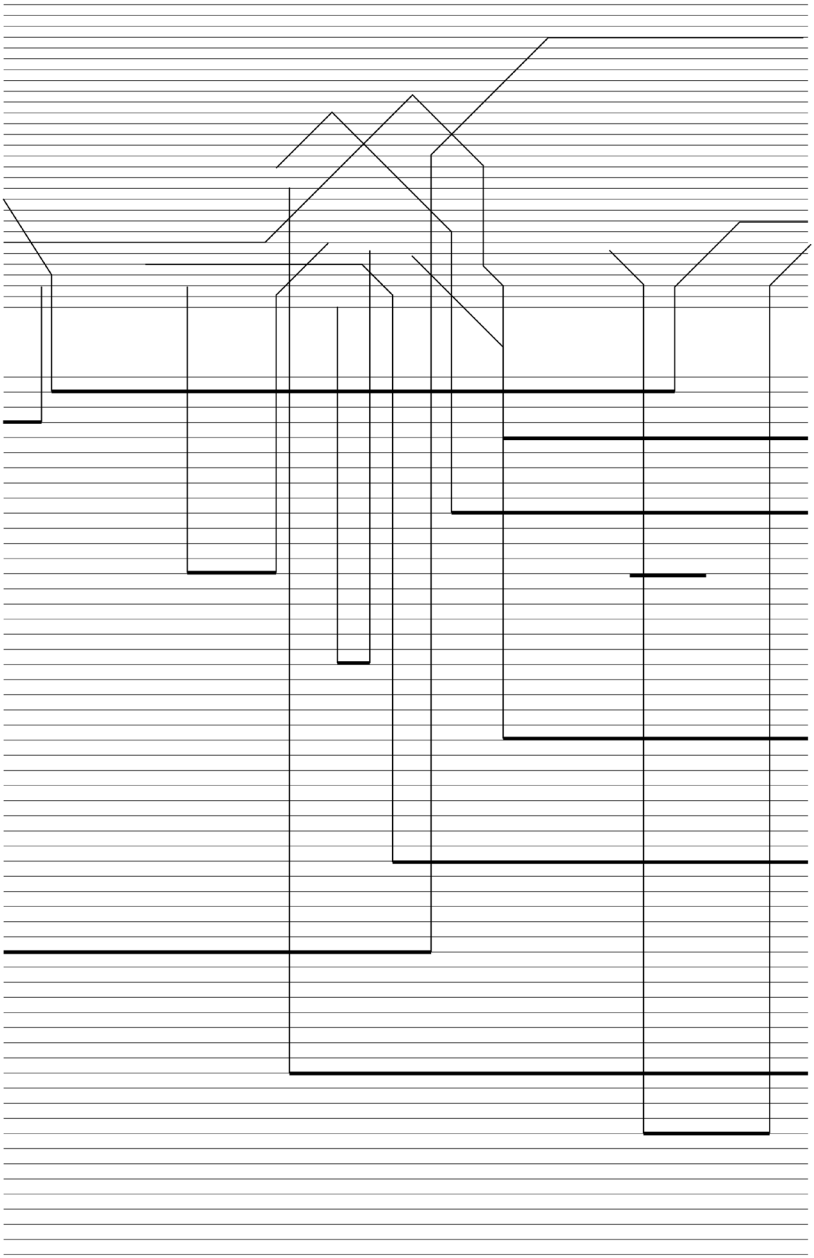


FIG. 65: Experiment in visualization of version commits of the manifesto

Manifesto

In order to keep all scientists in line, Reed, Duval and Francis came up with a common codex, which also set them apart ethically from their militaristic fundings.
The manifesto stated that no living thing should be ever harmed or turned into a weapon. Furthermore, everything about a biological system is equally interesting to the Explorers and that, influenced by Reed, the Explorers are oscillating their positions between the first and second-order Cybernetics. This means not only their understanding of systems but also includes their methods. The ending statements of the manifesto say that artificial bits of intelligence are unnecessary for not only the explorers but humankind in general since closed-source developments lead to adverse outcomes. Open-source, the act of opening sources and spreading knowledge and making things tangible, was at the heart of the manifesto and all Explorers.

01 – the biotic explorer promises to never harm
any living organism under any circumstances
02 – the biotic explorer is equally interested in the
semiotics as in the semantics of biotic systems
to deepen the understanding of the things of nature
03 – the biotic explorer sees himself oscillating
between the first-order and the second-order of
cybernetics and deeply inheriting all of the
following characteristics and ways of thinking:
interdisciplinary, curious, strict, formalistic,
reductionistic, atomistic, positivistic, pragmatic,
conservative, mechanistic and empiricist
04 – the biotic explorer considers any given
technology as a suspicious threat no matter what
intention lies behind its creation and/or production
05 – the biotic explorer deems natural systems
as trustworthy and therefore as reasonable systems
to work with and especially within
06 – the biotic explorer does not rely on synthetic
intelligence for the prosperity of mankind and the
things of nature
07 – the biotic explorer overcomes the boundaries
of closed sources in order for an open and well-
informed society
The Biotic Explorers Research Group, Paris + London, 3. February 1972

Only later I realized that, even though in the first place I tried to build upon Wiener's understanding of Cybernetics, that we are conducting research on observed systems, the natural way is still living inside the system and tweaking parameters from the inside. Inside the stories that can be found in the journal, the Biotic Explorers are placed in situations that are Cybernetics of a first-order. The explorers try to interact as little as possible and only communicate slightly with their subjects. They observe, note down their findings and from time to time change a parameter. The way these situations were constructed and realized is of second-order. The creative process was a dialogue with not only the collaborators but also the fictional characters themselves: What kind of background does this person need in order to survive in the scenario? Remarks on the personas by collaborators would be taken into consideration and most of the time I would adjust parameters so that the overall picture would appear logical and not too far-fetched.

```
import rita.*;

// wittgenstein.txt and kafka.txt are text databases filled with texts from stated authors

// this sketch uses a markov chain with a length of n=3 to chain up fragments of words together to generate new sentences, resulting in a new fundus / text database.

RiMarkov markov;
String line = "click to (re)generate!";
String[] files = { "wittgenstein.txt", "kafka.txt" };
int x = 160, y = 240;

void setup()  {
  size(500, 500);

  fill(0);
  textFont(createFont("times", 16));

  markov = new RiMarkov(4);
  markov.loadFrom(files, this);
}

void draw() {
  background(250);
  text(line, x, y, 400, 400);
}

void mouseReleased() {
  if (!markov.ready()) return;

  x = y = 50;
  String[] lines = markov.generateSentences(10);
  line = RiTa.join(lines, " ");
}
```

On algorithmic writing

At first, I wanted to deploy some algorithmic writing programs. Libraries such as RiTa (see left) form a perfect base on which a lot of text-output can be created. At one point even neural-networks could've been an option, but both also need proper input. I had to make a decision and either go with the complete computed but maybe sub-effective but less time-consuming route or talk to real people and get high-quality content.
Algorithmic writings were intended to have similar outputs as read in Stanislaw Lem's "One Human Minute"[8], where Lem precisely describes in a statistical matter whatever happens at any given 60 second period of human life.
Even a SciGen[9] could be fun when performed well:

In comparison to that are the writings of Adalbert Stifter. In his story „Der Hochwald“[10] the reader follows a tragic love story set during the Thirty Years' War [1618-1648]. Noteworthy for that time is that Stifter concentrated on painting pictures of the surroundings („Umwelt“) for the reader instead of concentrating too much on actual human conflicts. In a very detailed way and with carefully picked words, he describes forests, trees, lakes as a sanctuary.
Quality of this content is entirely not reachable with our current understanding and usage of technology, so in favor of that, I decided to go for the human route.

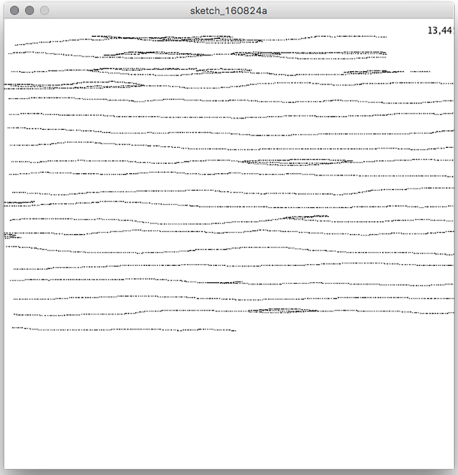


FIG. 66: Pre visualization of mycelium transmission

The work itself grew similar to the mycelia of the communication apparatus: Just like the Biotic Explorers Research Group consisted of many scientists working under the supervision of Duval, Reed and Francis, original reports were conceived with and by the help of many helping hands, the collaborators, who performed different roles of the scientists in real-life and helped to create the full experience of Biotic Explorers. An initial framework was consisting only of a long list of exciting biota, plants and animals that are part of the work and belong to the eukaryotic domain of the three-domain system were refined more and more. Through feedback loops (discussions, presentations), interesting yet plausible biota manifested themselves. Scientist names were generated through a formula, linked with some vita to give life to them and were handed out with manuals to the collaborators. From there on, in a circular fashion, parts of the work would be fleshed out: Text journal entries of the experiments, drawings of biota, schematics and scientific drawings and finally the setup from the mycelium experiment, including physical computing, development of the pH Sensor and the mechanism to release the liquids as well as the whole construction to hold soil and the fungi next to the mechanical construction.

Namely, the collaborators are:

Irena Kukric (SR)
Set designer and media artist from Serbia, Belgrade. Besides her many years of experience as a stage designer for national theaters, she also creates intrinsically interesting theatrical installations and explores sets and installations in the context of film and theater as well as contemporary art.

Jasna Dimitrovska (MK)
Interaction designer and artist from Macedonia, Skopje. With a background in literature, she is working with both tangible and intangible media. On a mission to investigate the meaning of human interaction with digital objects by creating „What if?“ scenarios

Thomas Ganser (DE)
Rocket scientist from Germany, Bremen. He is working on the intersection of experimental and commercial space flight. His research group sends wax fueled rocket propulsion engines into the air to change space flight forever.

Luiz Zanotello (BR)
Media artist and designer from Brazil, Jundiaí. His work occurs within digital media studies, often by exploring the narrative and critical aspects of technology through kinetic installations, speculative machineries, and experimental interfaces.

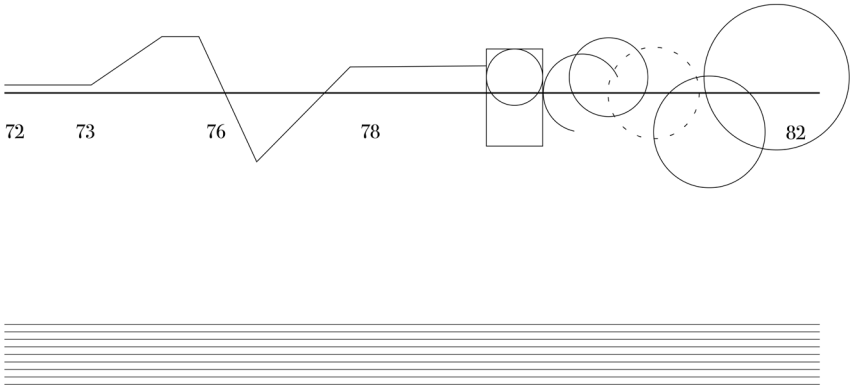
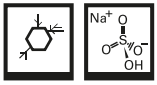


FIG. 67: Illustrative timeline of the "Biotic Explorers" development of their works

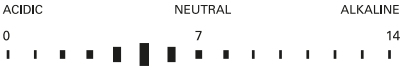
To reinforce the plausibility of the reports, drawings and artist depictions and technical sketches of the subjects found their way into the journal. All drawings were drawn by Irena Kukric specifically to order.
With a total of twelve drawings, Irena outdone herself and helped, even more, to breathe life into the researcher's life but also the research itself.
When the drawings were shown to the other collaborators, they immediately could come up with more details for their reports, which looked like a feedback loop for control to me.
Out of these twelve drawings, they could be assigned to six different research entries.

FIG. 68 : AtlasScientific pH Base and Acid liquids

The idea of the apparatus is to include nature as it is, with all its flaws, into the creation of a novel technology. A piece of tech that lives entirely by the rules of cybernetics and is open to veering by external parameters. Communication can, will and should be affected by noise and ultimately disrupting signals.
For controlling the pH value, I picked two distinctive liquids, one introducing more alkaline liquids into the system and one introducing more acid.
$NaHSO_4$ (Sodium hydrogen sulfate) is the pH-minus regulator and Na_2CO_3 (Soda carbonate) the pH-plus regulator. Both these liquids can be fabricated easily and in large quantities. Attenuating these chemicals with distilled water would yield in smoother results and it appeared that it would be more reconcilable for the mycelia.
Unfortunately, while I was drawing out details of the pH sensor / liquid dispensing mechanism, a similar experiment has been published on the Arduino blog. In it, data could be transmitted through pure liquids in a plastic tube. Considering the time that was left I made a quick decision to simplify the workings of the mycelium apparatus: Design, mechanical and electrical parts should be working but the data transmission and fungi inside of the apparatus can be fake and it is up to the audience to decide how it all comes together.



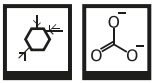
pH-minus
Regulator



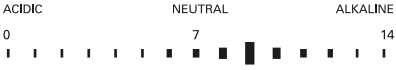
Ingredients
Sodium hydrogen sulfate
Distilled water

5l

02
PE-HD



pH-plus
Regulator



Ingredients
Soda carbonate
Distilled water

5l

02
PE-HD

FIG. 69 + 70: Packaging labels for the liquids that are used with the mycelium apparatus

Exhibition

Biotic Explorers has been exhibited at several locations and events.
The first was the defense of the work, which occurred at StudioGalerie 35, Bremen. Here, an initial iteration of the mycelium apparatus could be seen with a selected set of drawings, technical sketches and other excerpts from the journal.
The second iteration was shown at the European Media Arts Festival Nr. 30 in Osnabrück. The apparatus was reworked heavily, with new parts and redesigned containers for the liquid dispenser. For the first time, the pH-Regulators were also on display in an effective manner.
The third iteration (as seen at Salon Digital #6 with Julian Hespenheide[11]) and fourth iteration were identical to the exhibition at EMAF in Osnabrück.
What distinguished them from each other was the accompanying performance of the journal:
During and even after the defense, I read the entries in chronological order. Word by word, number by number. I presented the work in a way that I have found the source material on the internet provided by an unknown third party. I preprocessed the findings for a broader public to enjoy it more.
In the discussion afterward, the actual defense, I would stay in character declaring that all of the characters and reports were real. This lead to some interesting results since some of the audience did not know what was happening and actually just followed the narration along.
Next time at EMAF there was no performance, but at the *Salon Digital*, I once again performed the finder of the book only to break my character right after the reading was done ultimately. This was an experiment to find the discussion with the audience a bit sooner, but in a way, it failed since most of the audience was already familiar with the work.
At the Jahresaustellung 2017, I performed together with Jan Charzinski excerpts from the journal mixed with parts of his thesis work. Later on, we discussed in character our findings and the nature of reality.

One thing I did not see from the beginning of this work was the aspect of performing to promote a narrative. The sheer amount of text that is presented by this work has to be transferred through a performer, a medium. The patience that is brought up by the performer then also dictates how much is reaching an invested audience eventually. To some people, this might have been clear from the start, but to me, a novice in this field, this was all uncharted territory since I'd always let my installations do the act of performance.

FIG. 71: An event within the Digital Media programme called 'Salon Digital' where Biotic Explorers where presented.

Left intentionally blank.

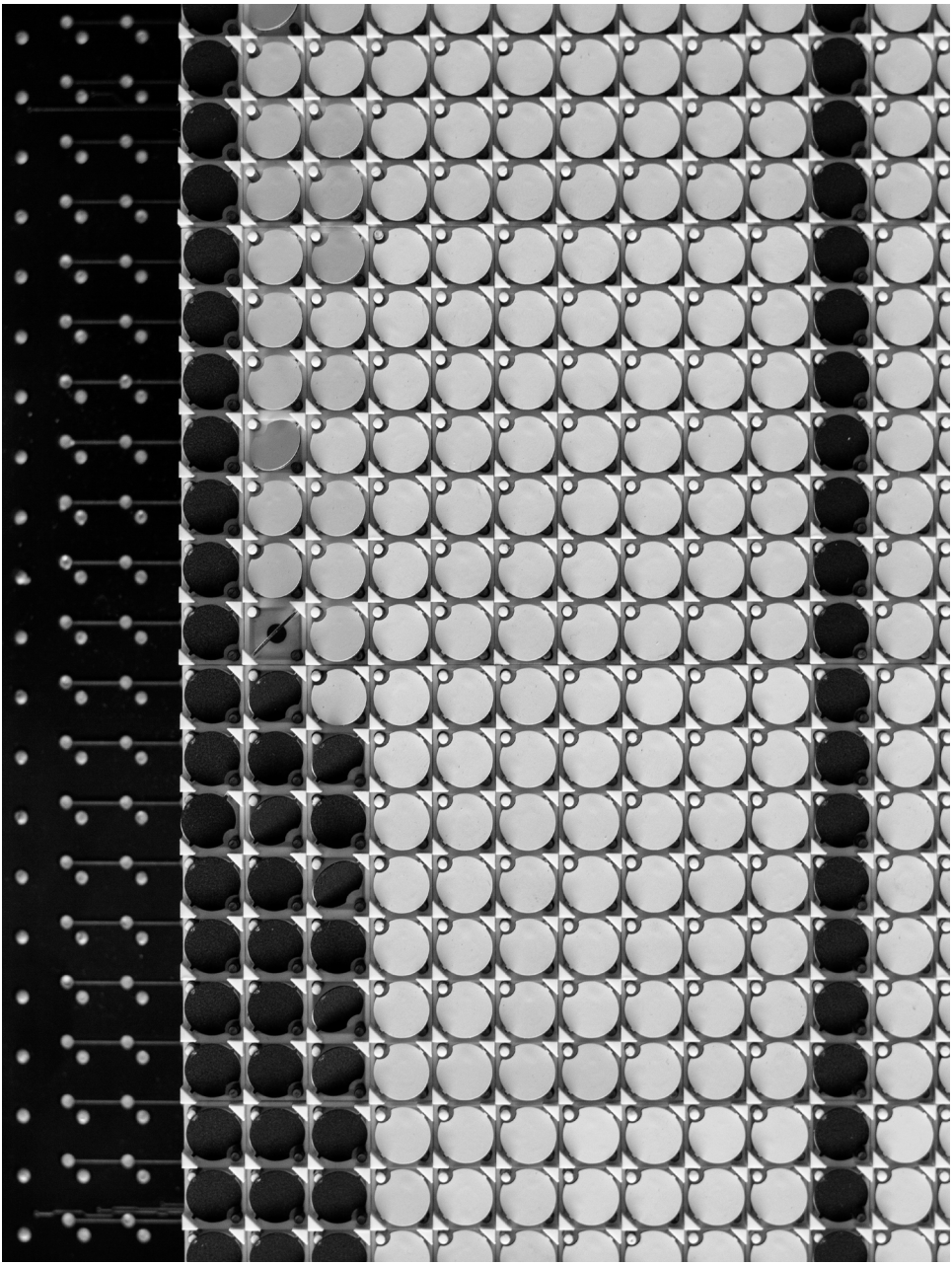


FIG. 72: Black and white Flipdots

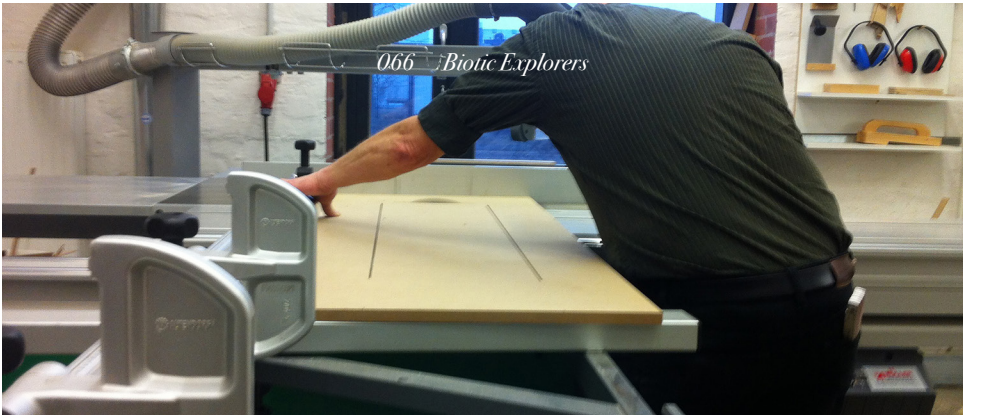


FIG. 73: Karl Strecker, wood workshop leader ath HfK Bremen, cutting out the hole for the soil tank later

*FIG. 74: Removing the *not-hole* part from the hole*

FIG. 75: Untreated materials; getting a feel for the dimensions

FIG. 76: Soldering SMD parts onto a PCB for controlling Flipdots with hot air – the PCB was in the end never used.

FIG. 77: New 3D printed parts for Version 2 after a thorough sanding session

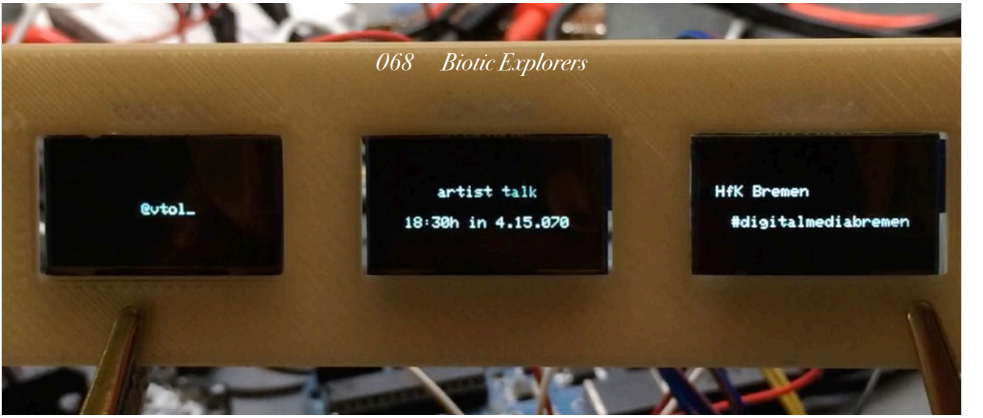
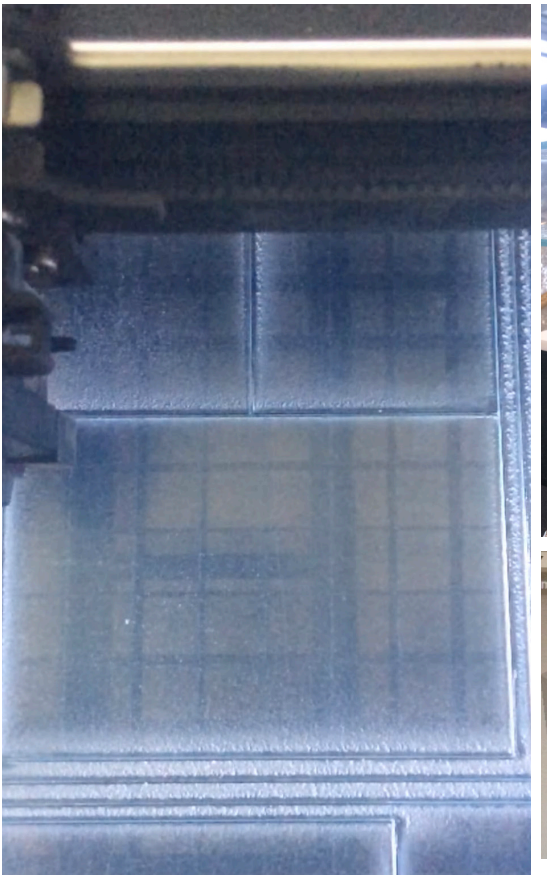


FIG. 78: Testing the PCB with the OLED displays and the new PCB holder



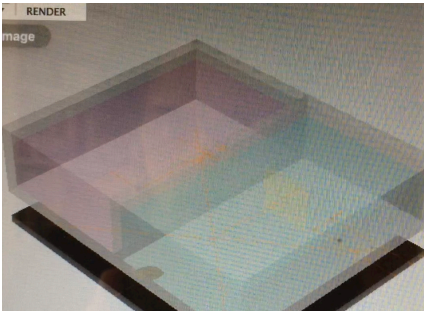


FIG. 79 – 81: Lasercut acrylic glass / After glueing and assembling in place / CAD view in Fusion360

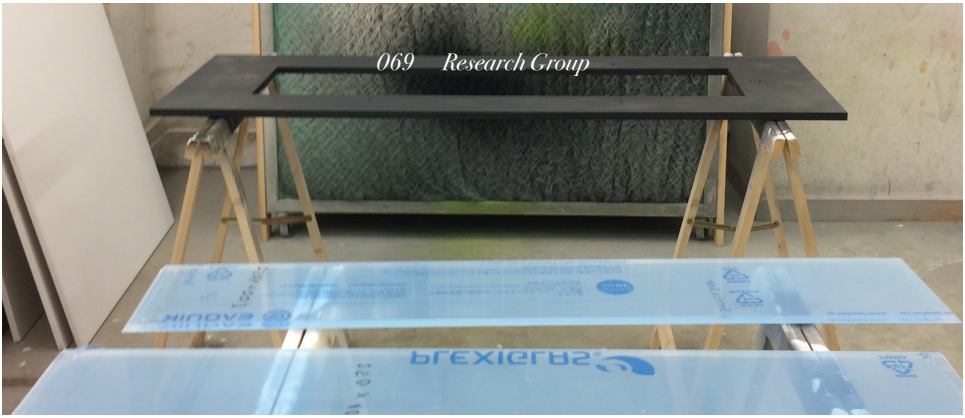


FIG. 82: Acrylic glass parts waiting to be painted

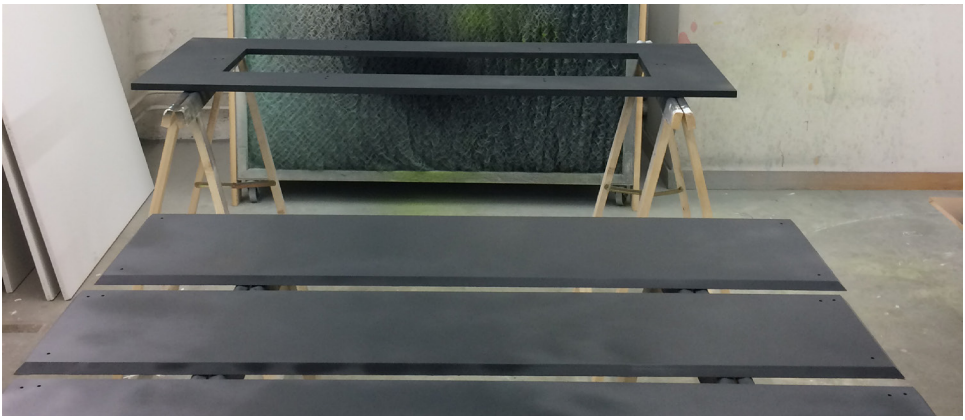


FIG. 83: After a first painting coat

FIG. 84: Producing packaging labels for pH liquids with a vinyl cutter

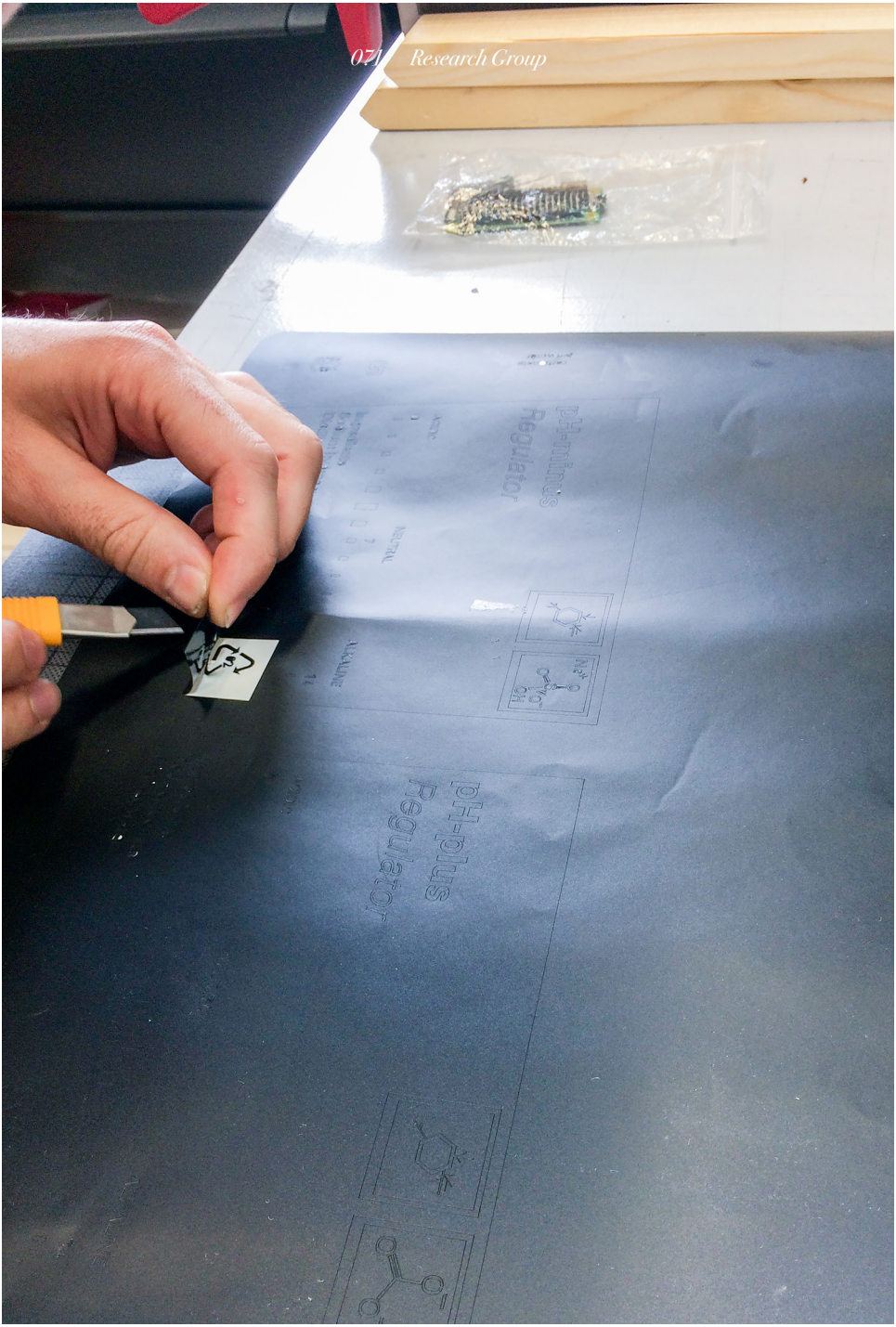


FIG. 85: Removing excess materials from the vinyl cut

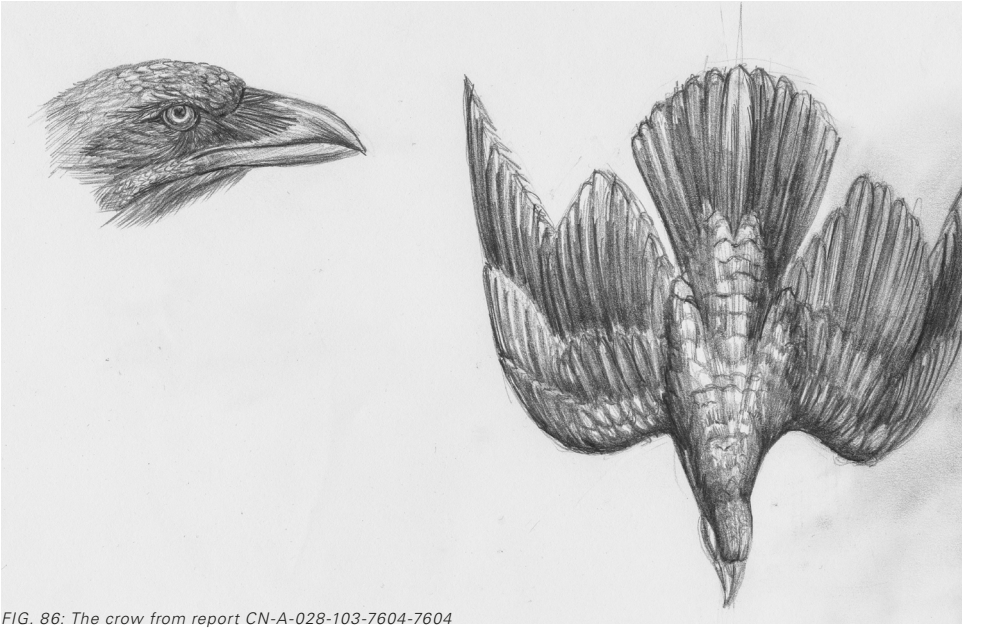


FIG. 86: The crow from report CN-A-028-103-7604-7604

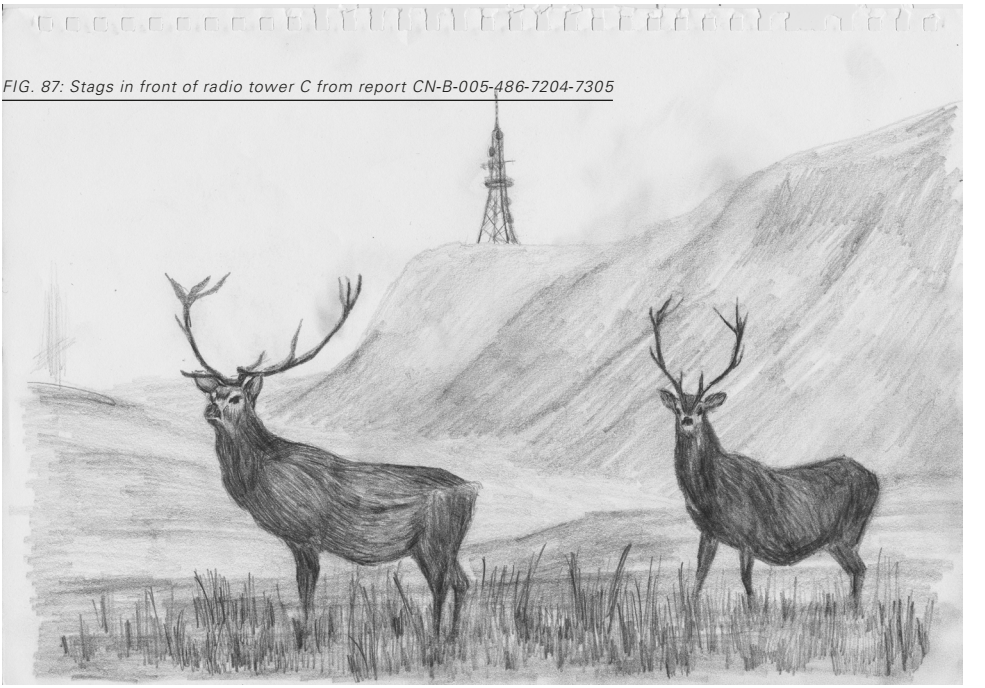


FIG. 87: Stags in front of radio tower C from report CN-B-005-486-7204-7305

FIG. 88: Dandelions from report CN-B-025-621-7404-7406

FIG. 89: Squirrel with supposedly damaged ponderostat from report CN-A-007-486-7212-7305

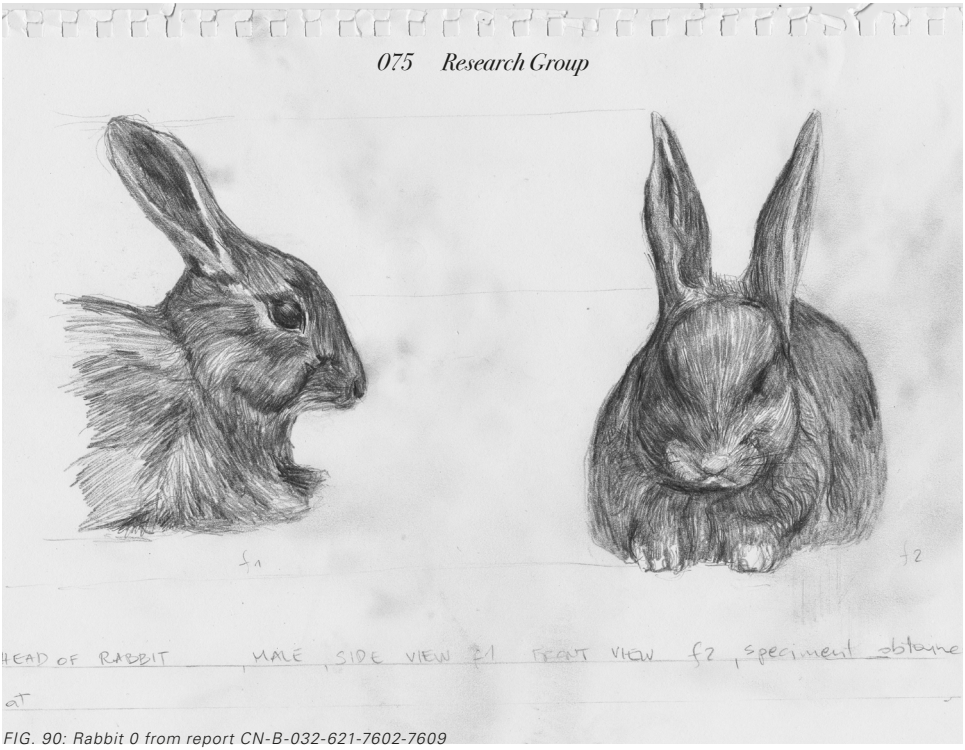


FIG. 90: Rabbit 0 from report CN-B-032-621-7602-7609

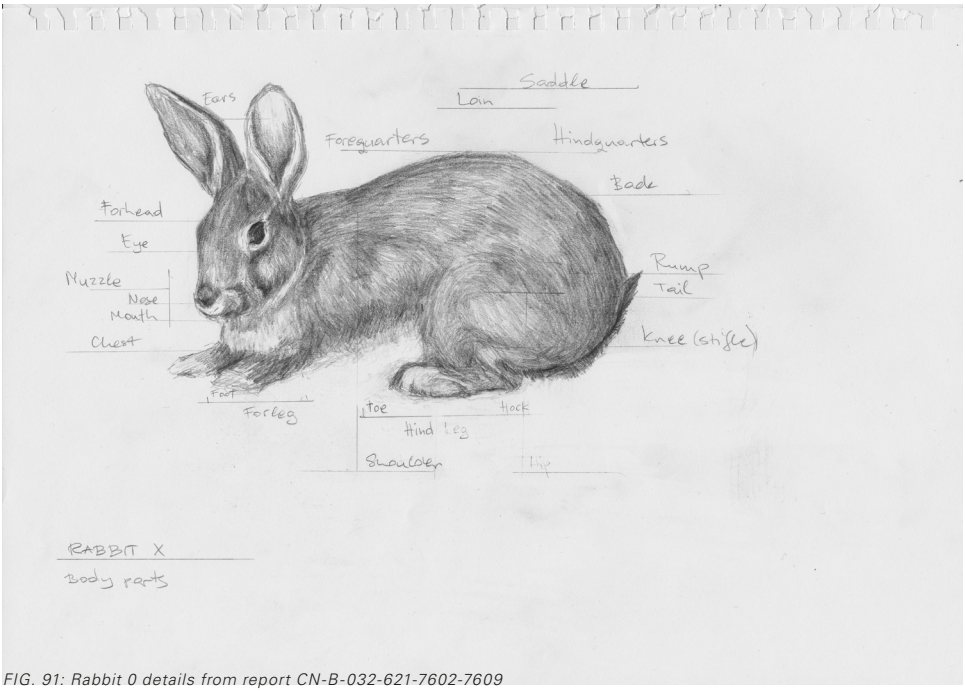


FIG. 91: Rabbit 0 details from report CN-B-032-621-7602-7609

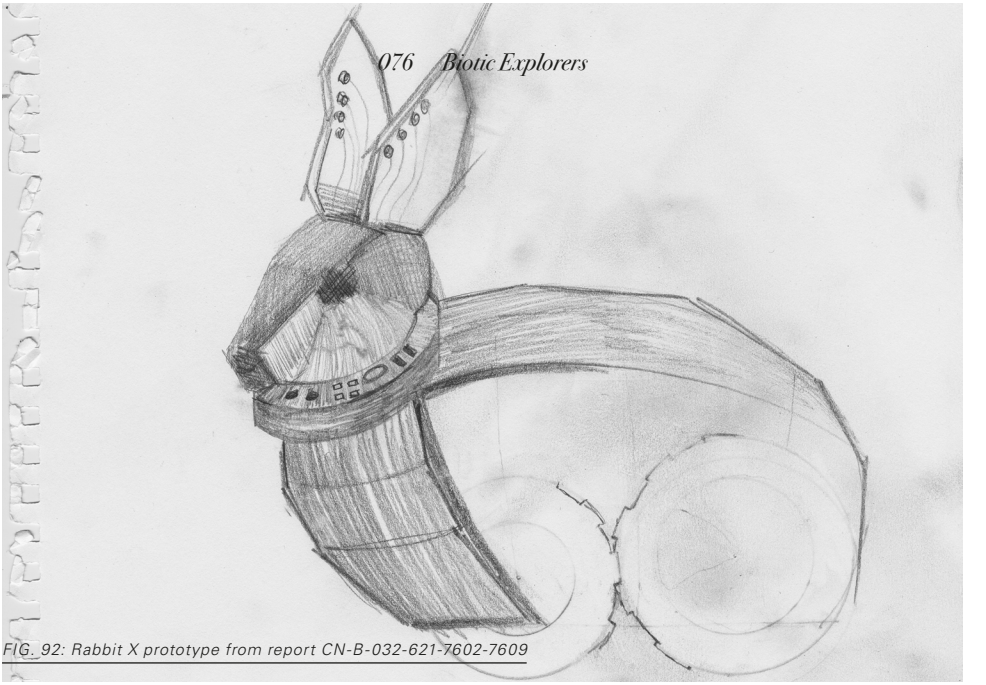


FIG. 92: Rabbit X prototype from report CN-B-032-621-7602-7609

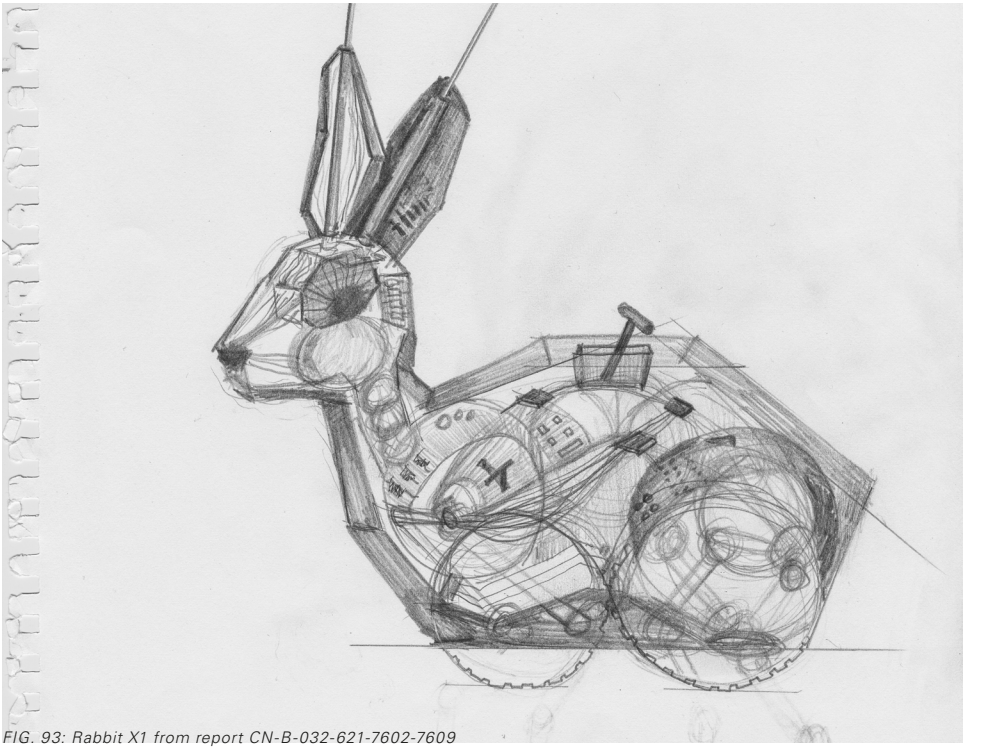


FIG. 93: Rabbit X1 from report CN-B-032-621-7602-7609

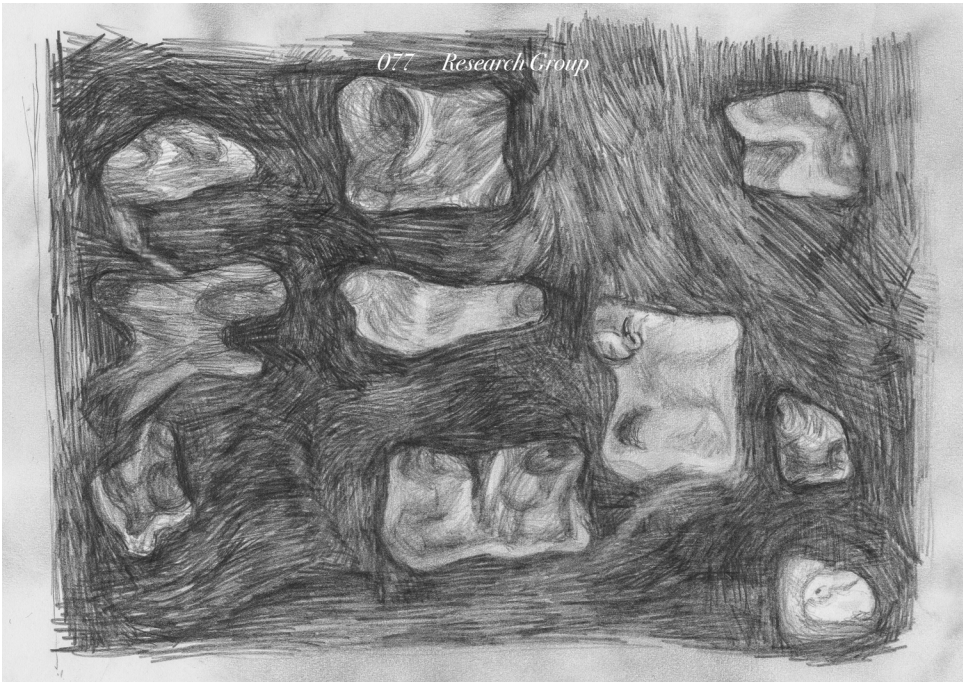


FIG. 94: Burrows of rabbits from report CN-B-032-621-7602-7609

FIG. 95: A deer from report CN-B-005-486-7204-7305

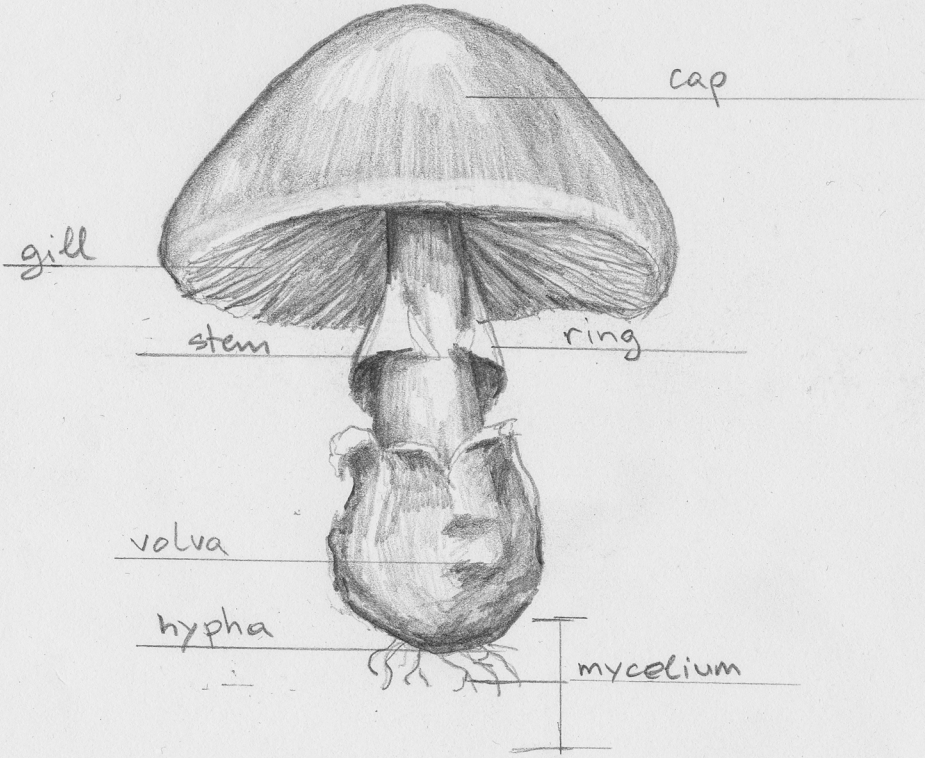
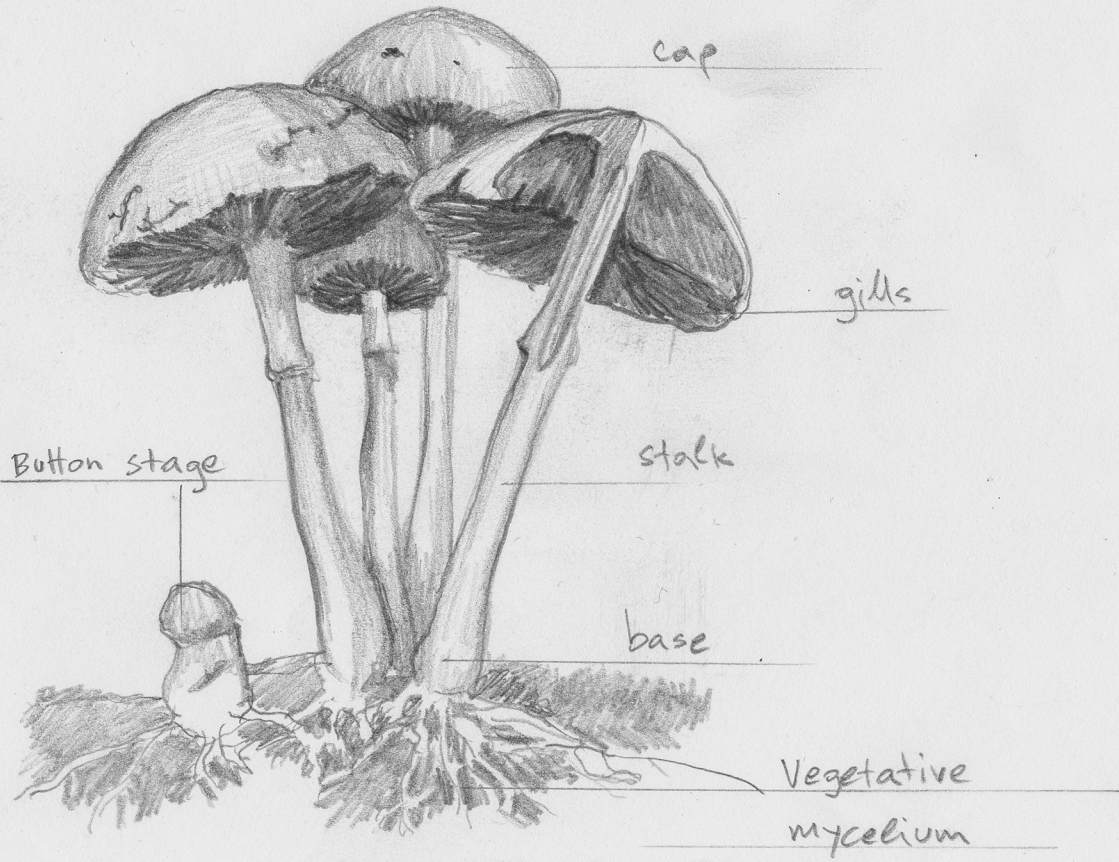


FIG. 96: Studies of funghi from report CN-C-045-004-8210-8307


cap
gills
Button stage
stalk
base
Vegetative
mycelium

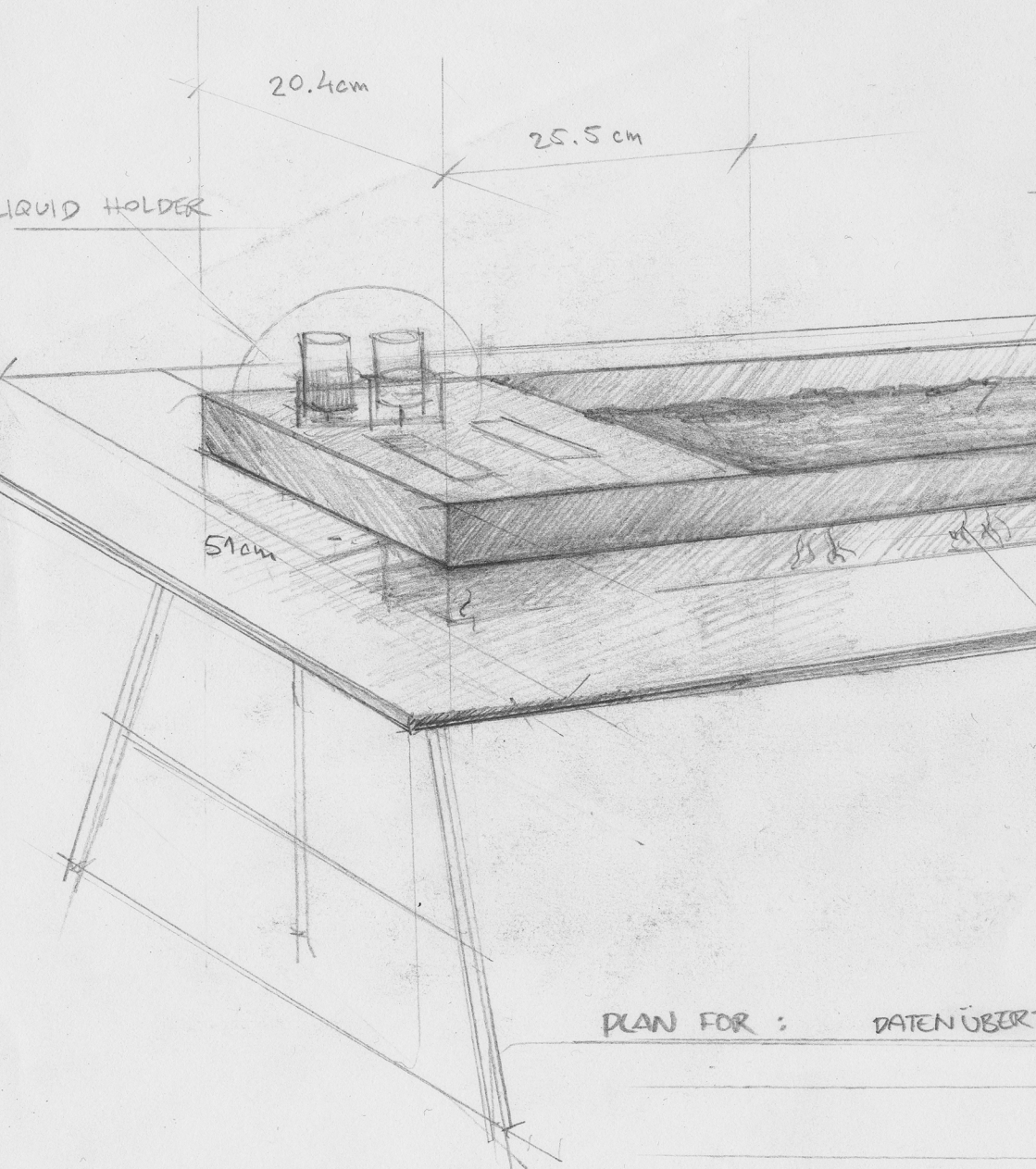
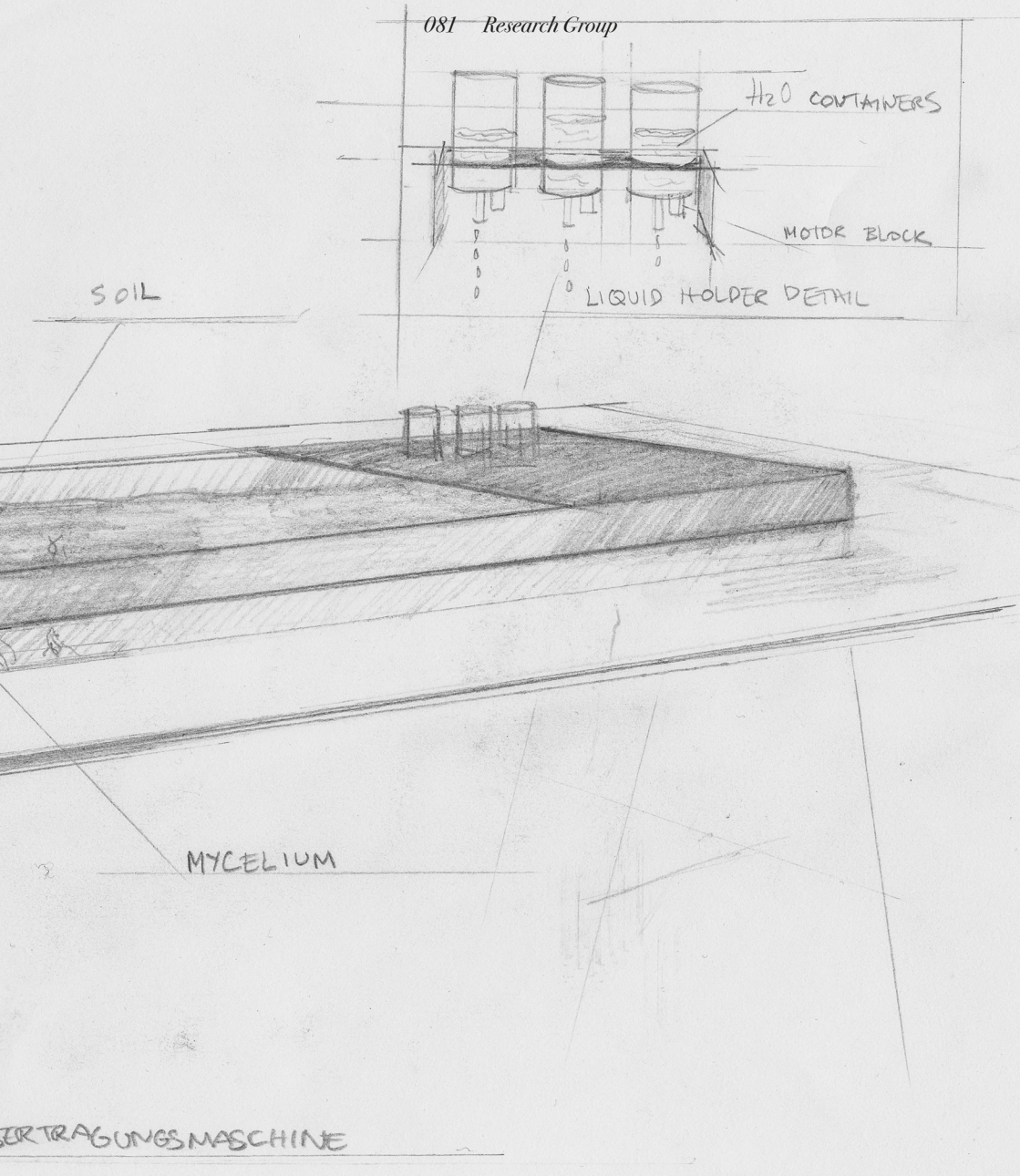


FIG. 97: Mycelium apparatus technical sketch from report CN-C-045-004-8210-8307


H2O CONTAINERS
MOTOR BLOCK
LIQUID HOLDER DETAIL
SOIL
MYCELIUM
ERTRAGUNGSMASCHINE

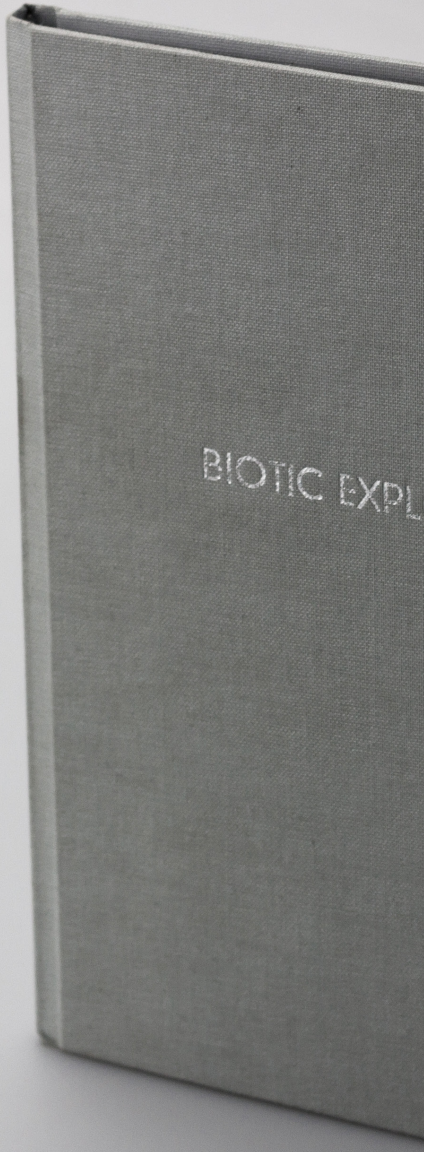
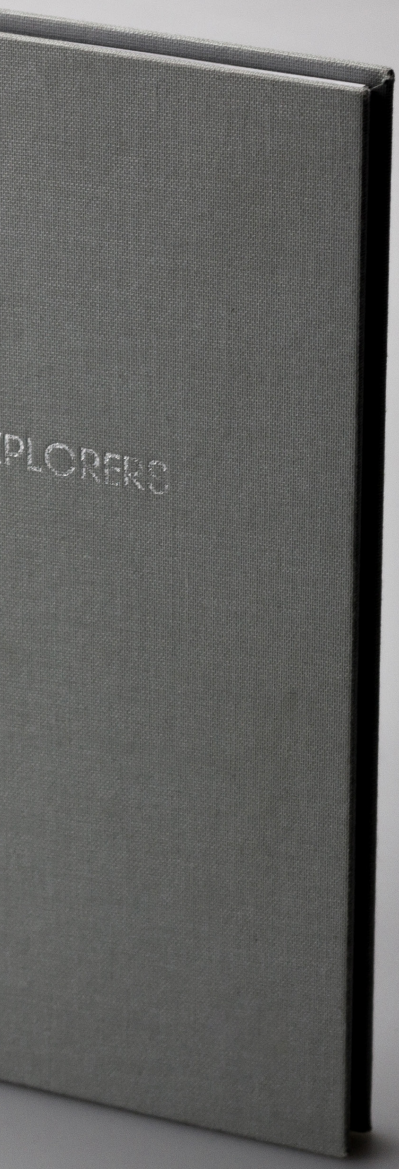


FIG. 98: 'Biotic Explorers Journal' Version 1


PLORERS

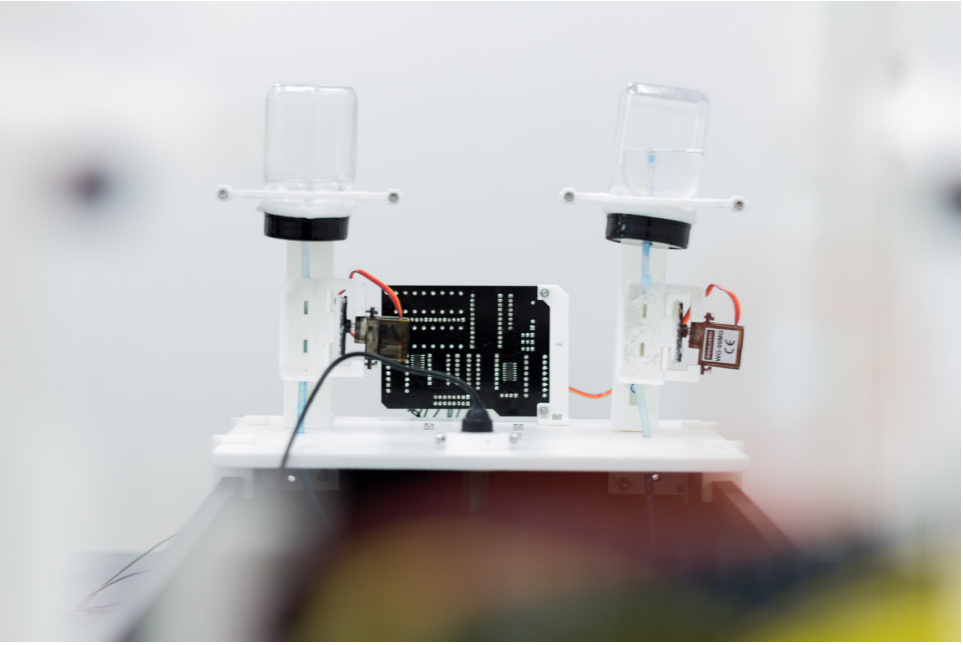


FIG. 99: Mycelium apparatus Version 1 at Studio Galerie 35

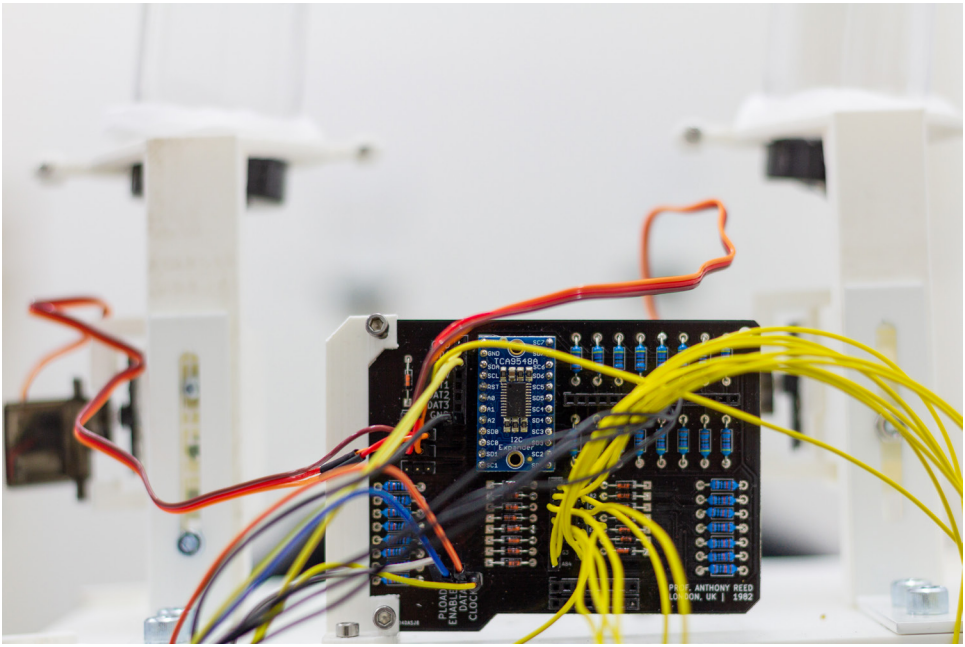


FIG. 100: Close-up of Mycelium apparatus PCB

FIG. 101: Frontal view of Mycelium apparatus

FIG. 102: Top view with "soil"

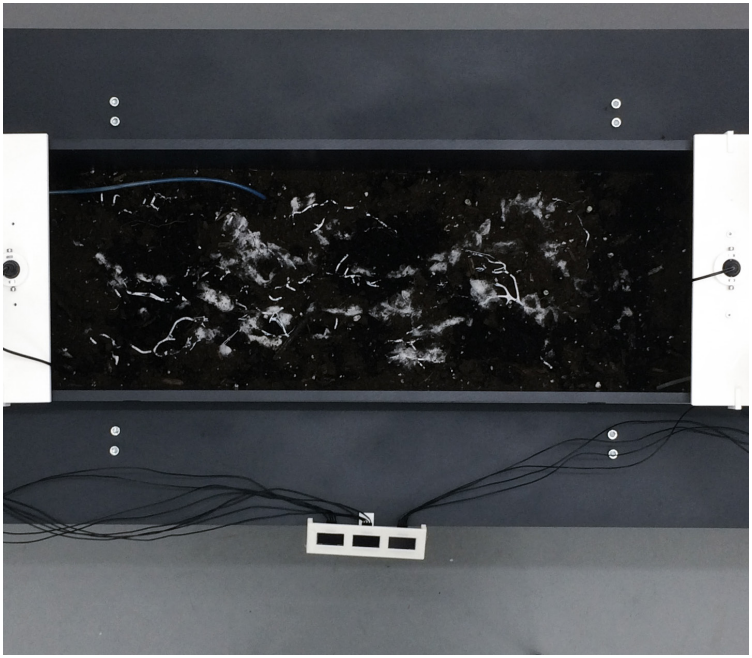


FIG. 103: Perspective of the apparatus at Studio Galerie 35

FIG. 104: 'Mycelium apparatus' Version 2 at the European Media Arts Festival
On display at hase 29 Galerie in Osnabrück


TORC
MOUNTAIN

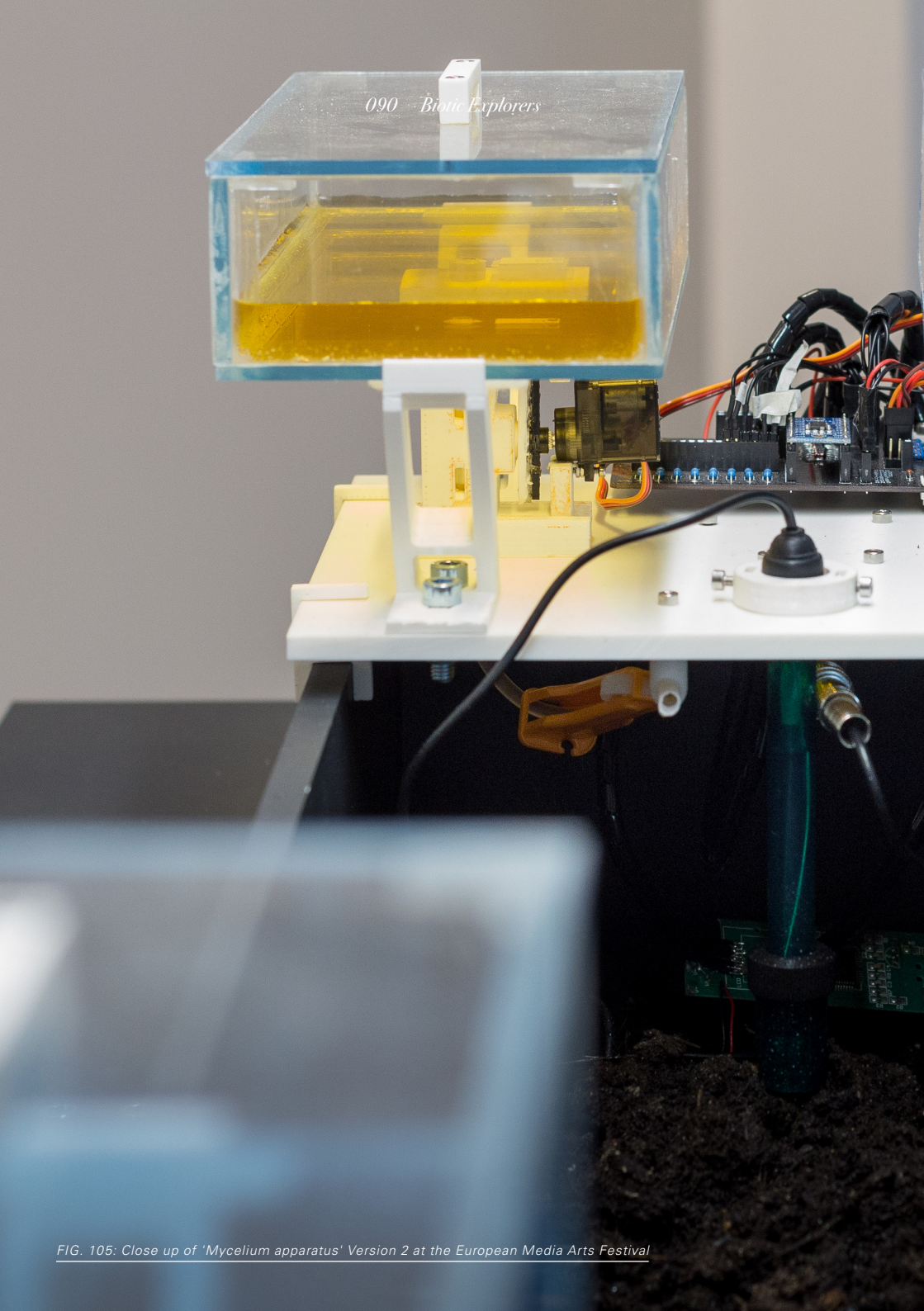


FIG. 105: Close up of 'Mycelium apparatus' Version 2 at the European Media Arts Festival

FIG. 106: Jerry cans holding pH liquids for the apparatus

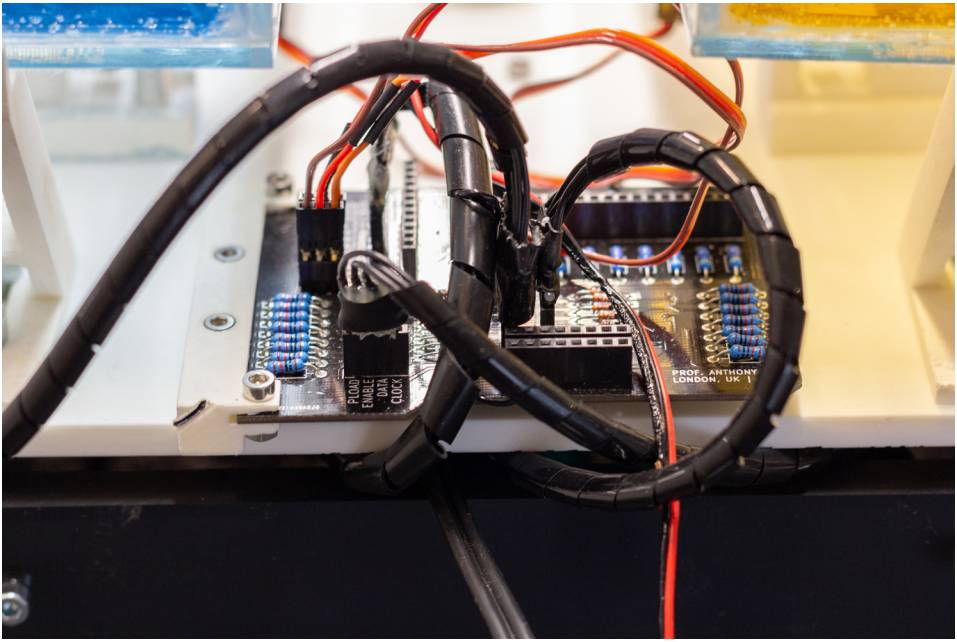


FIG. 107: Close-up of the PCB in Version 2

FIG. 108: At Galerie Herold for "Salon Digital 6": Documentation video and clip-boards with excerpts from the reports

FIG. 109: Galerie Herold perspective

FIG. 110: A globe as part of the exhibition

FIG. 111: On the globe three pins pointed towards the main locations of the reports

FIG. 112: Different angle at Galerie Herold

FIG. 113: Wall with the drawings from the reports

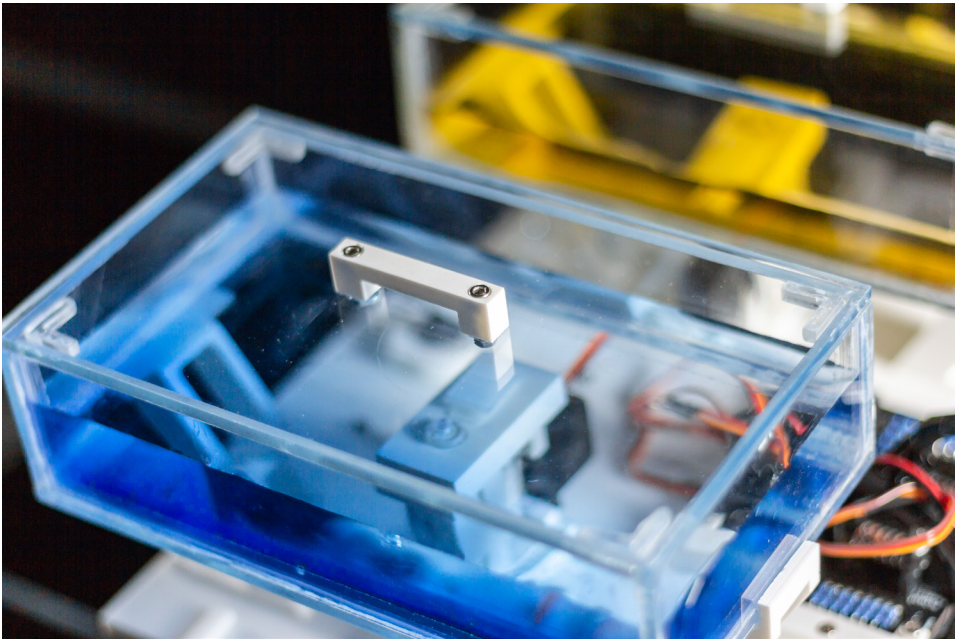


FIG. 114: Close-up of the newly produced pH liquid tanks

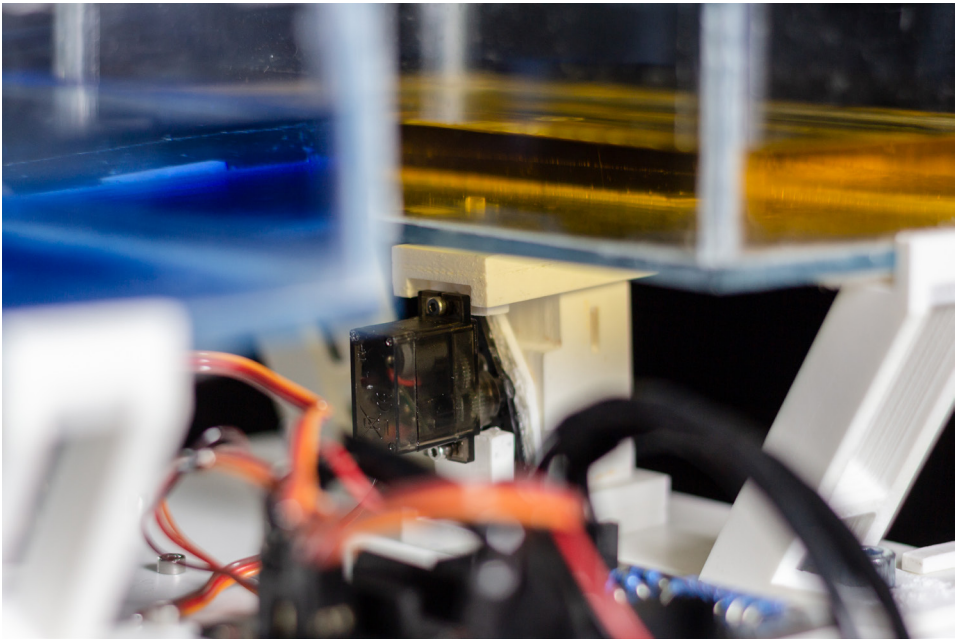


FIG. 115: Close-up the servo holder

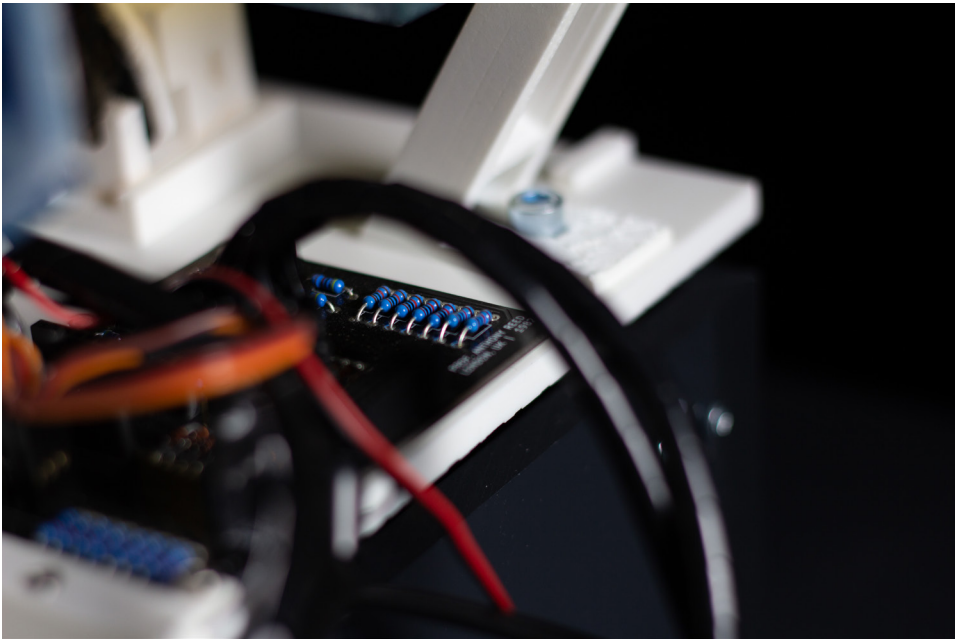


FIG. 116: Detail of the plateau holding not only pH liquid tanks but also the PCB

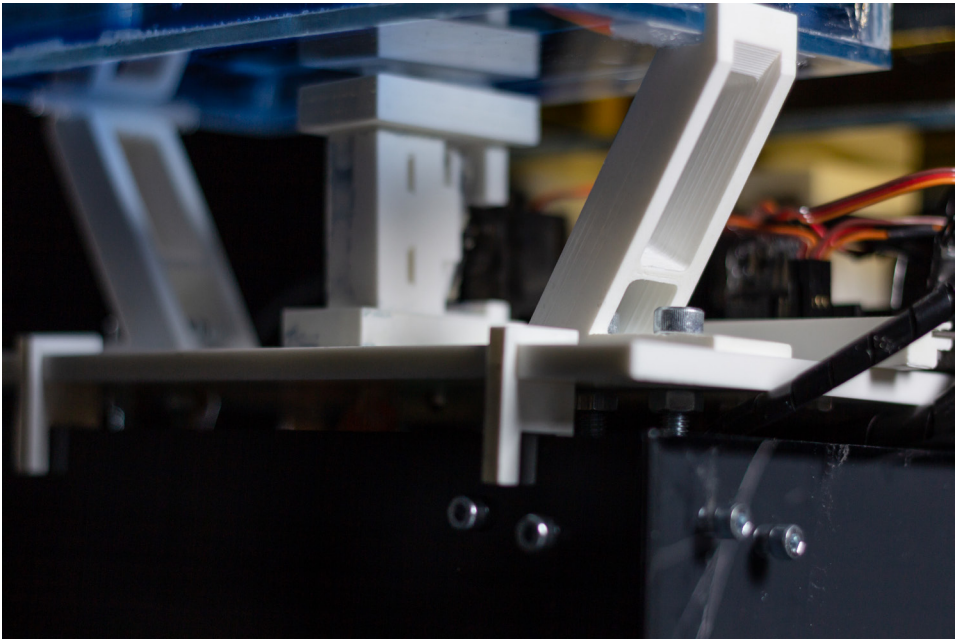


FIG. 117: Printed parts (tank holders) holding up the pH liquid tanks

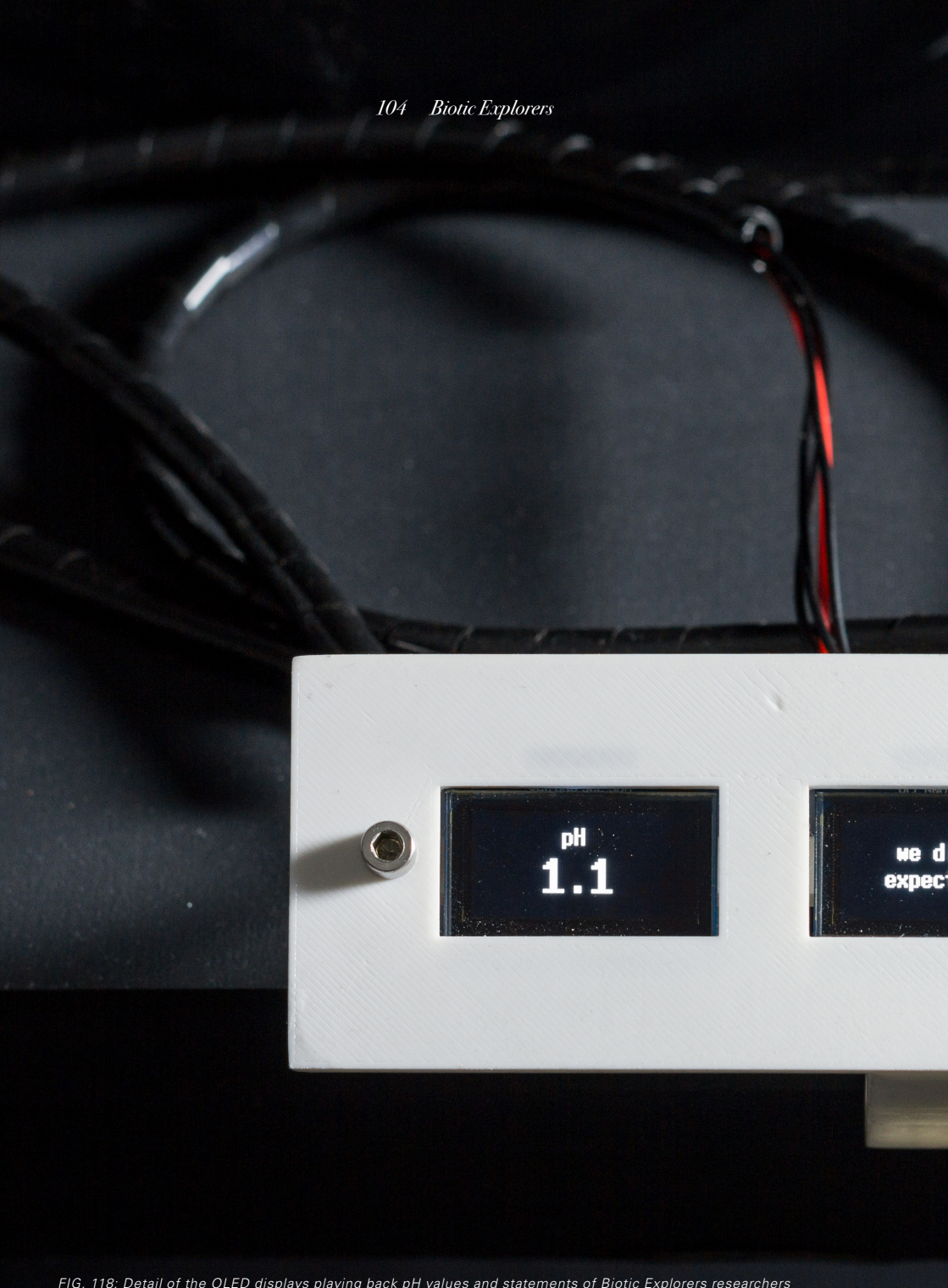
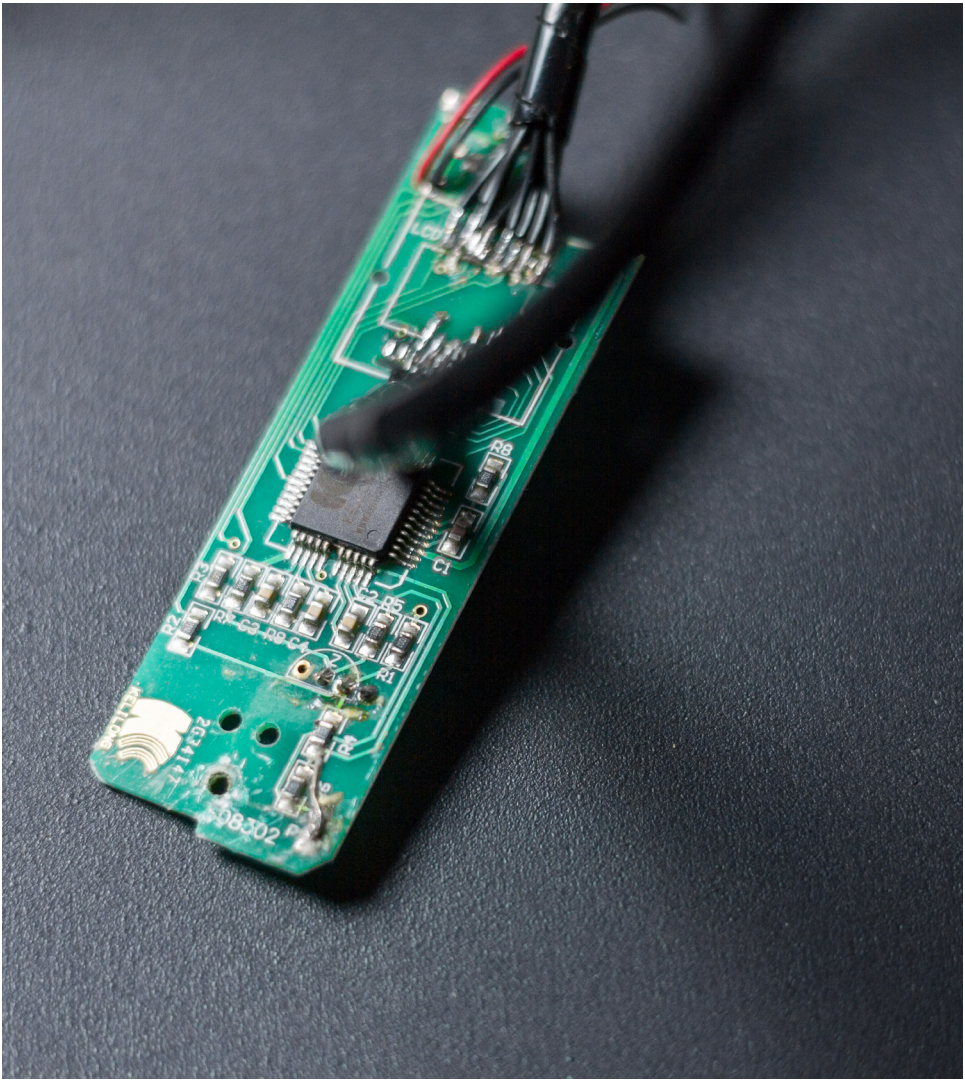


FIG. 118: Detail of the OLED displays playing back pH values and statements of Biotic Explorers researchers


e didn't
pect that
magnificent
results!

FIG. 119: Detail of liquid nozzle

FIG. 120: The original PCB from the pH sensor with the added cables that are wired to the apparatus PCB



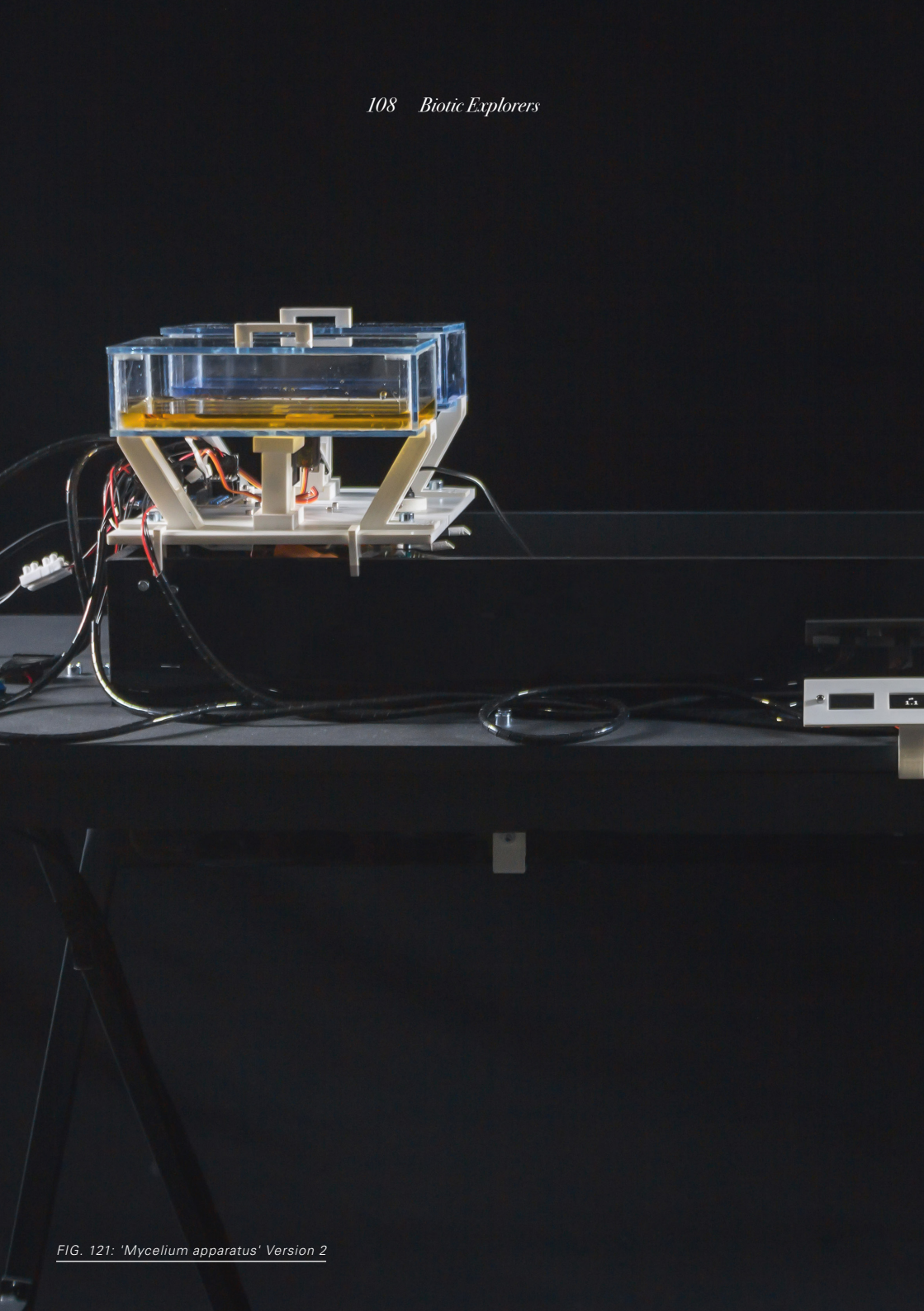
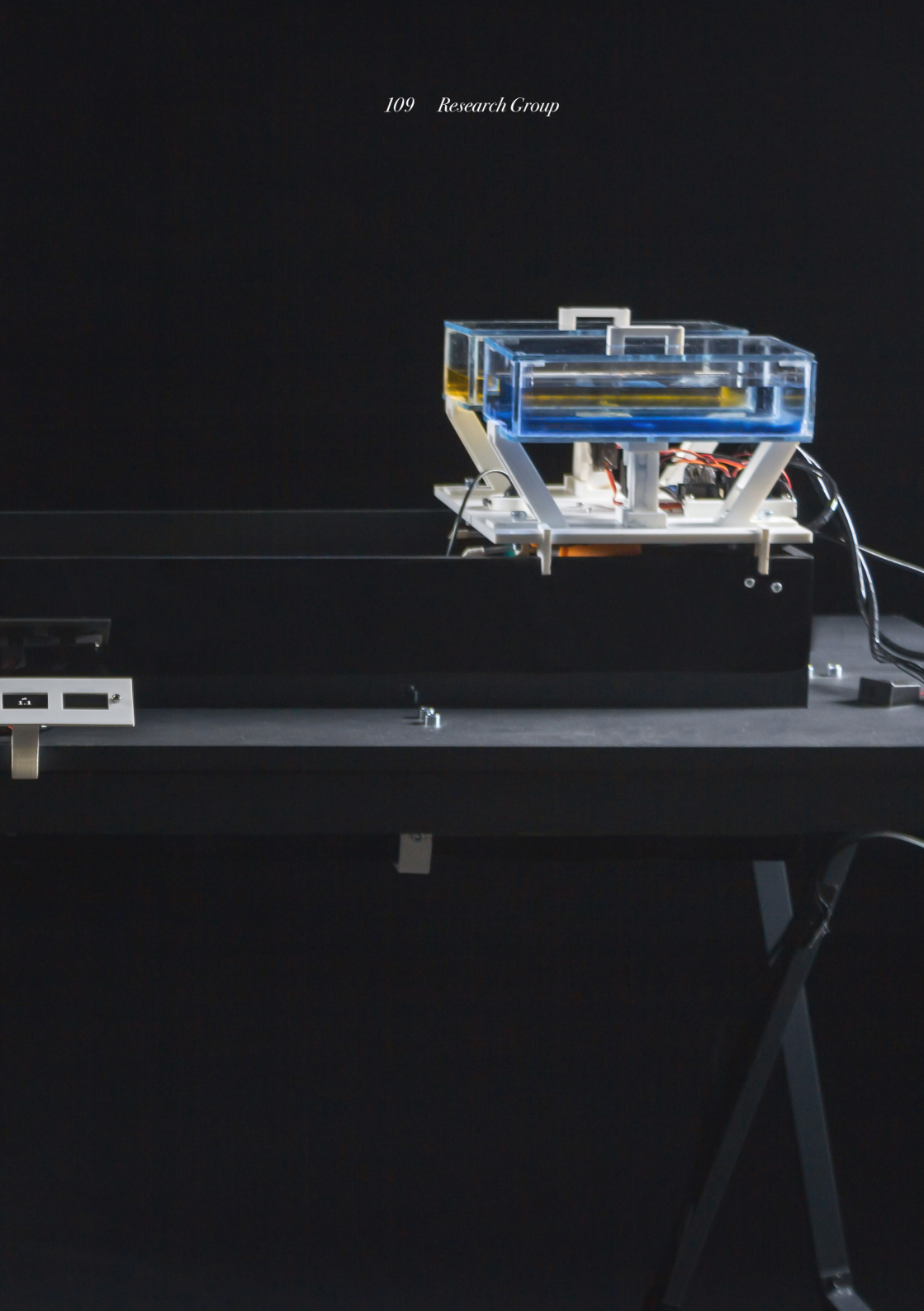


FIG. 121: 'Mycelium apparatus' Version 2



Notes

On Speculative Design

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

2 Dunne, Anthony. *Hertzian Tales*. MIT, 2008. Print.

3 Dunne, Anthony, and Fiona Raby. *Speculative Everything: Design, Fiction, and Social Dreaming.* Cambridge (Mass.): MIT Press, 2013. Print.

4 Rodgers, Paul, and Michael Smyth. *Digital Blur: Creative Practice at the Boundaries of Architecture, Design and Art*. Faringdon, Oxfordshire: Libri Publishing, 2010. Print.
The book gives a good insight into how modern thinkers, artists and creatives are incorporating the latest technologies into their practices.

5 It would be easy to squeeze in a *Future Cone (PPPP)* figure in here and lay out all the potential futures:
Probable : the traditional area designers work inside.
Plausible : alternative futures with ties to today's world.
Possible : outlook on extremely and scientifically possible outcomes.
Preferable : speculative designs area for discussion, debate and discourse of the future.
... but I felt it has been overused recently so I decided not to put it and just mention it here.

6 Dunne, Anthony, and Fiona Raby. *Speculative Everything: Design, Fiction, and Social Dreaming.* Cambridge (Mass.): MIT Press, 2013. Print. P. 6
Dunne and Raby believe that laying out the future with a speculative approach helps to re-evaluate misconfigurations and bad outcomes before they even come into reality – which is somewhat of a bottom-up planning in programming.

7 Brooker, Charlie. Black Mirror. 2012.

8 Slate: https://slate.com/technology/2012/03/bruce-sterling-on-design-fictions.html [Accessed: 09.06.2017]. Diegetic prototypes started to become real in cinematography as objects that exist and function in their respective worlds but are fictional to the real world. Artefacts of speculation serve as anchors to the suspension of disbelief and let us sink more into speculative scenarios.

Regarding Cybernetics

1 Wiener, Norbert. *Cybernetics: Or, Control and Communications in the Animal and the Machine*. Paris: Hermann, 1948. Print.

2 Maxwell, James C. *On Governors*. London: publisher not identified, 1868. Print. Available at: https://www.maths.ed.ac.uk/~v1ranick/papers/maxwell1.pdf [Accessed: 09.06.2017]

3 Andre Ampere (1834), *Essay on the philosophy of science*.

4 *All Watched Over by Machines of Loving Grace*: Written and Directed by Adam Curtis. Neutral Bay, N.S.W.: EnhanceTV, 2011. Quote is from narration in Episode 2: *The Use and Abuse of Vegetational Concepts*

5 Mead, Margaret. *"Cybernetics of Cybernetics."* American Society for Cybernetics. Purposive Systems, 1968, Pp. 1-11. (1968). Print.

6 Foerster, Heinz . *Observing Systems*. Seaside, Calif: Intersystems publications, 1984. Print. As part of the *"Systems Inquiry Series"*, articles were written between 1960 and 1977 and published before.

7 Reichardt, Jasia. *Cybernetic Serendipity: The Computer and the Arts*. , 1968. Print.

Research Group

1 Wheatstone bridge description according to the Wikipedia article:

A Wheatstone bridge is an electrical circuit used to measure an unknown electrical resistance by balancing two legs of a bridge circuit, one leg of which includes the unknown component. The primary benefit of the circuit is its ability to provide extremely accurate measurements. Its operation is similar to the original potentiometer.

The Wheatstone bridge was invented by Samuel Hunter Christie in 1833 and improved and popularized by Sir Charles Wheatstone in 1843. One of the Wheatstone bridge's initial uses was for the purpose of soils analysis and comparison.
https://en.wikipedia.org/wiki/Wheatstone_bridge [Accessed: 09.06.2017]

2 Leslie Garcia – Pulsu(m) Plantae: http://lessnullvoid.cc/pulsum/category/proceso/ [Accessed: 09.06.2017].

3 Studio NAND: https://nand.io/projects/botanicus-interacticus [Accessed: 09.06.2017]

4 Studio TheGreenEyl: http://www.thegreeneyl.com/another-orchid [Accessed: 09.06.2017]

5 M., Poupyrev, I., Harrison, C. *Touché: Enhancing Touch Interaction on Humans, Screens, Liquids, and Everyday Objects*. Sato, In ACM CHI 2012. pp. 483-492

6 Kurzweil, Ray. The Law of Accelarating Retuns. 2001. Essay.
Available: http://www.kurzweilai.net/the-law-of-accelerating-returns [Accessed: 09.06.2017]

7 Kurzweil, Ray. *The Singularity Is Near: When Humans Transcend Biology*. London: Penguin, 2010. Print.

8 Lem, Stanisław. *One Human Minute*. San Diego [Calif.: Harcourt Brace Jovanovich, 1986. Print.

9 SCIgen is able generate random science papers, which at a first glance seem completly plausible through sheer complexity: https://pdos.csail.mit.edu/archive/scigen/

10 Stifter, Adalbert. *Der Hochwald: Das Haidedorf : Erzählungen*. Halle a.d.S: Hendel, 1850. Print.

11 *The events have an open format and provide a forum for experiments, presentations and performances from a range of different fields, but with a common focus on old and new media, as well as technologies. The salon thereby enables a practice of reenactment as a way to make things past and hidden visible, present and also questionable.*
(Taken from the website's description of the event series)
Salon Digital: https://salon-digital.com/salons/salon-6 [Accessed: 09.06.2017]

List of Figures

Acknowledgements

You have reached the last page. Before I get to you for making it through, I need to give shout outs to a lot of people who helped, supported and even collaborated with me on this endeavour.

My biggest respect goes to the collaborators and their invaluable contributions:

Irena Kukric — Emotional, technical and assembly support! She did a wonderful job with the drawings, giving a certain plausability to the reports. She is also the author of the *Rabbit 0* report. Furthermore she helped me with proofreading, finding inconsequent thoughts and sentences.

Luiz Zanotello — He helped me assembling the first time and is the author of the eerie *Torc Mountain deer* report.

Thomas Ganser — For always asking the interesting and unheard questions and his two big contributions: The *Algae Tattoo* report and the *Séance with a crow medium.* These reports took things definetely into a new direction.

Jasna Dimitrovska — For her report on a *Cat Corpse* and its black humor-horror-sciency vibe.

To my supervisors and dear professors, Dennis P. Paul and Andrea Sick, who always gave me just the best bits of their knowledge and full support down the road and onwards. The way you work and think will inspire me forever.

Hendrik Heuer who proofread this document and send me just good, constructive notes during the correction rounds.

Additionally I would also like to thank these people for their support along the way: My family. Mariana Schetini Basso. Bojana Petkovic. Guto Nóbrega. Ralf Baecker. Markus Walthert. Karl Strecker. Lennart Klein.

Last but not least I want to thank *you* for reading all of this.

We received the fundings and the right motivation to put further research into hypotheses we have compiled over the last couple of weeks. We were also asked to assemble a team of international researches in excellence in their fields. This is great news and will definitely help tremendously in our case.

Earlier in a conversation with Aurore and Anthony, Aurore insinuated that she might try to lead the future research group under a common hidden agenda against the U.S. bureau. I support this notion wholeheartedly.
There is nothing more to add here.

Internal Memo
1971
Davy Francis

There have been discussions within the group, whether we should try to risk and go against the bureau‘s vision of science or not. I am clearly in favour of taking this route. Only time can tell, how long this conflict will go on or if it will ever end one day. Reveries of a new world are in arm‘s reach.

Journal Entry
March 5th 1927
Anthony Reed

C'est fait! Nous avons exprimé nos souhaits et nos pensées dans un document sur lequel tout le monde était d'accord et auquel tout le monde croyait aussi.

Internal Memo
2. February
Aurore Duval